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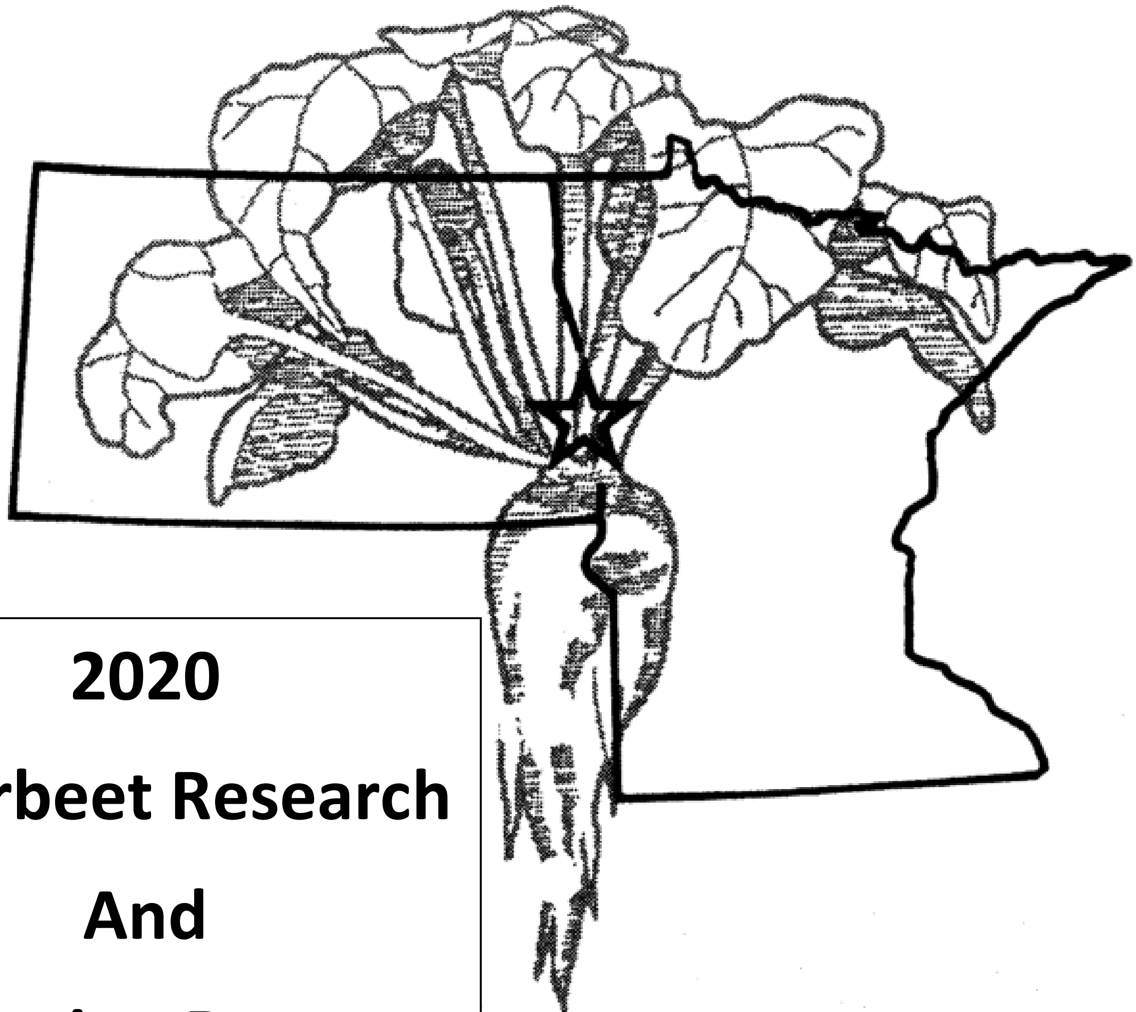

2020 Sugarbeet Research And Extension Reports

A portion of the contents of this booklet report on one year of work. Since results may vary from year to year, conclusions drawn from one year of work may not hold true in another year. The contents of this booklet are not for publication or reprint without permission of the individual author.

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TURNING POINT SURVEY OF WEED CONTROL AND PRODUCTION PRACTICES IN SUGARBEET IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2019

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The fifth annual weed control and production practices live polling questionnaire was conducted using Turning Point Technology at the 2020 winter Sugarbeet Grower Seminars. Responses are based on production practices from the 2019 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 160,150 acres reported by 245 respondents (Table 6) compared to 174,032 acres represented in 2018. The average sugarbeet acreage per respondent grown in 2019 was calculated from Table 6 at 662 acres compared to 697 acres in 2018.

Survey participants were asked a series of questions regarding their production practices used in sugarbeet in 2019. Fifty-five percent of respondents indicated wheat was the crop preceding sugarbeet (Table 7), 27% indicated corn, and 9% indicated soybean. Preceding crop varied by location with 92% of Grand Forks growers indicating wheat preceded sugarbeet and 72% of Willmar growers indicated corn as their preceding crop. Seventy percent of growers who participated in the winter meetings used a nurse or cover crop in 2019 (Table 8) which decreased from 77% in 2018. Cover crop species also varied widely by location with barley being used by 43% of growers at the Grand Forks meeting and oat or wheat being used by 40% of growers at the Willmar meeting.

Growers indicated Cercospora Leaf Spot (CLS) was their most serious production problem in sugarbeet in 2019 (Table 9) with 27% of all respondents naming CLS. Rhizoctonia was named the second most serious problem by 26% of participants. In 2018, CLS was named the most serious problem by 42% of all respondents. Weeds or emergence/stand were named as most serious by 16% of respondents.

Waterhemp was named as the most serious weed problem in sugarbeet in 2019 by 56% of respondents (Table 10) compared to 54% in 2018. Nine percent of respondents indicated common lambsquarters, 7% kochia, and 18% said common ragweed were their most serious weed problem in 2019. 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 96%, 80%, and 94% 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 56% of responses.

Respondents to the survey indicated making 0 to 4 glyphosate applications in their 2019 sugarbeet crop (Table 11) with a calculated average of 2.05 applications per acre. The calculated average in 2018 was 2.16 applications per acre.

Glyphosate was most commonly applied with a broadleaf herbicide postemergence in 2019 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 2019 with 31% of responses. Glyphosate alone and glyphosate plus a grass herbicide were the third and fourth most common at 22% and 10% of the responses.

Satisfaction to weed control from glyphosate applied alone is shown in Table 13 and ranged from 23% of responses indicating excellent control to 2% of responses indicating poor weed control. The majority of responses, 38%, indicated glyphosate was still providing good weed control in sugarbeet in 2019.

Preplant incorporated (PPI) or preemergence (PRE) herbicides were applied by 45% of survey respondents in 2019 (Table 14). The most commonly used soil herbicide was S-metolachlor with 21% of all responses followed by ethofumesate with 14% of responses (Table 14). Of the growers who indicated using a soil-applied herbicide, 72% indicated excellent to good weed control from that herbicide (calculated from Table 15).

The application of soil-residual herbicides applied 'lay-by' to the 2019 sugarbeet crop was indicated by 58% of respondents (Table 16). Outlook was the most commonly applied lay-by herbicide with 28% of responses. The majority of growers responding at the Willmar meeting indicated using Outlook (65% of responses), while S-metolachlor was more commonly applied by growers of the Wahpeton (60% of responses) and Fargo (58% of responses) meetings. Ninety-six percent, 100%, and 74% of Willmar, Wahpeton, and Fargo respondents, respectfully, applied glyphosate with Outlook, S-metolachlor, or Warrant but only 17% and 14% 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 glyphosate-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, 75% indicated excellent or good weed control (calculated from Table 17).

Sixty percent of survey respondents indicated using some form of mechanical weed control or hand labor in 2019 (Table 18). Of the responses given, 38% indicated at least some hand-weeding, 16% used row-cultivation, and 2% indicated using a rotary hoe for weed control in sugarbeet. Sixteen percent reported row-crop cultivation on less than ten percent of their acres (Table 19). Of respondents indicating they used row-cultivation, 49% indicated excellent or good weed control (Table 20).

Hand-weeding the 2019 sugarbeet crop was reported by 50% of respondents (Table 21). 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. 2020 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2019.

County	Number of Responses	Percent of Responses
Becker	1	3
Cass	4	11
Clay	15	41
Norman[1]	10	28
Richland	1	3
Traill	4	11
Wilkin[2]	1	3
Total	36	100

[1]Includes Mahnomen County
[2]Includes Otter Tail County

Table 2. 2020 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2019.

County	Number of Responses	Percent of Responses
Kittson	10	20
Marshall	2	4
Pembina	14	27
Polk	4	8
Walsh	21	41
Total	51	100

Table 3. 2020 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2019.

County	Number of Responses	Percent of Responses
Grand Forks	10	15
Marshall	11	16
Polk	36	54
Traill	4	6
Walsh	4	6
Other	2	3
Total	67	100

Table 4. 2020 Wahpeton Grower Seminar - Number of survey respondents by county growing sugarbeet in 2019.

County	Number of Responses	Percent of Responses
Grant	2	18
Richland	1	9
Wilkin	8	73
Total	11	100

Table 5. 2020 Willmar Grower Seminar - Number of survey respondents by county growing sugarbeet in 2019.

County	Number of Responses	Percent of Responses
Chippewa	31	34
Kandiyohi	10	11
Redwood	3	3
Renville	29	32
Stevens	4	4
Swift	9	10
Other	5	6
Total	91	100

Table 6. Total sugarbeet acreage operated by respondents in 2019.

		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	32	17	9	9	6	25	9	6	3	3	13
Grafton	49	10	6	9	12	16	18	6	4	0	9
Grand Forks	66	9	6	6	5	26	15	6	17	9	1
Wahpeton	8	0	13	13	24	13	13	0	0	24	0
Willmar	90	8	10	14	12	16	20	3	12	4	1
Total	245	9	8	10	10	20	17	5	12	5	4

Table 7. Crop grown in 2018 that preceded sugarbeet in 2019.

		Previous Crop						
Location	Responses	Field Corn	Dry Bean	Potato	Soybean	Wheat	Sweet Corn	Other
		-------------------------------% of responses---------------------------------------						
Fargo	32	3	0	0	16	78	3	0
Grafton	55	0	4	7	2	82	0	5
Grand Forks	66	0	2	2	4	92	0	0
Wahpeton	10	20	0	0	10	70	0	0
Willmar	90	72	1	0	15	1	10	1
Total	253	27	2	2	9	55	4	1

Table 8. Nurse or cover crop used in sugarbeet in 2019.

Location	Responses	Barley	Oat	Rye	Wheat	Other[1]	None
		----------------------------------% of responses------------------------------					
Fargo	36	39	3	0	19	0	39
Grafton	52	33	8	0	17	0	42
Grand Forks	72	43	1	1	18	0	37
Wahpeton	10	50	0	0	50	0	0
Willmar	91	0	40	2	40	0	18
Total	261	26	16	1	27	0	30

[1]Includes Mustard and 'Other'

Table 9. Most serious production problem in sugarbeet in 2019.

Location	Responses	Aph[1]	CLS[2]	Stand[3]	Fusarium	Herbicide Injury	Rhizoc-tonia	Rhizo-mania	Insects	Weeds
		-------------------------------------% of responses---								
Fargo	39	5	28	5	8	0	21	2	0	31
Grafton	56	14	11	21	0	4	29	7	9	5
Grand Forks	62	3	18	35	0	2	21	0	10	11
Wahpeton	9	0	78	0	0	0	22	0	0	0
Willmar	96	3	37	5	2	1	29	1	0	22
Total	262	6	27	16	2	1	26	2	4	16

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

Table 10. Most serious weed problem in sugarbeet in 2019.

Location	Responses	colq[1]	cora	kochia	gira	rrpw	RR Canola	wahe
		------% of responses------						
Fargo	35	3	0	3	0	0	0	94
Grafton	54	24	15	28	2	15	7	9
Grand Forks	66	12	56	5	3	6	0	18
Wahpeton	10	0	0	0	0	10	10	80
Willmar	89	1	0	0	1	0	2	96
Total	254	9	18	7	2	5	3	56

[1]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 2019 season.

Location	Responses	0	1	2	3	4	5
		------% of responses------					
Fargo	38	3	13	63	16	5	0
Grafton	50	0	12	66	22	0	0
Grand Forks	69	0	16	70	14	0	0
Wahpeton	9	0	0	44	56	0	0
Willmar	89	0	24	57	16	3	0
Total	255	<1	17	63	18	2	0

Table 12. Herbicides used in a weed control systems approach in sugarbeet in 2019.

		Glyphosate Application Tank-Mixes					
Location	Responses	Gly Alone	Gly+Lay-by	Gly+Broadleaf	Gly+Grass	Other	None Used
		------% of responses------					
Fargo	40	10	38	35	7	3	7
Grafton	54	70	7	19	2	0	2
Grand Forks	72	22	7	67	0	4	0
Wahpeton	13	0	61	23	8	8	0
Willmar	153	9	47	25	18	1	0
Total	332	22	31	34	10	2	1

Table 13. Satisfaction in weed control from glyphosate applied in sugarbeet in 2019.

		Satisfaction of Weed Control from Glyphosate					
Location	Responses	Excellent	Good	Fair	Poor	Unsure	Not Used Alone
		------% of responses------					
Fargo	37	5	22	38	8	3	24
Grafton	50	38	44	16	0	0	2
Grand Forks	68	23	46	9	0	0	22
Wahpeton	9	0	11	33	0	0	56
Total	164	23	38	19	2	<1	18

Table 14. Preplant incorporated or preemergence herbicides used in sugarbeet in 2019.

Location	Responses	PPI or PRE Herbicides Applied					
		S-metolachlor	ethofumesate	Ro-Neet SB	S-metolachor +ethofumesate	Other	None
		--------------------------------------% of responses----------------------------------					
Fargo	38	39	13	3	3	3	39
Grafton	55	2	5	2	0	2	89
Grand Forks	67	9	0	0	0	9	82
Wahpeton	11	18	27	0	9	0	46
Willmar	92	33	28	0	13	2	24
Total	263	21	14	<1	5	4	56

Table 15. Satisfaction in weed control from preplant incorporated and preemergence herbicides in 2019.

Location	Responses	PPI or PRE Weed Control Satisfaction					
		Excellent	Good	Fair	Poor	Unsure	None Used
		------------------------------% of responses--------------------------					
Fargo	35	6	34	14	0	9	37
Grafton	51	2	4	2	0	0	92
Grand Forks	72	10	10	0	0	0	80
Wahpeton	10	40	20	10	0	0	30
Willmar	92	12	42	22	3	1	20
Total	260	10	24	10	1	2	53

Table 16. Soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2019.

Location	Responses	Lay-by Herbicides Applied				
		S-metolachlor	Outlook	Warrant	Other	None
		----------------------------------% of responses---------------------------------				
Fargo	38	58	10	3	3	26
Grafton	44	10	0	2	2	86
Grand Forks	64	16	1	0	0	83
Wahpeton	10	60	30	10	0	0
Willmar	93	4	65	27	0	4
Total	249	18	28	11	1	42

Table 17. Satisfaction of weed control from soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2019.

Location	Responses	Lay-by Weed Control Satisfaction					
		Excellent	Good	Fair	Poor	Unsure	None Used
		-------------------------------% of responses--------------------------					
Fargo	35	6	57	9	3	11	14
Grafton	48	2	2	8	2	0	86
Grand Forks	64	8	8	2	0	2	80
Wahpeton	10	40	60	0	0	0	0
Willmar	90	16	57	21	2	0	4
Total	247	11	34	11	1	2	41

Table 18. Mechanical weed control methods used in sugarbeet in 2019.

Location	Responses	Rotary Hoe	Row-Cultivation	Hand-Weeded	Other	None
		--% of responses--				
Fargo	43	0	19	46	5	30
Grafton	51	2	10	31	2	55
Grand Forks	70	3	4	32	0	61
Wahpeton	10	0	10	20	0	70
Willmar	113	3	26	44	5	22
Total	287	2	16	38	4	40

Table 19. Percent of sugarbeet acres row-crop cultivated in 2019.

		% Acres Row-Cultivated				
Location	Responses	0	< 10	10-50	51-100	>100
		--% of responses--				
Fargo	36	69	28	3	0	0
Grafton	51	78	16	4	0	2
Grand Forks	67	81	19	0	0	0
Wahpeton	10	70	20	10	0	0
Willmar	86	63	9	8	8	12
Total	250	72	16	5	3	4

Table 20. Satisfaction of weed control from row-crop cultivation in sugarbeet in 2019.

		Cultivation Weed Control Satisfaction					
Location	Responses	Excellent	Good	Fair	Poor	Unsure	None Used
		--% of responses--					
Fargo	36	0	20	11	8	0	61
Grafton	50	0	12	4	0	6	78
Grand Forks	68	1	12	0	0	3	84
Wahpeton	10	20	0	10	0	0	70
Willmar	86	3	10	19	3	2	63
Total	250	2	12	9	1	3	72

Table 21. Percent of sugarbeet acres hand-weeded in 2019.

		% Acres Hand-Weeded				
Location	Responses	0	< 10	10-50	51-100	>100
		--% of responses--				
Fargo	35	26	51	17	3	3
Grafton	52	65	29	4	2	0
Grand Forks	71	68	31	1	0	0
Wahpeton	10	80	20	0	0	0
Willmar	88	32	24	27	9	8
Total	256	50	30	13	4	3

HOODED SPRAYER FOR APPLICATION OF NONSELECTIVE HERBICIDES IN SUGARBEET

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Summary

1. Liberty and Gramoxone are not approved for POST directed application in sugarbeet.
2. Gramoxone at 21 fl oz/A plus non-ionic surfactant (NIS) and Liberty at 32 fl oz/A plus ammonium sulfate (AMS) improved 4- and 6-inch waterhemp control as compared with repeat glyphosate applications at 28 fl oz/A / 28 fl oz/A plus NIS and AMS.
3. PowerMax was more effective than Liberty or Gramoxone for common lambsquarters control.
4. Growth reduction injury was negligible from Gramoxone or Liberty applied at the 6-lf sugarbeet stage or greater and Gramoxone or Liberty did not reduce root yield, sucrose content or recoverable sucrose as compared to repeat glyphosate application.

Introduction
Sugarbeet producers recognized waterhemp as their most troublesome weed control challenge on 373,064 acres or 59% of the production acreage in Minnesota and eastern North Dakota in 2020 (survey conducted at 2020 Sugarbeet Growers Seminars, Turning Technologies, Youngstown, OH). Waterhemp control is maximized by using soil residual herbicides applied preemergence, early postemergence, and postemergence in sugarbeet. Optimal control is dependent on timely rainfall following application to move herbicides into the weed seed zone, or from soil surface to 2-cm into soil. Postemergence (POST) applications of Betamix and UpBeet and inter-row cultivation have been used to control escaping weeds. However, remnant inventories of Betamix have been exhausted, UpBeet-resistant waterhemp populations are increasingly common in the production area, and (re)adoption of inter-row cultivation by sugarbeet growers has been slow.

Selective and nonselective herbicides applied through hooded sprayers are used in cotton production to control weeds between rows. The hood protects cotton plants from herbicides that may cause growth reduction injury. The practicality and value of a hooded sprayer is being evaluated in sugarbeet as herbicide-resistance continues to increase in species such as waterhemp and Palmer amaranth. Experiments conducted in 2020 evaluated sugarbeet tolerance and waterhemp and common lambsquarters control from Roundup PowerMax (glyphosate), Liberty (glufosinate) and Gramoxone (paraquat) applied through a hooded sprayer at multiple locations in North Dakota and Minnesota.

Objectives
Liberty and Gramoxone are not labeled in sugarbeet and will require action by Minnesota and North Dakota Department of Agriculture before use, even between rows through a hooded sprayer. Thus, sugarbeet tolerance and weed control must be measured before support can be solicited from industry and a petition submitted to the Department of Agriculture. The objectives of these research were to determine sugarbeet tolerance and weed control when Liberty or Gramoxone were applied at different rates and timings through a hooded sprayer.

Materials and Methods
Sugarbeet Tolerance. Experiments were conducted near Crookston, MN, Lake Lillian, MN, Hickson, ND, and Prosper, ND in 2020. The Hickson, ND location was not included in the analysis due to erratic sugarbeet stands. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage to each location. Sugarbeet was planted between April 27 and May 27, 2020.

Herbicide treatments were applied between each row within a 30-foot long by six row plot when sugarbeet was at the 2-, 6-, and 10-lf stage using a hooded sprayer traveling 3 mph delivering 22 gpa spray solution through 8002 EVS Teejet nozzles pressurized with CO_2 at 35 psi. The treatment list can be found in Table 1.

Table 1. Herbicide treatments, rates, and application timing in trials near Prosper, ND and Lake Lillian and Crookston, MN in 2020.

Herbicide treatment	Rate (fl oz/A)	Sugarbeet stage (lvs)
RU PowerMax / RU PowerMax[1]	28 /28	4 / 6-8
Liberty[2]	86	2-4
Liberty	86	6-8
Liberty	86	10-12
Gramoxone SL 3.0[3]	32	2-4
Gramoxone SL 3.0	32	6-8
Gramoxone SL 3.0	32	10-12

[1]Treatments with Roundup PowerMax applied with Prefer 90 NIS at 0.25% v/v + N-Pak AMS Liquid at 2.5% v/v.
[2]Treatments with Liberty applied with dry AMS at 3 lb/A.
[3]Treatments with Gramoxone SL 3.0 applied with Prefer 90 NIS at 1 qt/A.

Sugarbeet injury was evaluated as a visual estimate of percent growth reduction (0 to 100% scale, 0 is no visible injury and 100 is complete loss of plant / stand) in the middle four rows of the six-row plot compared to the glyphosate check. Leaf damage ratings were also evaluated by counting the number of sugarbeet plants within treated rows with visual damage. Damage factors included herbicide drift, operator or equipment error, environment, etc. Sugarbeet was harvested from the center two rows within a plot in the fall and assessed for yield and quality. Data were analyzed using either SAS Data Management software PROC MIXED procedure to test for significant differences at p=0.05 or the ANOVA procedure of ARM, version 2020.2 software package depending on variable. Experimental design was randomized complete block with six replications.

Hooded Sprayer Efficacy. Experiments were conducted on native populations of common lambsquarters and waterhemp in sugarbeet fields near Moorhead and Lake Lillian, MN and Galchutt and Hickson, ND in 2020. The Galchutt location was dropped due to insufficient waterhemp populations; the Hickson site was dropped due to sprayer mechanical challenges. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage to each location. Sugarbeet was planted April 28th and May 19th at Lake Lillian and Moorhead, respectively.

Herbicide treatments were applied between each row within a 30-foot long by six row plot when waterhemp was 3- or 6-inches tall using a hooded sprayer delivering 22 gpa spray solution through 8002 EVS Teejet nozzles pressurized with CO_2 at 35 psi. The treatment list can be found in Table 2.

Table 2. Herbicide treatments, rates, and application timing in trials near Moorhead and Lake Lillian, MN in 2020.

Herbicide treatment	**Rate (fl oz /A)**	**Waterhemp (inch)**
RU PowerMax / RU PowerMax[1]	28 / 28	2 to 4 fb 10 d
Liberty[2]	32	3-4
Liberty	32	6-8
Liberty	43	3-4
Liberty	43	6-8
Gramoxone SL 3.0[3]	21	3-4
Gramoxone SL 3.0	21	6-8
Gramoxone SL 3.0	32	3-4
Gramoxone SL 3.0	32	6-8

[1]Treatments with Roundup PowerMax applied with Prefer 90 NIS at 0.25% v/v + N-Pak Liquid AMS at 2.5% v/v.
[2]Treatments with Liberty applied with dry AMS at 3 lb/A.
[3]Treatments with Gramoxone SL 3.0 applied with Prefer 90 NIS at 1 qt/A.

Weed control was evaluated as a visual estimate of percent fresh weight reduction (0 is no injury and 100 is complete control) in the four treated rows compared to the glyphosate check at 7, 14, and 21 days (+/- 3 days) after application. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2020.4 software package.

Tolerance Results

Tolerance Probe. Experiments conducted by BASF Corp at two locations in 2020 evaluated RR sugarbeet tolerance to glufosinate in an over-the-top application using a rate titration of 1x, 1/10x, 1/100x, and 1/1000x the recommended rate applied to 4- and 8-lf sugarbeet (Table 3). The research simulated sugarbeet injury from spray solution escaping from hoods at two growth stages. Sugarbeet were sensitive to Liberty, especially at 43 fl oz/A at the 4-lf stage. However, injury was less at the 10-lf stage or with the 1/10, 1/100 or 1/1000x Liberty rate. No injury to either the 4- or 10-lf stage sugarbeet was observed at the 1/100x or 1/1000x rate. The experiment demonstrated sugarbeet sensitivity to glufosinate when sprayed over the top of sugarbeet; however, sugarbeet may not be as susceptible to injury when applications are made through a hooded sprayer.

Table 3. RR sugarbeet tolerance to Liberty herbicide following broadcast application.[1]

			Injury 4 DAT[2]	
Treatment	Rate	Rate	4-lf Sugarbeet	10-lf Sugarbeet
	fl oz/A		----------------%----------------	
Liberty[3]	43	1x	100	70
Liberty	4.3	1/10x	30	15
Liberty	0.43	1/100x	0	0
Liberty	0.043	1/1000x	0	0

[1]Bird Island, MN plot ratings by Dr. Duane Rathmann, BASF Corp.
[2]DAT=Days after treatment.
[3]All Liberty treatments applied with dry AMS at 3 lb/A.

Sugarbeet growth reduction injury from herbicides applied through a hooded sprayer was negligible across application timings (Table 4). Injury was divergence from a uniform stand and tended to represent damage to specific sugarbeet plants and not uniform damage across the plot. Numerically, growth reduction injury was greatest following either Liberty or Gramoxone application at the 2 to 4 leaf sugarbeet. We did not observe any difference in injury between Liberty and Gramoxone. Injury became less as sugarbeet grew and was not observed or was negligible at 14 or 21 DAT (data not presented). Leaf damage counts represent single locations since the cause of damage was experiment specific (Table 4). Leaf damage injury from Gramoxone was generally greater than from Liberty. Leaf damage at the 2- to 4-lf stage at Lake Lillian may have been extenuated by breeze conditions at application. Damage ratings at the 10- to 12-leaf stage is likely from wheel traffic, especially since it was not supported by the growth reduction observations. Damage was less as sugarbeet developed and was negligible 14 or 21 DAT (data not presented). Root yield, % sucrose, and recoverable sucrose from Liberty or Gramoxone through the hooded sprayer was the same as yield parameters treated with repeat glyphosate application (Table 5). However, Liberty and Gramoxone at the 2- to 4-leaf stage applications tended to give root yield less than the glyphosate check.

Table 4. Growth reduction, averaged across three environments and number of damaged plants in plots, by environment, in response to POST herbicides through the hooded sprayer in 2020.[1]

		Growth Reduction	Damaged Plants		
		Across Locations	Crookston, MN	Prosper, ND	Lake Lillian, MN
Herbicide treatment	**Sugarbeet stage**	7 DAT[2]	7 DAT	7 DAT	7 DAT
	--lvs--	--%--	-------------# plants/plot------------------		
RU PowerMax / RU PowerMax	4 / 6-8	1	6 a	2 a	4 a
Liberty	2-4	15	11 ab	2 a	81 b
Liberty	6-8	7	5 a	2 a	19 ab
Liberty	10-12	9	80 e	45 c	13 a
Gramoxone SL 3.0	2-4	16	23 bc	2 a	134 c
Gramoxone SL 3.0	6-8	10	46 d	9 a	31 ab
Gramoxone SL 3.0	10-12	7	27 c	30 b	30 ab
		---------------------------------*P*-value----------------------------			
		0.0925	<0.0001	<0.0001	<0.0001

[1]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.
[2]DAT=Days after treatment.

Table 5. Root yield, sucrose content, and recoverable sucrose in response to POST herbicides through the hooded sprayer, across three environments, in 2020.[1]

Herbicide treatment	**Sugarbeet stage**	**Root Yield[2]**	**Sucrose Content**	**Rec. Suc[3]**
	--lvs--	--Tons/A--	--%--	--lb/A--
RU PowerMax / RU PowerMax	4 / 6-8	30.1	16.2	8,628
Liberty	2-4	27.9	16.4	8,055
Liberty	6-8	29.3	16.2	8,789
Liberty	10-12	29.2	16.0	8,468
Gramoxone SL 3.0	2-4	27.9	16.4	8,392
Gramoxone SL 3.0	6-8	29.2	16.1	8,680
Gramoxone SL 3.0	10-12	28.6	16.0	8,362
		-----------------------------*P*-value--------------------		
		0.3146	0.8799	0.6049

[1]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.
[2]Root yield reported in ton per acre.
[3]Recoverable sucrose reported in pound per acre.

Efficacy Results

The first observation of symptomology was herbicide specific in efficacy experiments. A necrosis phenotype was observed from Gramoxone 1 DAT on waterhemp and common lambsquarters. Symptomology from Liberty was observed first on waterhemp and second on lambsquarters 5- to 7-DAT. Symptomology from glyphosate was slowest to be observed, especially on waterhemp. Gramoxone applied through the hooded sprayer improved waterhemp control compared to repeat glyphosate applications (Table 6). Waterhemp control from Gramoxone was not influenced by weed size or application rate. Waterhemp control from Liberty was dependent on rate and weed size. Liberty at 32 fl oz/A provided or tended to provide control of 3- to 4-inch waterhemp greater than 6- to 8-inch waterhemp. Waterhemp size did not influence control when Liberty was applied at 43 fl oz/A. However, Liberty applied at 43 fl oz/A tended to provide greater control of 3- to 4-inch waterhemp compared to 6-to 8-inch waterhemp.

Table 6. Waterhemp and common lambsquarters control in response to POST herbicides applied through the hooded sprayer, 2020.[1]

Herbicide treatment	Rate	Weed Height	Waterhemp	Common Lambsquarters Lake Lillian	Common Lambsquarters Moorhead
	-fl oz/A-	----inch----	----	----%----	----
RU PowerMax / RU PowerMax	28 / 28	2 to 4 fb 10 d	55 c	94 a	99 a
Liberty	32	3-4	81 ab	65 c	77 de
Liberty	32	6-8	56 c	29 e	81 cd
Liberty	43	3-4	86 ab	79 b	85 bcd
Liberty	43	6-8	70 bc	41 d	86 bcd
Gramoxone SL 3.0	21	3-4	90 a	89 a	77 de
Gramoxone SL 3.0	21	6-8	90 a	65 c	73 e
Gramoxone SL 3.0	32	3-4	96 a	94 a	93 ab
Gramoxone SL 3.0	32	6-8	96 a	85 ab	89 bc
			----	----*P*-value----	----
			0.0020	<0.0001	<0.0001

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

Common lambsquarters ranged from 6- to 12-inches at Lake Lillian due to high wind conditions in June which delayed application timings. Lambsquarters was sprayed according to protocol at Moorhead, MN. Thus, lambsquarters control was not combined and are reported separately for each experiment. Glyphosate was equally effective at controlling small and large common lambsquarters in this experiment. At Lake Lillian, control from Liberty was dependent on rate and lambsquarters size at application. However, common lambsquarters control from Liberty was the same across rates and height at Moorhead where applications were successfully timed to protocol. Lambsquarters control from Liberty was less than control from glyphosate and tended to be less than control from Gramoxone at both locations. Common lambsquarters control differences from Liberty and Gramoxone were much less at Moorhead than at Lake Lillian where Gramoxone gave greater lambsquarters control at a given weed size compared with control from Liberty. At Moorhead, common lambsquarters height did not affect control from Gramoxone at 21 fl oz/A. However, at Lake Lillian, applying Gramoxone to smaller lambsquarters resulted in greater control at both 21 and 32 fl oz/A.

Conclusions

Liberty and Gramoxone are effective herbicides for controlling waterhemp and can be safely applied inter-row through a hooded sprayer when sugarbeet are at the 6-8 leaf stage or greater. Liberty might be slightly safer than Gramoxone. Weed control from Liberty generally decreases as weed height increases and numerically was better on waterhemp than common lambsquarters. Waterhemp control from Gramoxone was not influenced by rate or height but control of taller lambsquarters was less at Lake Lillian as compared to Moorhead. Waterhemp should be the primary weed control focus when using a hooded sprayer since glyphosate remains highly effective for common lambsquarters control. Liberty at 32 fl oz/A applied to small weeds or Gramoxone at 21 fl oz/A applied to small or large weeds provided improved waterhemp control than glyphosate.

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KOCHIA CONTROL IN SUGARBEET

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Summary

1. Apply ethofumesate preplant incorporated (PPI) or preemergence (PRE) at 6 to 7.5 pt/A in sugarbeet fields where kochia is identified as the most important weed control challenge in sugarbeet.
2. Consult with your Agriculturalist, ag-retailer or crop consultant to determine if your field is a glyphosate-resistant kochia biotype.
3. Time herbicide applications to kochia growth stage to optimize control.
4. Betamix improved control from PowerMax + ethofumesate postemergence (POST) in these experiments. However, we highly recommend you carefully manage Betamix rate based on sugarbeet growth stage to ensure sugarbeet safety, especially when Betamix follows ethofumesate soil applied.
5. Kochia control from crops in sequence with sugarbeet are often more effective than sugarbeet herbicides for kochia control.

Introduction

Kochia is an invasive annual broadleaf native to Asia. Kochia was introduced into the United States at the end of the 1800s as an ornamental from Europe (Friesen et al. 2009). Kochia is found in grasslands and pastures, along roadsides and ditch banks, and in cultivated fields in North Dakota and northwestern Minnesota. Kochia has been ranked among the most serious weed species in the United States due to its high rate of spread (Forcella 1985). In North Dakota and Minnesota, kochia is a major concern because it is competitive with many crop species. Traits including early-season emergence, rapid growth, and drought tolerance confer upon kochia a unique competitive ability, especially in slow growing crops like sugarbeet. Kochia was ranked in a Weed Science Society of America member's survey as one of the top six most troublesome weeds in row crops production (Van Wychen 2016) and has been documented to cause yield loss in sugarbeet (Mesbah et al. 1994).

Herbicides are a major component of kochia control programs. The outcome of relying on herbicides combined with kochia's competitive characteristics and high genetic diversity, has created weed population shifts and led to the evolution of herbicide-resistant populations. These resistant populations are often found in sugarbeet. Kochia has evolved resistance to at least four herbicide sites of action, including (ALS) inhibitors, synthetic auxins, photosystem II (PSII) inhibitors, and EPSP synthase inhibitors or glyphosate. Glyphosate-resistant kochia is widespread and concerning to farmers since glyphosate is relied upon in many cropping systems.

Objective

The objectives of this research were to 1) evaluate non-glyphosate herbicide options in sugarbeet or crops grown in sequence with sugarbeet in North Dakota and; 2) provide kochia control options in Minnesota and North Dakota fields when corn, soybean, or wheat is seeded in sequence with sugarbeet.

Material and Methods

Experiments were conducted on natural kochia populations near Hickson, ND and Manvel, ND in 2020. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in 22-inch rows at about 62,000 seeds per acre with 4.7 inch spacing between seeds.

Treatment list can be found in Table 1. All treatments were applied with a bicycle sprayer through appropriate nozzles and CO_2 pressure to deliver 17 gpa spray solution to the center four rows of six row plots 35 feet in length. Herbicides were immediately incorporated using a field cultivator set 3 to 4 inches deep. The entire experimental area received field cultivation after PPI treatments were applied to remove the variability that could otherwise be caused by the incorporating tillage.

Table 1. Herbicide treatment, rate, and application timing.

Herbicide Treatment	Rate (fl oz/A)	Sugarbeet or kochia growth stage (lvs/ size)
Ethofumesate	32	PPI
Ethofumesate	64	PPI
Ethofumesate	96	PPI
Ethofumesate	32	PRE
Ethofumesate	64	PRE
Ethofumesate	96	PRE
Ethofumesate	16	2 lf
Ethofumesate	32	2 lf
Ethofumesate + Roundup PowerMax	16 + 28	2 lf
Ethofumesate + Roundup PowerMax	32 + 28	2 lf
Ethofumesate + Roundup PowerMax	4 +28 / 4 + 28 / 4 + 22	Dime size / 10 day / 10 day
Ethofumesate + Roundup PowerMax + Betamix	4+28+10 / 4+28+12 / 4 + 22+16	Dime size / 10 day /10 day
+ Ultra Blazer	16	10 lf
Ethofumesate + Roundup PowerMax + Ultra Blazer	4 + 28 + 16	10 lf

[1]Treatments with ethofumesate POST applied with HSMOC (High Surfactant Methylated Oil Concentrate) at 1.5 pt/A.
[2]Treatments with Roundup PowerMax plus ethofumesate applied with HSMOC at 1.5 pt/A plus N-Pak AMS at 2.5% v/v.
[3]Treatments with Ultra Blazer applied with Prefer 90 NIS at 0.25% v/v plus N-Pak AMS at 2.5% v/v.

Sugarbeet injury was evaluated as a visual estimate of percent growth reduction (0 to 100% scale, 0 is no visible injury and 100 is complete loss of plant / stand) of the middle 4 rows per plot compared with the adjacent untreated rows. Weed control was evaluated as a visual estimate of percent fresh weight reduction (0 is no injury and 100 is complete control) in the four treated rows compared to the adjacent untreated rows 7, 14, and 21 days (+/- 3 days) after application. Experimental design was randomized complete block with 6 replications. All data were analyzed with the ANOVA procedure of ARM, version 2020.2 software package.

Results

Sugarbeet injury ranged from 0 to 80% and 0 to 25% in Manvel, ND and Hickson, ND, respectively (Table 2). Sugarbeet stands were variable in both experiments. Increased rates of ethofumesate plus PowerMax or ethofumesate plus PowerMax plus Betamix caused unacceptable sugarbeet injury across locations. The first POST application was applied to 2-lf sugarbeet with 10 fl oz of Betamix in mixtures with PowerMax plus ethofumesate. The rate of Betamix was too great in this combination which was made evident by 45% sugarbeet injury compared with 29% from repeat applications of PowerMax and ethofumesate at Manvel, ND.

Table 2. Sugarbeet growth reduction at Manvel, ND and Hickson, ND in 2020.[1]

Treatment	Rate	Sugarbeet or kochia growth stage	Sugarbeet Growth Reduction Manvel, ND	Sugarbeet Growth Reduction Hickson, ND
	--fl oz/A--	--lvs/size--	---------------%	--------------
Ethofumesate	32	PPI	0 a	0 a
Ethofumesate	64	PPI	3 ab	15 bc
Ethofumesate	96	PPI	7 ab	15 bc
Ethofumesate	32	PRE	0 a	0 a
Ethofumesate	64	PRE	3 ab	0 a
Ethofumesate	96	PRE	-[2]	0 a
Ethofumesate	16	2 lf	23 abc	0 a
Ethofumesate	32	2 lf	3 ab	0 a
Ethofumesate + Roundup PowerMax	16 + 28	2 lf	15 ab	13 abc
Ethofumesate + Roundup PowerMax	32 + 28	2 lf	55 cd	20 bc
Ethofumesate + Roundup PowerMax	4 +28 / 4 + 28 / 4 + 22	Dime size / 10 day / 10 day	29 abc	8 ab
Ethofumesate + Roundup PowerMax + Betamix	4+28+10 / 4+28+12 / 4 + 22+16	Dime size / 10 day /10 day	45 bc	25 c
Ultra Blazer	16	10 lf	60 cd	0 a[3]
Ethofumesate + Roundup PowerMax + Ultra Blazer	4 + 28 + 16	10 lf	80 d	0 a[3]
			------------*P*-value	-----------
			0.0001	0.0015

[1]Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.
[2]Treatments contained too much variability across experiments.
[3]Evaluation made before treatment effects could be observed.

Kochia control with herbicide treatments was unacceptable at Hickson and Manvel in 2020. Kochia control from ethofumesate applied PPI or PRE ranged from 13% to 40% control (Table 3) across locations. A rate response was observed with kochia control from ethofumesate applications. Ethofumesate at 96 fl oz/A, applied as either a PPI or PRE, provided greater kochia control than ethofumesate at 32 or 64 fl oz/A across locations. There was no difference between ethofumesate applied before or after planting, although there was a slight numeric advantage to ethofumesate applied PPI.

Table 3. Kochia control 14 days after the last application, across environments, 2020.[1]

Treatment	Rate	Sugarbeet or kochia growth stage	Kochia Control
	--fl oz/A--	--lvs/size--	---------%----------
Ethofumesate	32	PPI	18 c
Ethofumesate	64	PPI	21 bc
Ethofumesate	96	PPI	40 bc
Ethofumesate	32	PRE	13 c
Ethofumesate	64	PRE	23 bc
Ethofumesate	96	PRE	33 bc
Ethofumesate	16	2 lf	41 bc
Ethofumesate	32	2 lf	47 bc
Ethofumesate + Roundup PowerMax	16 + 28	2 lf	95 a
Ethofumesate + Roundup PowerMax	32 + 28	2 lf	93 a
Ethofumesate + Roundup PowerMax	4 +28 / 4 + 28 / 4 + 22	Dime size / 10 day / 10 day	97 a
Ethofumesate + Roundup PowerMax + Betamix	4+28+10 / 4+28+12 / 4 + 22+16	Dime size / 10 day /10 day	98 a
Ultra Blazer	16	10 lf	54 b
Ethofumesate + Roundup PowerMax + Ultra Blazer	4 + 28 + 16	10 lf	91 a
			---*P*-value---
			0.0003

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

The most efficacious treatment with the least amount of sugarbeet injury in the experiment across locations were POST applications of PowerMax (Manvel and Hickson contained glyphosate sensitive kochia populations) plus ethofumesate in a single or repeat applications (Table 3). PowerMax plus ethofumesate plus Betamix provided excellent kochia control. However, was too injurious to the sugarbeet crop.

Ethofumesate POST at 32 fl oz/A gave a disappointing lack of early kochia control. Kochia was at least 1-inch tall at application which apparently was too large for POST control from ethofumesate. Ultra Blazer, an herbicide not yet approved for in season sugarbeet production, provided greater than 83% control but resulted in unacceptable sugarbeet injury at Manvel, ND (data not presented). Ultra Blazer provided less kochia control at the Hickson, ND site. Ultra Blazer was applied to smaller sugarbeet than intended due to the robust kochia density. The result was good kochia control but an unacceptable level of sugarbeet injury. Sugarbeet must be at least the 8-lf stage before Ultra Blazer applications are made. These results suggest Ultra Blazer in sugarbeet will only be useful for POST control of kochia following ethofumesate soil applied or PowerMax and ethofumesate POST. These data reinforce the necessity for focusing on kochia control in preceding crops to minimize kochia infestations during a sugarbeet cropping season.

Kochia control in crops in sequence with sugarbeet. Researchers selected their preferred programs for kochia control in corn, soybean, sugarbeet, wheat and fallow in 2010 and 2011. Preferred programs were a combination of soil residual and POST programs applied singly or used in sequence in a kochia control program. Kochia control was arranged by crop and location across years (Figure 1). Herbicide programs labeled for kochia control in corn or soybean demonstrated less variability in kochia control compared with fallow, wheat, and sugarbeet (Sbettala et al. 2019). The potential for kochia control failure was relatively low in corn, regardless of the herbicide program evaluated, whereas there was no herbicide program evaluated in sugarbeet that provided greater than 86% kochia control at any field location with the median control of 40% across all sites (Figure 1).

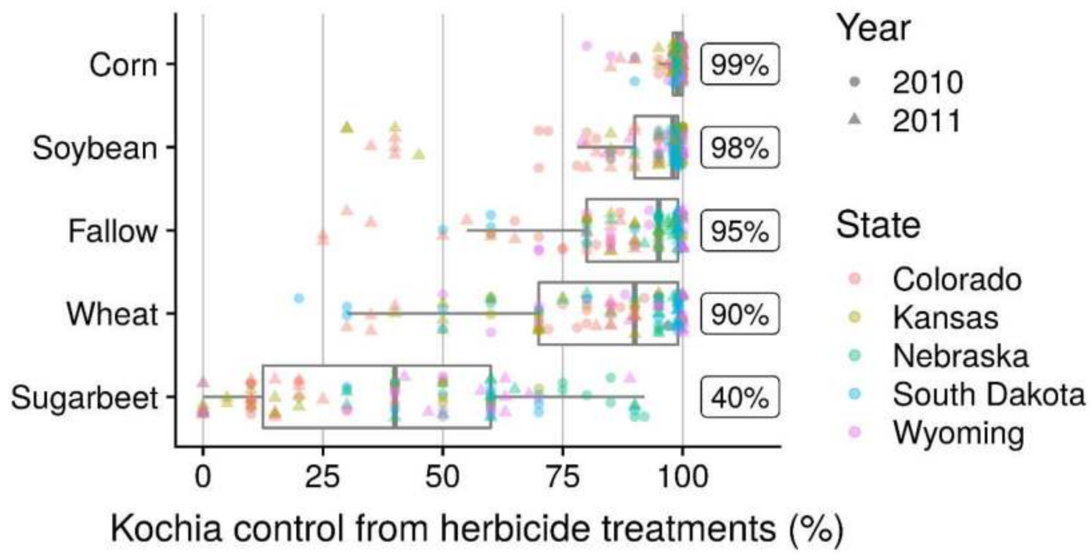

Figure 1. Kochia control 30 days after final application of herbicide treatment labeled for corn, soybean, fallow, wheat and sugarbeet. Each point represents a plot in a field. Number are the median kochia control from herbicide treatments.

Effective long-term kochia management in sugarbeet will likely depend on rotation with crops such as corn and soybean for which effective herbicides are available. However, rotations with these crops create challenges as kochia control programs in corn and soybean will often not permit the planting of sugarbeet the following year. Corn and soybean herbicide treatments included combinations of PRE plus POST herbicide applications. Corn, wheat, and to an extent, soybean, have dense canopies forming early in the growing season, allowing them to compete with kochia. In contrast, sugarbeet is a poor competitor with kochia because it has a slow developing and short canopy structure.

Dr. Joseph Ikley, North Dakota Extension Weed Control Specialist, has provided his preferred kochia control programs in corn, soybean, and wheat. Recommendations are presented as product per acre. Please use the North Dakota Weed Control Guide to verify herbicide rates and crop rotation restrictions for soils and crop sequences on your farm.

Corn

1) Verdict (16-18 fl oz) + atrazine[1] (0.38 to 0.5 lb) or Harness MAXX (2 qt) + atrazine (0.38 to 0.5 lb) PRE fb PowerMax + Status (5 fl oz) POST (requires RR corn)
2) Acuron[2] (1.25 qt) or Acuron Flexi (1.25 qt) fb Acuron (1.25 qt) or Acuron Flexi (1.25 qt) + PowerMax (requires RR corn)
3) Capreno (3 fl oz) + PowerMax + atrazine (0.38 to 0.5 lb) EPOST (V2 to V4 corn, (less than 3-inch kochia) (requires RR Corn)

Soybean

1) Authority Edge[3] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty use requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans)
2) Fierce MTZ[4] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty use requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans)
3) Authority MTZ[5] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty use requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans

[1]Atrazine requires a second cropping season after herbicide application crop rotation restriction to sugarbeet.
[2]Acuron/Flexi requires an 18 month after application crop rotation restriction to sugarbeet.
[3] Authority Edge requires up to 36 months after application crop rotation restriction to sugarbeet.
[4] Fierce MTZ requires up to 18 months after application crop rotation restriction to sugarbeet.
[5] Authority MTZ requires up to 24 months after application crop rotation restriction to sugarbeet.

Wheat

1) Huskie FX[6] (full rate)
2) Starane NXT[7] (full rate)
3) Talinor[8] (full rate)

Recommendations

Ethofumesate should be applied preplant or preemergence at 6 to 7.5 pt/A in sugarbeet fields where kochia is identified as the most important weed control challenge in sugarbeet. Herbicide applications should be timed to kochia growth stage rather than sugarbeet. The addition of Betamix improved control from PowerMax + ethfofumesate POST in these experiments. However, we highly recommend you carefully manage Betamix rate based on sugarbeet growth stage to ensure sugarbeet safety, especially when Betamix follows soil applied (PPI or PRE) ethofumesate. Experiments will be conducted in 2021 to evaluated soil applied applications of ethofumesate. Betamix, Ultra Blazer, and ethofumesate rates and timings must be further evaluated to reduce sugarbeet injury.

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References

Forcella F (1985) Final distribution is related to rate of spread in alien weeds. Weed Res 25:81–191

Friesen LF, Morrison IN, Rashid A, Devine MD (1993) Response of a chlorsulfuron-resistant biotype of Kochia scoparia to sulfonylurea and alternative herbicides. Weed Sci. 41:100-106

Mesbah A, Miller SD, Fornstrom KJ, Legg DE (1994) Kochia (Kochia scoparia) and green foxtail (Setaria viridis) interference in sugarbeets (Beta vulgaris). Weed Technol 8:754–759

Sbatella GM, Adjesiwor AT, Kniss AR, Stahlman PW, Westra P, Moechnig M, Wilson RG (2019) Herbicide options for glyphosate-resistant kochia (Bassia scoparia) management in the Great Plains. Weed Technol. 33: 658–663

Van Wychen L (2016) 2016 Survey of the Most Common and Troublesome Weeds in Broadleaf Crops, Fruits & Vegetables in the United States and Canada. Weed Science Society of America National Weed Survey Dataset. http://wssa.net/wp-content/uploads/2016-Weed-Survey_Broadleaf-crops. xlsx. Accessed: November 2, 2020

[6] Huskie FX requires a 9 month after application crop rotation restriction to sugarbeet.
[7] Starane NXT requires a 9 month after application crop rotation restriction to sugarbeet.
[8] Talinor requires a 15 month after application crop rotation restriction to sugarbeet.

SUGARBEET TOLERANCE TO COMPLEX MIXTURES IN 2020

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Summary
1. Ethofumesate preemergence (PRE) followed by postemergence (POST) herbicides alone or in combinations did not increase sugarbeet injury in the field.
2. High surfactant methylated oil concentrate (HSMOC) increased growth reduction injury from Lorsban plus Stinger applied with glyphosate, ethofumesate and Outlook, 7 days after treatment (DAT). HSMOC with herbicide combinations did not increase growth reduction or impact fresh weigh at 14 DAT.
3. Stinger plus Lorsban mixed with glyphosate, ethofumesate and Outlook caused greater growth reduction injury compared with Outlook plus glyphosate and ethofumesate.
4. HSMOC rate should be reduced when Lorsban is mixed with glyphosate, ethofumesate and a chloroacetamide. HSMOC should be eliminated from the mixture when/if Stinger and Lorsban are mixed with glyphosate, ethofumesate and a chloroacetamide herbicide.

Introduction
Sugarbeet herbicides may be tank mixed legally if all herbicides in the mixture are registered for use on sugarbeet and if no prohibitions against tank mixes appear on a label. Combinations of postemergence herbicides can improve the spectrum of weeds controlled and provide greater total weed control, compared with individual treatments. Mixtures also improve time efficiency as compared with making individual applications. However, the risk of sugarbeet injury also increases with combinations, so combinations should be used with caution. Glyphosate is frequently combined with other herbicides including ethofumesate, Stinger, or a chloroacetamide herbicide (Dual, Outlook, or Warrant) in sugarbeet. On occasion, growers may mix as many as five active ingredients into a single mixture.

Observations of malformation and necrosis injury from POST Betamix and Stinger applied in combination with glyphosate, ethofumesate, and S-metolachlor were assessed in a field near Amenia, ND in 2019. We later learned the sugarbeet field had also been treated with ethofumesate PRE at 3 pt/A. Researchers have reported ethofumesate PRE may change the texture of surface waxes thus increasing the sensitivity of sugarbeet to POST herbicides (Abulnaja et al. 1992).

We have coined the term ‘complex mixtures’ to describe combinations of three or more herbicides applied POST to sugarbeet. We anticipate two outcomes for the immediate future. First, ethofumesate PRE will be used on more acres for control of waterhemp and kochia in sugarbeet. Second, complex mixtures will be more commonplace in our pursuit of broad spectrum and effective control of glyphosate-resistant weeds.

Objective
The objective of this research was a) to investigate sugarbeet injury from ethofumesate PRE followed by POST mixtures with glyphosate and b) to investigate the role of HSMOC in relation to sugarbeet injury when applied with complex mixtures.

Materials and Methods
Field. Experiments evaluating sugarbeet injury from ethofumesate PRE followed by POST mixtures with glyphosate were conducted near Christine, ND and Prosper, ND in 2020. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in 22-inch rows at about 62,000 seeds per acre with 4.6 inch spacing between seeds. Herbicide treatments were applied on May 12 and June 11, and May 30 and June 18 at Christine and Prosper, respectively, with a bicycle wheel sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 43 psi. The treatment list can be found in Table 1. Visible sugarbeet necrosis, malformation, and growth reduction injury was evaluated at both field locations. All evaluations were a visual estimate of injury phenotypes in the four treated rows compared to the adjacent, two-row, untreated strip. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2020.2 software package.

Table 1. Herbicide treatment, rate, and application timing at Christine and Prosper, ND in 2020.

Preemergence (PRE) Treatment	Postemergence (POST) Treatment	Rate (fl oz / A)	Sugarbeet stage (lvs)
-[1]	Glyphosate + Nortron[2]	32 + 12	2-4
-	Glyphosate + Nortron + Stinger	32 + 12 + 6	2-4
-	Glyphosate + Nortron + Stinger + Outlook	32 + 12 + 6 +21	2-4
-	Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx	32 + 12 + 6 +21 + 4	2-4
-	Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx + Betamix	32 + 12 + 6 +21+ 4 + 32	2-4
Nortron[3]	Glyphosate + Nortron	32 + 12	PRE / 2-4
Nortron	Glyphosate + Nortron + Stinger	32 + 12 + 6	PRE / 2-4
Nortron	Glyphosate + Nortron + Stinger + Outlook	32 + 12 + 6 +21	PRE / 2-4
Nortron	Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx	32 + 12 + 6 +21 + 4	PRE / 2-4
Nortron	Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx + Betamix	32 + 12 + 6 +21+ 4 + 32	PRE / 2-4

[1] – indicates that no PRE herbicide was applied but that POST applications were applied at the leaf stage shown.
[2]All POST entries included Destiny HC (HSMOC) + N-Pak Liquid AMS at 1.5 pt/A + 2.5% v/v. Glyphosate used was Roundup PowerMax.
[3]Nortron was applied at 3 pt/A PRE.

Greenhouse. Greenhouse experiments were conducted in 2019, 2020, and 2021 to evaluate sugarbeet injury from complex mixtures POST with or without ethofumesate PRE as well as complex mixtures with or without HSMOC. Greenhouse experiments were a randomized complete block design with a factorial treatment arrangement and three or four replications. Treatment factors were herbicide treatment and PRE herbicide treatment or adjuvant depending on the experiment. Herbicides were applied PRE to 2-4 leaf sugarbeet. Plants were grown at 24 to 27C for a 16 h photoperiod under natural light supplemented with artificial lighting. Plants were watered and fertilized as necessary. Herbicide treatments were applied using a spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a single 8001 XR nozzle calibrated to deliver 11 gpa spray solution at 40 psi and 3 mph. The herbicide treatment lists are found in Tables 2 and 3.

Table 2. Herbicide treatment, rate, and application timing in the greenhouse in 2019 and 2020.

Preemergence (PRE) Treatment	Postemergence (POST) Treatment	Rate (fl oz / A)	Sugarbeet stage (lvs)
-[1]	Glyphosate + Nortron[2]	32 + 12	2-4
-	Glyphosate + Nortron + Stinger	32 + 12 + 6	2-4
-	Glyphosate + Nortron + Stinger + Dual Magnum	32 + 12 + 6 + 20	2-4
-	Glyphosate + Nortron + Stinger + Dual Magnum + Betamix	32 + 12 + 6 + 20 + 32	2-4
-	Glyphosate + Nortron + Stinger + Dual Magnum + Betamix + Lorsban	32 + 12 + 6 + 20 + 32 + 16	2-4
Ethofumesate 4 SC[3]	Glyphosate + Nortron	32 + 12	PRE / 2-4
Ethofumesate 4 SC	Glyphosate + Nortron + Stinger	32 + 12 + 6	PRE / 2-4
Ethofumesate 4 SC	Glyphosate + Nortron + Stinger + Dual Magnum	32 + 12 + 6 + 20	PRE / 2-4
Ethofumesate 4 SC	Glyphosate + Nortron + Stinger + Dual Magnum + Betamix	32 + 12 + 6 + 20 + 32	PRE / 2-4
Ethofumesate 4 SC	Glyphosate + Nortron + Stinger + Dual Magnum + Betamix + Lorsban	32 + 12 + 6 + 20 + 32 + 16	PRE / 2-4

[1]– indicates that no PRE herbicide was applied but that POST applications were applied at the leaf stage shown.
[2]All POST entries included Destiny HC (HSMOC) + N-Pak AMS at 1.5 pt/A + 2.5% v/v. Glyphosate was Roundup PowerMax.
[3]Ethofumesate 4 SC was applied at 3 pt/A PRE.

Table 3. Herbicide treatment, rate, and application timing in the greenhouse in 2020 and 2021.

Postemergence Treatment[1]	Rate (fl oz / A)	Adjuvant	Sugarbeet stage (lvs)
Glyphosate + ethofumesate	32 + 12	-	2-4 lvs
Glyphosate + ethofumesate + Outlook	32 + 12 + 21	-	2-4 lvs
Glyphosate + ethofumesate + Outlook + Lorsban	32 + 12 + 21 + 16	-	2-4 lvs
Glyphosate + ethofumesate + Outlook + Lorsban + Stinger	32 + 12 + 21 + 16 + 6	-	2-4 lvs
Glyphosate + ethofumesate	32 + 12	HSMOC[2]	2-4 lvs
Glyphosate + ethofumesate + Outlook	32 + 12 + 21	HSMOC	2-4 lvs
Glyphosate + ethofumesate + Outlook + Lorsban	32 + 12 + 21 + 16	HSMOC	2-4 lvs
Glyphosate + ethofumesate + Outlook + Lorsban + Stinger	32 + 12 + 21 + 16 + 6	HSMOC	2-4 lvs

[1]All mixtures contained N-Pak Liquid AMS at 2.5% v/v. Glyphosate used was Roundup PowerMax and ethofumesate was Ethofumesate 4SC.
[2]HSMOC=Destiny HC at 1.5 pt/A.

Visual sugarbeet injury evaluations (0 to 100% with 100% reflecting complete sugarbeet death) were completed 3, 7, and 14 (±3) DAT. Above-ground fresh weight (g pot^{-1}) were collected at the conclusion of the experiment or after the 14 DAT evaluation. Data were analyzed with the ANOVA procedure of ARM, version 2020.4 software package.

Results
Field. The Christine experiment was discontinued due to poor sugarbeet stands. At Prosper, PRE ethofumesate had minimal effect on sugarbeet injury across POST treatments (Factor A) or ethofumesate did not increase sugarbeet injury from postemergence herbicides, even when Betamix was part of the mixture (Factor A × B) (Table 4).

Table 4. Sugarbeet growth reduction in response to preemergence and postemergence herbicide treatments at Prosper, ND in 2020.

Preemergence Herbicide	Postemergence (POST) Herbicide	Rate	Growth Reduction 10 DAT[1]	20 DAT	Mean[2]
		------fl oz/A------	------------%------------		
-	Glyphosate + Nortron[4]	32 + 12	5	0	5
-	Glyphosate + Nortron + Stinger	32 + 12 + 6	0	0	0
-	Glyphosate + Nortron + Stinger + Outlook	32 + 12 + 6 +21	26	9	20
-	Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx	32 + 12 + 6 +21 + 4	30	25	26
-	Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx + Betamix	32 + 12 + 6 +21+ 4 + 32	58	28	47
Nortron[3]	Glyphosate + Nortron	32 + 12	3	0	4
Nortron	Glyphosate + Nortron + Stinger	32 + 12 + 6	10	9	13
Nortron	Glyphosate + Nortron + Stinger + Outlook	32 + 12 + 6 +21	12	10	16
Nortron	Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx	32 + 12 + 6 +21 + 4	31	21	33
Nortron	Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx + Betamix	32 + 12 + 6 +21+ 4 + 32	67	20	41
P-Value, Factor A	PRE ethofumesate		0.2847	0.5560	0.6842
P-Value, Factor B	POST Herbicide treatments		0.0001	0.0001	0.0001
P-Value, Factor A×B	PRE herbicide × POST Herbicide treatment		0.1954	0.5112	0.6258

[1]DAT=Days after POST treatment.
[2]Average of growth reduction 5, 10, and 20 DAT.
[3]Nortron was applied at 3 pt/A.
[4]All POST entries included Destiny HC (HSMOC) + N-Pak Liquid AMS at 1.5 pt/A + 2.5% v/v. Glyphosate used was Roundup PowerMax.

Sugarbeet injury 10 DAT, 20 DAT or the average across evaluations was greater when the number of herbicides mixed with glyphosate and ethofumesate increased, averaged across ethofumesate PRE (Table 5). Growth reduction injury was negligible when Stinger was mixed with glyphosate plus ethofumesate but increased when Mustang Maxx was combined with glyphosate, ethofumesate, Stinger and Outlook. Necrosis and malformation damage varied from plant to plant in plots. Sugarbeet injury was greatest or tended to be greatest when Betamix was combined with glyphosate, ethofumesate, Stinger, Outlook and Mustang Maxx. Sugarbeet necrosis injury from mixtures including Betamix was not consistent but generally was negligible (data not presented). Malformation injury was greater when Outlook, Mustang Maxx or Betamix was mixed with glyphosate, ethofumesate and Stinger (data not presented).

Table 5. Sugarbeet growth reduction in response to postemergence herbicide treatments with or without ethofumesate PRE at Prosper, ND in 2020.

		Growth Reduction		
Postemergence (POST) Herbicide[1]	Rate	10 DAT[2]	20 DAT	Mean[2]
	--------fl oz/A--------	------------------%	------------------	
Glyphosate + Nortron	32 + 12	4 c	0 c	5 d
Glyphosate + Nortron + Stinger	32 + 12 + 6	5 c	4 bc	6 d
Glyphosate + Nortron + Stinger + Outlook	32 + 12 + 6 +21	19 b	9 b	18 c
Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx	32 + 12 + 6 +21 + 4	30 b	23 a	29 b
Glyphosate + Nortron + Stinger + Outlook + Mustang Maxx + Betamix	32 + 12 + 6 + 21+ 4 + 32	62 a	24 a	44 a
P-value		0.0001	0.0001	0.0001

[1]All POST entries included Destiny HC (HSMOC) + N-Pak Liquid AMS at 1.5 pt/A + 2.5% v/v. Glyphosate used was Roundup PowerMax.DAT=Days after POST treatment.
[2]Average of growth reduction 5, 10, and 20 DAT.

Greenhouse. Ethofumesate 4SC at 3 pt/A PRE did not affect sugarbeet malformation or growth reduction from POST herbicide treatments and, in general, did not have any effect on sugarbeet necrosis (Table 6).

Table 6. Sugarbeet necrosis, malformation, and growth reduction injury from postemergence herbicide treatments with and without Ethofumesate 4SC PRE at 3 pt/A in the greenhouse in 2020.

	Necrosis[2]		Malformation		Growth Reduction	
Herbicide treatment[1]	No PRE	PRE	No PRE	PRE	No PRE	PRE
	------------------------	--------	--------%	--------	--------	------------------------
Base[3]	1 c[4]	1 c	3	5	2	3
Base + Stinger	0 c	2 c	17	15	2	4
Base + Stinger + Dual Magnum	7 bc	0 c	12	10	0	4
Base + Stinger + Dual Magnum + Betamix	11b	11 b	30	27	22	11
Base + Stinger + Dual Magnum + Betamix + Lorsban	23 a	13 b	25	27	18	19
P-Value	0.0241		0.9159		0.1594	

[1]All POST entries included Destiny HC (HSMOC) + N-Pak Liquid AMS at 1.5 pt/A + 2.5% v/v.
[2]Necrosis, malformation and growth reduction averaged across evaluations.
[3]Base = Roundup PowerMax at 32 fl oz/A + Ethofumesate 4SC at 12 fl oz/A.
[4]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.

Due to the lack of effect from Ethofumesate 4SC PRE, data were combined to the POST treatment level (Table 7). The addition of Betamix and Lorsban increased sugarbeet necrosis, malformation, and growth reduction injury compared with glyphosate plus ethofumesate or glyphosate plus ethofumesate plus Stinger.

Table 7. Sugarbeet necrosis, malformation, and growth reduction injury in response to postemergence herbicide treatments averaged across PRE herbicide in the greenhouse in 2020.

Herbicide treatment[1]	Necrosis[2]	Malformation	Growth Reduction
	------------------------------%	------------------------------	
Base[3]	1 c[4]	4 c	3 b
Base + Stinger	1 c	16 b	3 b
Base + Stinger + Dual Magnum	3 c	11 bc	2 b
Base + Stinger + Dual Magnum + Betamix	11 b	28 a	17 a
Base + Stinger + Dual Magnum + Betamix + Lorsban	18 a	26 a	18 a
P-Value	0.0001	0.0001	0.0001

[1]All POST entries included Destiny HC (HSMOC) + N-Pak Liquid AMS at 1.5 pt/A + 2.5% v/v.
[2]Necrosis, malformation and growth reduction averaged across evaluations.
[3]Base = Roundup PowerMax at 32 fl oz/A + Ethofumesate 4SC at 12 fl oz/A.
[4]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.

The second greenhouse experiment considered both the visual assessment of sugarbeet growth reduction injury and sugarbeet fresh weight (g/pot) in response to herbicide mixtures both with and without HSMOC. Sugarbeet injury from glyphosate + ethofumesate + Outlook + Stinger + Lorsban was greatest 7 DAT and was greater or tended to be greater when HSMOC was added with the mixture (Table 8). Injury decreased with time and HSMOC, when added to herbicide mixtures, did not influence growth reduction or fresh weight at 14 DAT.

Visible sugarbeet growth reduction injury at 7 and 14 DAT increased when Outlook or Outlook + Lorsban +/- Stinger was mixed with glyphosate plus ethofumesate (Table 9). Growth reduction injury tended to be less 14 DAT than 7 DAT indicating that plants were starting to recover from their injury. Sugarbeet fresh weight per pot tended to be reduced as the complexity of mixtures increased.

Table 8. The effect of herbicide mixtures both with and without high surfactant methylated oil (HSMOC) on visual sugarbeet growth reduction injury and fresh weight averaged across two greenhouse runs in 2020 to 2021.

Herbicide treatment	Rate	Growth Reduction 7 DAT[1]		Growth Reduction 14 DAT		Fresh Weight	
		No HSMOC	HSMOC	No HSMOC	HSMOC	No HSMOC	HSMOC
	--fl oz/A--	---------------------%		---------------------		-------g/pot-------	
Base[2]		6 ab[3]	1 a	6	12	32.6	30.3
Base + Outlook	21	18 c	15 bc	17	23	30.3	27.8
Base + Outlook and Lorsban	21 + 16	22 c	34 d	19	23	29.4	26.3
Base + Outlook, Lorsban and Stinger	21 + 16 + 6	38 d	49 e	32	39	29.8	28.0
P-Value		0.0257		0.9401		0.9869	

[1]DAT=Days after POST treatment.
[2]Base= Roundup PowerMax at 32 fl oz/A + Ethofumesate 4SC at 12 fl oz/A + N-Pak Liquid AMS at 2.5% v/v.
[3]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.

Table 9. The effect of herbicide mixtures averaged across both with and without high surfactant methylated oil (HSMOC) on visual sugarbeet growth reduction injury and fresh weight averaged across two greenhouse runs in 2020 to 2021.

Herbicide treatment	Rate	Growth Reduction 7 DAT[2]	Growth Reduction 14 DAT	Sugarbeet Fresh Weight
	--fl oz/A--	-------------%-------------		--g/pot--
Base[2]		4 d[3]	9 c	31.4
Base + Outlook	21	16 c	20 b	29.0
Base + Outlook and Lorsban	21 + 16	28 b	21 b	28.9
Base + Outlook, Lorsban and Stinger	21 + 16 + 6	43 a	35 a	28.1
P-Value		0.0001	<0.0001	0.1436

[1]DAT=Days after POST treatment.
[2]Base= Roundup PowerMax at 32 fl oz/A + Ethofumesate 4SC at 12 fl oz/A + N-Pak Liquid AMS at 2.5% v/v.
[3]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.

Malformation injury from Stinger was negligible in these greenhouse experiments (data not presented). However, Stinger did cause greater sugarbeet growth reduction injury when added to Outlook + Lorsban compared with Outlook + Lorsban alone. Sugarbeet growth reduction injury was observed as both stature reduction and speckling of the leaves, presumably from the oils in some of the herbicide formulations as well as in the HSMOC adjuvant.

Conclusion

Pesticides (herbicides, fungicides, and insecticides) approved for use in sugarbeet usually are safe to sugarbeet when applied individually. These same pesticides applied in mixtures, however, occasionally injure sugarbeet since each pesticide must be detoxified by the plant. Environmental stressors such as low air and soil temperatures or saturated soil-water content are conditions that often reduce photosynthesis and may reduce energy needed for the developing sugarbeet to metabolize pesticides (Smith and Schweizer 1983), thus increasing the risk of sugarbeet injury. Sugarbeet is better able to manage biotic or abiotic stressors as it develops; sugarbeet with more leaf area have greater metabolic activity, dissipating the effect of herbicides, and other stressors.

These field and greenhouse experiments suggest sugarbeet injury concerns with complex pesticide mixtures. For example, we observed injured phenotypes suggesting Betamix or Betamix plus Lorsban caused sugarbeet injury. However, we do not believe Betamix or Lorsban alone are the culprits since Betamix with glyphosate and ethofumesate caused necrosis and malformation injury 14 DAT similar to glyphosate and ethofumesate (in full disclosure we never evaluated Lorsban plus glyphosate or ethofumesate compared with glyphosate and ethofumesate alone). But rather injury from Betamix and/or Lorsban are exacerbated by 'activators' such as a Stinger combined with glyphosate, ethofumesate and chloroacetamide herbicides in complex mixtures under certain environmental conditions. HSMOC had less effect on sugarbeet injury than the herbicides did and it's unclear how much of the injury from the herbicide can be attributed to the active ingredient versus the oil content of the formulation.

Literature Cited

Abulnaja KO, Tighe CR, Harwood JL (1992) Inhibition of fatty acid elongation provides a basis for the action the herbicide, ethofumesate, on surface wax formation. Phytochemistry 31:1155-1159

Smith GA, Schweizer EE (1983) Cultivar x herbicide interaction in sugarbeet. Crop Sci 23:325-328

WATERHEMP CONTROL IN SUGARBEET IN 2020

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Summary

1. Ethofumesate provided partial waterhemp control at 1.5 pt/A, even when activating rainfall was 21 day after treatment (DAT). However, ethofumesate at rates less than 6 pt/A provided less than 85% waterhemp control. Ethofumesate at greater than 6 to 7.5 pt/A provided 36 or 54 days, respectively, of greater than 85% waterhemp control.
2. Preemergence herbicides are effective for controlling early germinating waterhemp. Waterhemp control was similar with ethofumesate at 2 pt/A and Dual Magnum at 0.75 pt/A but was less than waterhemp control from ethofumesate at 4 pt/A.
3. Herbicide, herbicide rate, or timing of herbicide application did not influence waterhemp control from treatments applied layby.
4. Inter-row cultivation or Liberty applied through a hooded sprayer controlled escaped waterhemp.

Introduction

A survey conducted at the 2020 winter Sugarbeet Growers Seminars indicated waterhemp is the primary weed control challenge in sugarbeet fields in Southern Minnesota Beet Sugar Cooperative, Minn-Dak Farmers' Cooperative, and American Crystal Sugar Cooperative. Early-season weed escapes turn into late-season weed control failures which can lead to weed issues at harvest. There are minimal effective POST herbicide options for rescue control of glyphosate-resistant biotypes, especially when waterhemp is greater than 4-inches tall. Three experiments were conducted in 2020 to evaluate herbicide treatments, timing of herbicide application, and methods of herbicide application to create an effective weed management program.

Objective

The objective of these studies was to understand the weed control methods available and how to best to combine them into a weed control program to control waterhemp in sugarbeet.

Materials and Methods

Experiment 1

Experiments were conducted on natural weed populations near Moorhead, MN and Blomkest, MN in 2020 to evaluate waterhemp control and wheat nurse-crop tolerance to ethofumesate preemergence (PRE) at multiple rates. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Spring wheat at 0.75 bu/A was evenly spread throughout the plot area and incorporated with shallow tillage before ethofumesate application. Sugarbeet was seeded in rows spaced 22 inches apart at approximately 62,000 seeds/A or approximately 4.6 inch spacing between seeds along the row in the experiment at Blomkest, MN but sugarbeet was not planted in the experiment at Moorhead, MN.

Herbicide treatments were applied PRE after planting 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 of the 11 by 40 feet long plots. Treatments consisted of one application of ethofumesate at 0, 1.5, 3.0, 4.5, 6.0 and 7.5 pt/A

Wheat injury and waterhemp control were evaluated visually, beginning approximately twenty-three days after ethofumesate application. Additional waterhemp control was evaluated 43, 56, and 62 DAP (days after planting) at Moorhead and 36, 44, 58, and 77 DAP at Blomkest. All evaluations were a visual estimate of control in the treated area 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 2020.2 software package.

Experiment 2

Experiments were conducted on natural weed populations near Hickson, ND and Blomkest, MN in 2020 to consider sugarbeet tolerance and waterhemp control from preemergence and postemergence herbicides. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in rows spaced 22 inches apart at approximately 62,000 seeds/A or approximately 4.6 inch spacing between seeds along the row.

Herbicide treatments were applied on April 27, May 27, and June 12 at Hickson and Blomkest with a bicycle wheel sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2. Treatment list for Hickson and Blomkest can be found in Table 1 and 2, respectively.

Table 1. Herbicide treatment, rate, and application timing at Hickson, ND in 2020.

Preemergence Herbicide	PRE Rate	Lay-by Herbicide	Lay-by Rate	Stage
	(pt/A)		(fl oz/A)	(lvs)
–	–	–[1]	–[1]	4 / 8
–	–	Dual Magnum[2]	18	4
–	–	Dual Magnum	18	8
–	–	Dual Magnum / Dual Magnum	18 / 18	4 / 8
Dual Magnum	0.75	–	–	4 / 8
Dual Magnum	0.75	Dual Magnum	18	4
Dual Magnum	0.75	Dual Magnum	18	8
Dual Magnum	0.75	Dual Magnum / Dual Magnum	18 / 18	4 / 8
Ethofumesate 4SC	2	–	–	4 / 8
Ethofumesate 4SC	2	Dual Magnum	18	4
Ethofumesate 4SC	2	Dual Magnum	18	8
Ethofumesate 4SC	2	Dual Magnum / Dual Magnum	18 / 18	4 / 8
Ethofumesate 4SC	4	–	–	4 / 8
Ethofumesate 4SC	4	Dual Magnum	18	4
Ethofumesate 4SC	4	Dual Magnum	18	8
Ethofumesate 4SC	4	Dual Magnum / Dual Magnum	18 / 18	4 / 8

[1] – indicates that no lay-by herbicide was applied but that applications of Roundup PowerMax at 28 fl oz/A + Prefer 90 NIS at 0.25% v/v + N-Pak Liquid AMS at 2.5% v/v were applied at the leaf stage shown.
[2]All POST treatments of Dual Magnum also included Roundup PowerMax at 28 fl oz/A + HSMOC at 1.5 pt/A + AMS 2.5% v/v.

Table 2. Herbicide treatment, rate, and application timing at Blomkest, MN in 2020.

Preemergence Herbicide	PRE Rate	Lay-by Herbicide	Lay-by Rate	POST Stage
	(pt/A)		(fl oz/A)	(lvs)
–	–	–[1]	–[1]	4 / 8
–	–	Warrant[2]	48	4
–	–	Warrant	48	8
–	–	Outlook / Outlook	12 / 12	4 / 8
–	–	Warrant / Warrant	48 / 48	4 / 8
–	–	Outlook / Warrant	12 / 48	4 / 8
Ethofumesate 4SC	2	–	–	4 / 8
Ethofumesate 4SC	2	Warrant	48	4
Ethofumesate 4SC	2	Warrant	48	8
Ethofumesate 4SC	2	Outlook / Outlook	12 / 12	4 / 8
Ethofumesate 4SC	2	Warrant / Warrant	48 / 48	4 / 8
Ethofumesate 4SC	2	Outlook / Warrant	12 / 48	4 / 8
Ethofumesate 4SC	4	–	–	4 / 8
Ethofumesate 4SC	4	Warrant	48	4
Ethofumesate 4SC	4	Warrant	48	8
Ethofumesate 4SC	4	Outlook / Outlook	12 / 12	4 / 8
Ethofumesate 4SC	4	Warrant / Warrant	48 / 48	4 / 8
Ethofumesate 4SC	4	Outlook / Warrant	12 / 48	4 / 8

[1] – indicates that no lay-by herbicide was applied but that applications of Roundup PowerMax at 28 fl oz/A + Prefer 90 NIS at 0.25 % v/v + N-Pak Liquid AMS at 2.5% v/v were applied at the leaf stage shown.
[2]All POST treatments of Warrant and Outlook also included Roundup PowerMax at 28 fl oz/A + HSMOC at 1.5 pt/A + AMS at 2.5% v/v.

Sugarbeet tolerance and waterhemp control were evaluated. 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 four replications. Data were analyzed with the ANOVA procedure of ARM, version 2020.2 software package.

Experiment 3
Experiments were conducted on natural weed populations near Moorhead, MN and Blomkest, MN in 2020 investigating waterhemp control and sugarbeet tolerance from a program approach. The program utilized PRE ethofumesate (either broadcast or in a band) followed by POST herbicides (with or without lay-by herbicides or lay-by timed to different sugarbeet growth stage) and followed by inter-row weed control from either Liberty (glufosinate) (applied through a hooded sprayer) or from inter-cultivation. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in rows spaced 22 inches apart at approximately 62,000 seeds/A or approximately 4.6 inch spacing between seeds along the row.

Preemergence ethofumesate was applied at 6 pt/A. Banded treatments of ethofumesate were applied at 6 pt/A broadcast equivalent in an 11-inch band. Herbicide treatments were applied on May 2, June 1, June 11, and June 17 at Moorhead and April 27, May 27, June 9 and June 16 at Blomkest with a CO_2-pressurized bicycle-wheel sprayer in 17 gpa spray solution. Preemergence treatments were made using TeeJet TP4002E flat fan nozzles and EPOST, POST, and LPOST treatments were broadcast using 8002 XR flat fan nozzles. Liberty treatments were banded between rows using a hooded sprayer at 22 gpa spray solution through TP4002E nozzles pressurized with CO_2 at 35 psi. The treatment list can be found in Table 3.

Table 3. Treatment, application method, and herbicide rate at Moorhead and Blomkest, MN in 2020.

Preemergence Herbicide[1]	Application Method	EPOST[2] / POST Herbicide	Rate	Stage	LPOST[4] Treatment	Rate
	(broadcast or band)		(fl oz/A)	(lvs)		(fl oz/A)
Ethofumesate 4SC	broadcast	RUPM[4] / RUPM[4]	28 / 28	4 / 8	RUPM[4]	22
Ethofumesate 4SC	band	RUPM[4] / RUPM[4]	28 / 28	4 / 8	RUPM[4]	22
Ethofumesate 4SC	band	RUPM[5] + Dual Magnum	32 + 16	4	Liberty	32
Ethofumesate 4SC	band	RUPM[3] + Dual Magnum	32 + 16	8	Liberty	32
Ethofumesate 4SC	band	RUPM[3] + Dual Magnum	32 + 16	4	cultivation	–
Ethofumesate 4SC	band	RUPM[3] + Dual Magnum	32 + 16	8	cultivation	–

[1]Preemerge ethofumesate was applied at 6 pt/A broadcast or equivalent (3 pt/A in 11 inch band)
[2]EPOST = early postemergence at 4 lf-stage; POST = postemergence at 8-lf state; LPOST = late postemergence at 12-lf stage
[3]LPOST treatments were applied as follows: RUPM + N-Pak Liquid AMS at 2.5% v/v was broadcast, Liberty + dry AMS at 3 lb/A was applied to inter-row areas with a hooded sprayer, cultivation was directed to inter-row areas.
[4]RUPM = Roundup PowerMax applied with Ethofumesate at 4 fl oz/A + HSMOC at 1.5 pt/A + N-Pak Liquid AMS at 2.5% v/v.
[5]RUPM = Roundup PowerMax applied with Ethofumesate at 12 fl oz/A + HSMOC at 1.5 pt/A + N-Pak Liquid AMS at 2.5% v/v.

Sugarbeet tolerance and waterhemp control were evaluated. 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 four replications. Data were analyzed with the ANOVA procedure of ARM, version 2020.2 software package.

Results

Experiment 1. Ethofumesate requires rainfall for activation. The experimental area near Moorhead, MN received 0.4- and 0.5-inch rains 48 and 72 hours, respectively, after ethofumesate application on May 2. Rain fell on the experiment near Blomkest, MN 1 and 9 days after ethofumesate application. However, these rain events did not provide sufficient moisture (0.7-inch rainfall or greater) to activate ethofumesate and activating rainfall did not occur until 21 days after application. Ethofumesate at 4.5 pt/A or greater reduced wheat stand by more than 50% at 23 and 43 DAT. Wheat ground cover loss was negligible at Blomkest, even at the 7.5 pt/A rate.

Growers frequently ask if ethofumesate can be used in concert with a nurse crop to reduce effect of blowing soil on sugarbeet. Our research indicates that oat tolerates soil residual herbicides better than wheat or barley and S-metolachlor is safer on nurse crops than ethofumesate. However, our data from 2020 clearly demonstrated nurse crop survival if offered the opportunity to achieve a head-start before activation of soil applied herbicides.

Waterhemp control was dependent on ethofumesate rate and evaluation timing (Figure 1). Waterhemp control of 85% or greater was seen from ethofumesate at 7.5 pt/A, only as far as 54 days after application, indicating ethofumesate at the full rate does not provide season long waterhemp control. Ethofumesate at 6 pt/A provided greater than 90% control but only for 36 days after planting. Eighty percent or greater waterhemp control was accomplished with ethofumesate at 7.5 pt/A, 6 pt/A, and 4.5 pt/A at 79, 56, and 36 DAP, respectively.

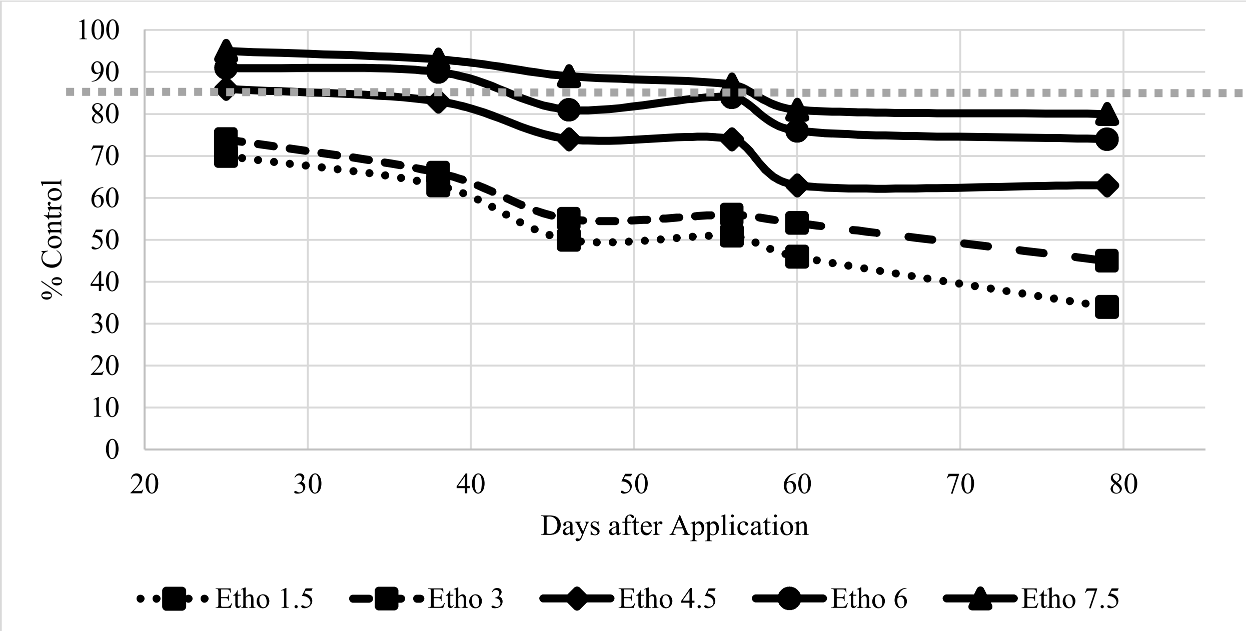

Figure 1. Waterhemp control from increasing ethofumesate rates at Blomkest in 2020.

These spring wheat and waterhemp data suggest we did not properly activate ethofumesate in either experiment in 2020. In addition, waterhemp emergence was much earlier than normal in 2020 than in previous years. An early germinating seed bank means there is less time for herbicide activation before waterhemp emergence.

Experiment 2. This experiment considered a weed management program including preemergence, early postemergence and postemergence herbicides for season-long waterhemp control. Waterhemp control 25 to 28 DAP was dependent on location (Table 4). At Hickson, ND, waterhemp control from ethofumesate at 4 pt/A provided greater waterhemp control than ethofumesate at 2 pt/A or Dual Magnum at 0.75 pt/A. However, at Blomkest, MN, preemergence herbicides did not influence waterhemp control. Preemergence control was influenced by waterhemp emergence date. Waterhemp emergence was documented near Fargo, ND on May 1 and near Mapleton, ND on May 2 (communication with Dr. Joe Ikley, NDSU and Mr. Greg Krause, Minn-Dak Farmers Cooperative) and waterhemp was a uniform and heavy infestation from cotyledon to 2-lf stage on May 28 at Hickson. The waterhemp infestation at Blomkest was sporadic across the experimental area, probably related to dry surface moisture conditions in April and May. Thus, waterhemp PRE control at Blomkest was an estimate of ground cover since the running checks were unreliable due to a light and uneven waterhemp infestation.

Waterhemp control was evaluated 14, 28 and 42 days (+/- 3 days) after POST application at Hickson and 14 days (+/- 3 days) after POST application at Blomkest. Waterhemp control at Hickson will not be presented since there was a tremendous amount of plot to plot variation in POST waterhemp control in the experiment. At Blomkest, waterhemp control from POST herbicide treatments tended to be greatest following ethofumesate at 4 pt/A PRE (Table 5). POST herbicide treatments generally provided similar waterhemp control within PRE treatment.

Table 4. Waterhemp control from the main effect of preemergence herbicide treatment when averaged across postemergence herbicide treatment, 28 DAP at Hickson, ND and 25 DAP at Blomkest, MN in 2020.[1]

Treatment	Rate	Hickson	Blomkest
	--pt/A--	---%---	---%---
No PRE		27 c	81
Dual Magnum	0.75	86 b	–[2]
Ethofumesate	2	85 b	87
Ethofumesate	4	91 a	87
P-value		0.0001	0.1917

[1]Means not sharing any letter are significantly different by t-test at the 5% level of significance.
[2]- treatment was not part of the trial at Blomkest.

Table 5. Waterhemp control 14 days after POST application from PRE, EPOST and POST herbicides at Blomkest in 2020.[1]

Lay-by Treatment[2]	Rate	Timing[3]	No Preemergence Herbicide	Ethofumesate 2 pt/A	Ethofumesate 4 pt/A
	---pt/A---	--lf stage--	------------------------%------------------------		
Warrant	3	4	73 bc	83 ab	90 ab
Warrant	3	8	76 abc	86 ab	89 ab
Outlook/Outlook	0.75 / 0.75	4/8	64 c	79 abc	89 ab
Warrant/Warrant	3 / 3	4/8	76 abc	83 abc	92 a
Outlook/Warrant	0.75 / 3	4/8	72 bc	88 ab	90 ab

[1]Means not sharing any letter are significantly different by t-test at the 20% level of significance.
[2]All POST treatments of Warrant and Outlook also included Roundup PowerMax at 28 fl oz/A + HSMOC at 1.5 pt/A + AMS at 2.5% v/v.
[3]Timing=Sugarbeet leaf stage.

Experiment 3. Grower survey results indicated escaped waterhemp occurred following PRE, EPOST, and POST herbicide treatments. Band applying ethofumesate was a common grower practice before the development of Roundup Ready (RR) sugarbeet. Ethofumesate at 6-pt/A broadcast PRE followed by repeat applications of Roundup PowerMax + ethofumesate controlled waterhemp better than ethofumesate at 6-pt per treated acre (band applied) followed by repeat applications of Roundup PowerMax + ethofumesate (Table 6). Improved control from broadcast applied ethofumesate was most likely due to complete soil coverage as compared with only 11-inches of soil coverage from ethofumesate banded over the sugarbeet row. Waterhemp that emerged between the ethofumesate bands were only partially controlled due to the presence of glyphosate-resistant biotypes. Waterhemp control was improved in treatments where ethofumesate was banded by including Dual Magnum (S-metolachlor) and ethofumesate with Roundup PowerMax applied POST and followed with either inter-row cultivation or an inter-row application of Liberty through a hooded sprayer at the 12 leaf, LPOST, stage.

Table 6. Waterhemp control and recoverable sucrose in response to preemergence and postemergence herbicide treatment, Blomkest and Moorhead, 2020.[1]

		Blomkest, MN		Moorhead, MN	
Herbicide Treatment	Rate	58 DAP[2]	67 DAP	62 DAP	Rec. Suc.[3]
	----fl oz/A----	------------------%------------------			--lb/A--
Ethofumesate / RUPM[4] / RUPM[4] / RUPM[4]	96 / 28 / 28 / 22	99 a	99 a	84 b	6,555
Etho (band) / RUPM[4] / RUPM[4] / RUPM[4]	48 / 28 / 28 / 22	69 b	79 c	76 bc	6,796
Etho (band) / Dual Mag + RUPM[5] + Etho / Liberty (hood)	48 / 16 + 32 + 12 / 32 (hood)	93 a	91 abc	68 c	6,777
Etho (band) / Dual Mag + RUPM[5] + Etho / Inter-row cultivation	48 / 16 + 32 + 12 / (cold hard steel)	100 a	99 ab	99 a	6,952
P value		0.0001	0.0201	0.0001	0.6013

[1]Means not sharing any letter are significantly different by t-test at the 5% level of significance.
[2]DAP=Days after planting.
[3]Rec. Suc. = Recoverable Sucrose.
[4]RUPM = Roundup PowerMax applied with Ethofumesate at 4 fl oz/A + HSMOC at 1.5 pt/A + NPak Liquid AMS at 2.5% v/v.
[5]RUPM = Roundup PowerMax applied with Ethofumesate at 12 fl oz/A + HSMOC at 1.5 pt/A + NPak Liquid AMS at 2.5% v/v.

Summary

Waterhemp control in sugarbeet has been our most important weed management challenge since the beginning of my tenure in 2014. Our research in creating a waterhemp control strategy is based on results from 86 sugarbeet tolerance and waterhemp control experiments since 2014 and has been successfully implemented on over 373,064 acres, where producers identify waterhemp as their most important weed management challenge (according to the 2020 Turning Point survey). The foundation for the program is use of chloroacetamide herbicides (SOA15) early postemergence (EPOST) and postemergence (POST) and in combination with glyphosate and ethofumesate in sugarbeet.

We observed integrating a PRE herbicide into the management plan improved waterhemp control, especially when sugarbeet emergence or timely rainfall to activate chloroacetamide herbicides is delayed (Figure 2). Growers planting after April 20 were encouraged to use a PRE since waterhemp emergence may occur before chloroacetamide herbicide activation. However, 2020 research and commercial experience indicates a PRE should be used regardless of plant date.

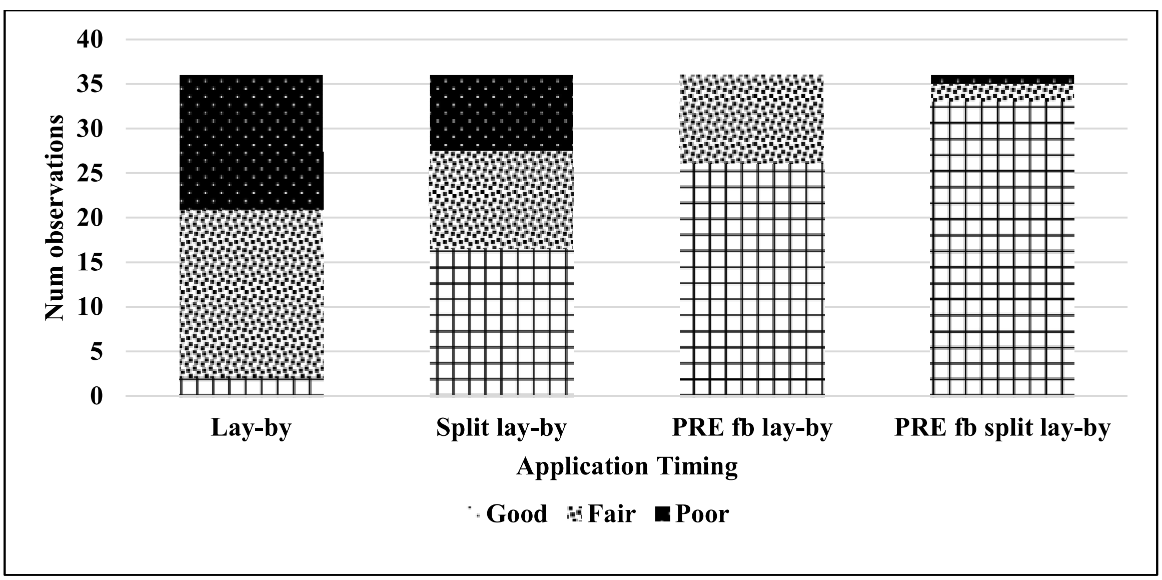

Figure 2. Number of good, fair, and poor estimates of waterhemp control across herbicides and application timing, summed across evaluations, locations, and years.

Surveyed growers attending the 2020 SMBSC seminar in Willmar indicated waterhemp control following PRE and layby application in 2019 did not meet their expectations (31% and 24% of respondents, respectively). POST control of escapes is difficult due to widespread ALS inhibitor (SOA 2) resistance biotypes and depleting Betamix inventories. In 2020, we observed escaped waterhemp can be controlled using inter-row cultivation or by the use of inter-row application of Liberty through a hooded sprayer. BASF Corp is drafting a 24c local needs label for Minnesota and North Dakota for 2021 to allow for this type of application.

Acknowledgements
We wish to thank the Sugarbeet Research and Education Board for funding this research in 2020. Thank you to our cooperators, Vince Ulstad, Hickson, ND and Youngkrantz Family Farms, Blomkest, MN. We also want to thank the Sugarbeet Cooperatives, American Crystal Sugar, Minn-Dak Farmers Cooperative, and Southern Minnesota Beet Sugar Cooperative for collaborating with field research. We also thank our summer student employees Ryan Borgen and Brad Stewart along with other NDSU colleagues for their contributions.

WATERHEMP CONTROL IN SMALL GRAIN STUBBLE

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Introduction
Waterhemp is troublesome weed that can begin emerging in May and continue to emerge through early August (Hartzler et al. 1999). Many producers have expressed concern about controlling waterhemp after small grains have been harvested.

Objective
The objective of this experiment was to evaluate waterhemp control in small grain stubble.

Materials and Methods
The experiment was conducted in wheat stubble on natural waterhemp populations near Hickson, ND in 2020. Experimental area consisted of a uniform infestation of waterhemp ranging from newly emerged to 12 inches tall.

Herbicide treatments were applied on August 8 and September 2, 2020 with a bicycle wheel sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 43 psi. Treatment list can be found in Table 1.

Table 1. Herbicide treatments and rates in trial near Hickson, ND in 2020.

Herbicide Treatment	Rate (fl oz/A)
RoundUp PowerMax[1]	32
RoundUp PowerMax + Weedar 64[1]	32 + 64
RoundUp PowerMax + Sharpen[2]	32 + 1
RoundUp PowerMax + Sharpen[2]	32 + 2
RoundUp PowerMax + Sharpen + Valor SX[2]	32 + 1 + 1
RoundUp PowerMax + Sharpen + Valor SX[2]	32 + 1 + 2
RoundUp PowerMax / RoundUp PowerMax[1]	32 / 32
RoundUp PowerMax + Weedar 64 / RoundUp PowerMax + Weedar 64[1]	32 + 64 / 32 + 64

[1]Treatment applied with Prefer 90 NIS at 0.25 % v/v + NPak AMS at 2.5% v/v.
[2]Sharpen and Valor SX applied with methylated seed oil at 1.5 pt/A + NPak AMS at 2.5% v/v.

Waterhemp control were evaluated visually, beginning approximately six days after the first herbicide application was made and continued on a generally weekly interval for three weeks. All evaluations were a visual estimate of control in the treated area 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
Waterhemp control ranged from 26 to 30% from a single glyphosate (RoundUp PowerMax) application at 32 fl oz/A and from 33 to 50% control from a two-spray glyphosate program (Table 2). One or two glyphosate applications did not provide acceptable control of a glyphosate-resistant waterhemp population. 2, 4-D (Weedar 64) at 64 fluid ounces per acre plus glyphosate improved waterhemp control compared to glyphosate alone. Control ranged from 64 to 88% control from a single application and from 63 to 78% from repeat applications. There was no statistical difference between a single or repeat applications of 2, 4-D plus glyphosate.

Sharpen at 1 or 2 fl oz plus glyphosate provided greater than 89% waterhemp control. There was no observable benefit from increasing the Sharpen rate from one to two fluid ounces/A. Sharpen plus glyphosate were applied with N-Pak and MSO (methylated seed oil) to maximize Sharpen performance. Valor SX plus Sharpen plus RoundUp PowerMax provided the best numerical control of waterhemp and there was no difference in control between Valor SX at 1 versus 2 oz/A. Likewise, there was no significant difference in waterhemp control between Sharpen plus RoundUp PowerMax and Sharpen plus Valor SX plus RoundUp PowerMax.

Table 2. Percent visual waterhemp control by treatment and evaluation date near Hickson, ND in 2020.

Treatment	Rate	Waterhemp Control		
		6 DAT[3]	15 DAT	22 DAT
	--fl oz/A--	----------------------------%----------------------------		
RoundUp PowerMax[1]	32	26 c	30 c	28 d
RoundUp PowerMax + Weedar 64[1]	32 + 64	64 b	73 b	88 ab
RoundUp PowerMax + Sharpen[2]	32 + 1	90 a	91 a	98 a
RoundUp PowerMax + Sharpen[2]	32 + 2	89 a	90 a	98 a
RoundUp PowerMax + Sharpen + Valor SX[2]	32 + 1 + 1	99 a	99 a	98 a
RoundUp PowerMax + Sharpen + Valor SX[2]	32 + 1 + 2	97 a	100 a	100 a
RoundUp PowerMax / RoundUp PowerMax[1]	32 / 32	33 c	40 c	50 c
RoundUp PowerMax + Weedar 64 / RoundUp PowerMax + Weedar 64[1]	32 + 64 / 32 + 64	63 b	65 b	78 b
LSD (0.05)		**13**	**13**	**11**

[1]Treatment applied with Prefer 90 NIS at 0.25 % v/v + NPak AMS at 2.5% v/v.

[2]Sharpen and Valor SX applied with methylated seed oil at 1.5 pt/A + NPak AMS at 2.5% v/v.

[3]DAT=Days after treatment.

Conclusion

The previous recommendation to control waterhemp in small grain stubble was 2,4-D at 32 fl oz/A (esther or amine depending on nearby crops) plus RoundUp PowerMax. This recommendation was statistically similar to Sharpen at 1 fl oz/A plus RoundUp PowerMax 22 DAT (days after treatment) but numerically provided waterhemp control 10% less than Sharpen plus RoundUp PowerMax. These results suggest the new recommendation should be Sharpen at 1 fl oz/A plus RoundUp PowerMax at 32 fl oz/A for waterhemp control.

References

Hartzler RG, Buhler DD, Stoltenberg DE (1999) Emergence characteristics of four annual weed species. Weed Science Society of America. 47(5):578-584

WEED CONTROL USING HIGH VOLTAGE ELECTRICITY

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Summary

1. The Weed Zapper™ provided greater than 80% waterhemp (primary stem) control, 14 days after treatment (DAT). Kochia (highly branched stem) control 14 DAT was less.
2. Operating speed did not influence waterhemp control (Univ of Missouri research).
3. One pass across the field controlled waterhemp in a dense canopy but multiple passes provided better control in an open canopy.
4. Seed viability experiments on harvested seed will be conducted in January to March 2021.
5. The Weed Zapper is not a replacement for soil residual herbicides but appears to be an effective approach for rescue control of glyphosate resistant weeds.

Introduction

Herbicide resistance is on the rise in many weed species, including waterhemp (Heap 2020). Herbicide resistance has redefined weed thresholds since weed escapes produce large quantities of resistant seed, adding to weed seedbanks and potentially affecting crops the following season (Oerke and Dehne 2004; Schweizer and Dexter 1987). One tool that is being utilized by growers to control weed escapes is the electric discharge system (EDS). This machine is comprised of a front-end tractor mounted boom/bar with a rear-mounted PTO-driven generator that creates high-voltage electricity. The front-end tractor mounted boom can unfold to provide up to a 44-foot swath and the generator can produce 200,000 watts or up to 15,000 volts. Voltage is adjusted with three settings based on target species and density; broadleaf (low), broadleaf (medium), and grass (high). The EDS is operated from and powered by a 275+ horsepower tractor. The boom height is set just above the sugarbeet canopy and operating speeds range from 2 to 6 mph. The boom contacts the stem and leaves of weed escapes that have grown above the canopy as the tractor moves through the field. Once contacted, the electricity heats cellular fluids and bursts vascular bundles. The EDS system is commercially marketed as the "Weed Zapper™" and manufactured in Sedalia, Missouri. The Weed Zapper is a modern-day prototype of the original EDS the "Lasco Lightening Weeder" developed in Grand Forks County in 1979. The Weed Zapper features more wattage and major safety improvements for the operator compared to the original EDS. Growers have been utilizing this equipment to manage weed escapes late in the growing seasons of 2019 and 2020.

Objectives

The objectives of this study were to: 1) determine waterhemp control using the Weed Zapper; 2) determine if increasing passes over the same area will improve waterhemp control; and 3) determine the viability of waterhemp seed at sugarbeet harvest.

Material and Methods

On-farm experiments were conducted in 2020 in collaboration with three local sugarbeet producers on eight production fields. In the first experiment, waterhemp control was estimated after operating the Weed Zapper at a consistent speed across the field beginning mid-July through late August or when waterhemp grew above the sugarbeet canopy. Waterhemp density was scored in each field (0 to 10, 0 indicating no waterhemp and 10 indicating a uniform and complete waterhemp infestation) and ranged from '1' to '9'. Sugarbeet fields were considered replications and waterhemp control was evaluated in two 5 x 5 square foot quadrats within each field. Quadrats were placed in areas of each field that represented the weed density of that location. A second experiment was established to evaluate waterhemp control following one, two, or four passes of the Weed Zapper through each quadrat, with multiple passes immediately following one another. This experiment was conducted in two fields; the first field had a waterhemp density score of '4' and the second field was scored a '9.' A third experiment considered kochia control from the Weed Zapper and was conducted at a single location where quadrats corresponded to replications. The standard speed used was 4 mph and the controller voltage was adjusted to broadleaf (low).

Visible percent necrosis (0 to 100% with 100% being complete darkening of vegetation), visible percent wilting (0 to 100% with 100% being complete wilting phenotype), and visible percent weed control (0 to 100% with 100% being complete waterhemp control) were collected 1, 3, 7, and 14 DAT (days after treatment). Data were analyzed using SAS Data Management software PROC MIXED procedure to test for significant differences at p=0.05.

To evaluate the effect of the Weed Zapper on weed seed viability, seed samples were collected from representative kochia or waterhemp plants in each quadrat before sugarbeet harvest. Samples were dried in the greenhouse, were threshed, and seed was stored in the cold storage room at Waldron Hall, NDSU, at 52 degrees F and 37% humidity for 30 days to vernalize seed and break dormancy in preparation for growth room and greenhouse experiments to determine seed viability (germination and emergence).

Results and Discussion

Waterhemp control. Waterhemp wilting phenotype was observed immediately following Weed Zapper application and changed very little 1 to 14 DAT (Table 1). However, necrosis injury or blackening of the stem and leaves increased from 26% to 79%, 1 to 14 DAT, respectively. Waterhemp overall control corresponded more closely to necrosis injury than wilting and increased significantly from 3 to 14 DAT.

Table 1. Waterhemp wilting, necrosis, and overall control with the Weed Zapper from 1 to 14 days after treatments, averaged across eight locations, 2020.

	Waterhemp		
Days after treatment	Wilting Phenotype	Necrosis	Control
	------------------------------------%------------------------------------		
1	72 a	0 d	15 c
3	73 a	26 c	39 b
7	74 a	71 b	76 a
14	70 a	79 a	85 a

Waterhemp control as influenced by number of passes. Waterhemp control was evaluated following 1, 2, or 4 passes of the Weed Zapper in two fields. The first field had a waterhemp density that scored ‘9’ (Figure 1) and the second field had a waterhemp density that scored ‘4’ (Figure 2). We were interested in determining if multiple passes affected waterhemp control, especially in the Kragnes field where waterhemp density scored ‘9’. We observed improved waterhemp control over time in both fields. Waterhemp control following four passes increased at 3 and 7 DAT compared to a single pass and tended to increase control 14 DAT at Kragnes. Waterhemp control was significantly improved from making two passes through the field compared to a single pass at Felton (Figure 2).

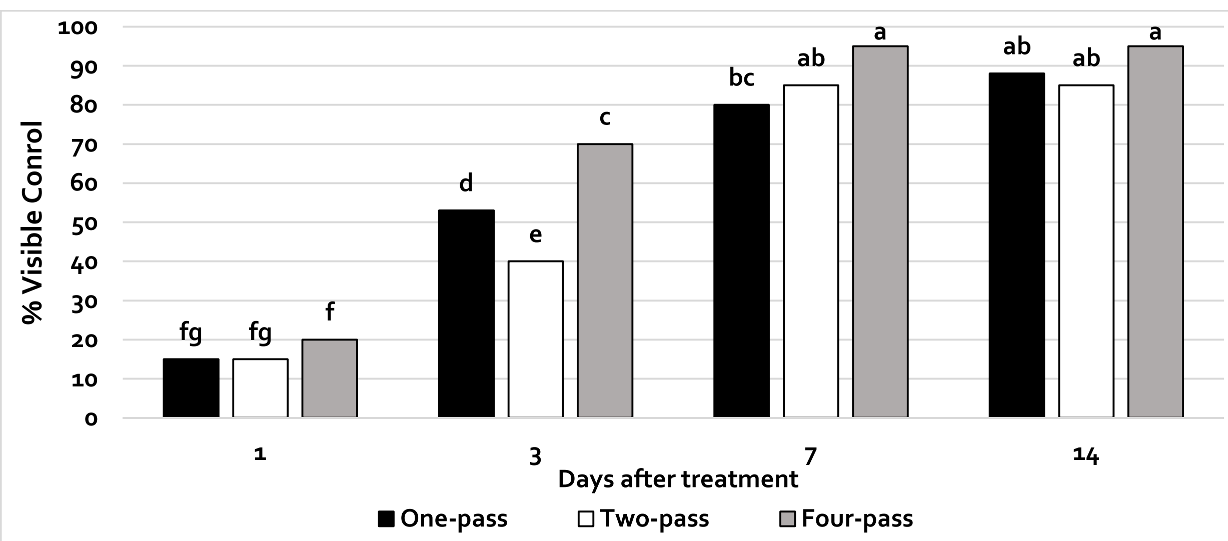

Figure 1. Waterhemp control by treatment, Kragnes, MN, 2020.

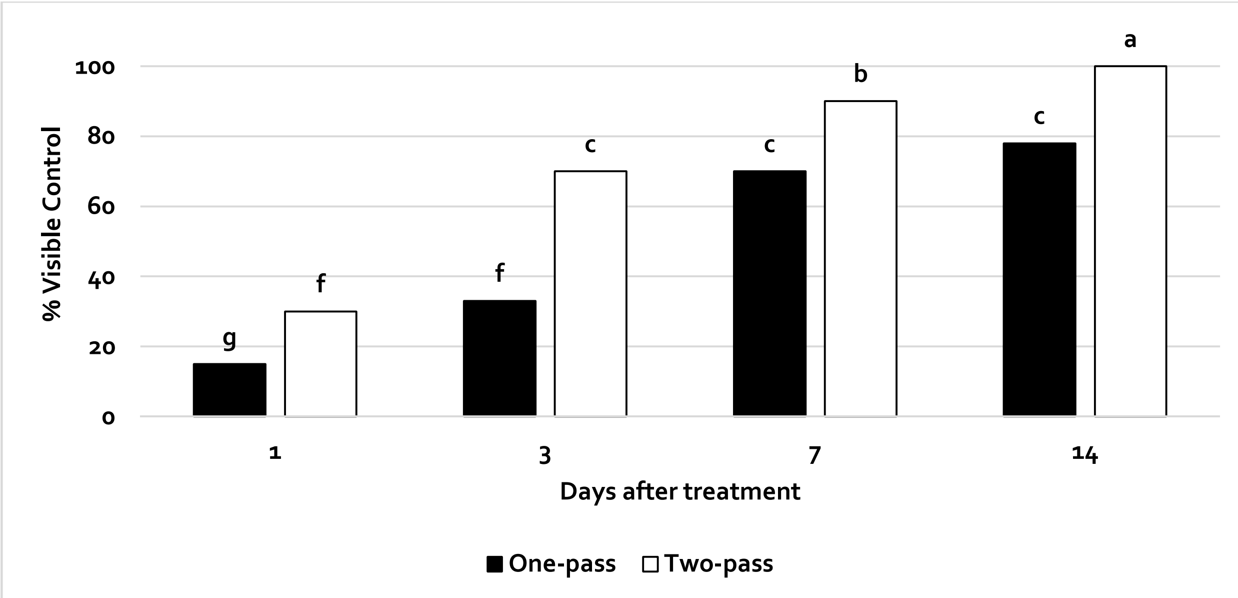

Figure 2. Waterhemp control by treatment, Felton, MN, 2020

Kochia control. Kochia control with the Weed Zapper was evaluated at one location in 2020. We observed the immediate wilting phenotype with kochia, similar to waterhemp, but observed less necrosis and overall kochia control compared with waterhemp (Table 2). Our results were similar to observations with the Lasco Lightening Weeder. Rasmusson et al. (1979) observed better control from the Lasco Lightening Weeder on weeds with a primary stem (i.e. giant ragweed or sunflower) than those with highly branched stems (kochia) or grasses. Our data, though limited to one kochia location, suggested the Weed Zapper gave greater waterhemp control than kochia control.

Table 2. Kochia wilting, necrosis, and overall control with the Weed Zapper from 1 to 14 days after treatment, Glyndon, MN, 2020.

	Kochia		
Days after treatment	Wilting Phenotype	Necrosis	Control
	---------------------------------	%	-----------------------------------
1	86 a	0 f	14 d
3	73ab	5 ef	19 d
7	65 ab	18 de	44 c
14	51 b	43 c	76 b

The Weed Zapper is used for weed control when weed height extends above the cultivated crop height. In Minnesota and North Dakota, waterhemp generally extends above the sugarbeet canopy and begins to flower in July. The Weed Zapper was used in July and early August in 2019. However, in 2020, we observed the Weed Zapper in use in fields in late August, well beyond when waterhemp typically begins flowering. Waterhemp seed becomes viable very rapidly following flowering. Researchers at the University of Illinois reported waterhemp seed was viable 9 to 12 days after flowering (Bell and Tranel, 2010), thereby leading to questions about how the Weed Zapper will affect weed seed viability.

Seed was collected in quadrats from waterhemp and kochia plants treated with the Weed Zapper. We hypothesize that waterhemp seed could be killed if the electrical treatment resulted in heating the seed to the extent that proteins were denatured. Growth room and greenhouse experiments are planned to examine seed viability and seed emergence.

Conclusions

Wilting was observed immediately after application and the Weed Zapper effectively controlled 80% of escaped waterhemp and 76% of escaped kochia, 7 to 14 days after treatment. Multiple passes may improve efficacy in moderately dense waterhemp infestation but may not improve efficacy in dense waterhemp infestations. However, weed interference resulting in reduced sugarbeet root yield and quality will presumably occur since the Weed Zapper is operated after weeds extended above the crop canopy. Growers that purchased the Weed Zapper indicate that treatment in July and August kills weeds and reduces weed biomass, thus improving harvest efficiency and storage. We believe the Weed Zapper can be a component of a weed management system in sugarbeet, much like a rescue herbicide treatment, but it is not a substitute for soil residual herbicides for waterhemp or kochia control. Replicated plot research will be needed to investigate the effect on yield, sucrose content, harvestability, seed viability, the relationship with soil applied herbicides, timing of application, voltage settings, speed, etc. to determine more precise evaluation of this equipment.

References

Bell MS, Tranel PJ (2010) Time requirement from pollination to seed maturity in waterhemp (*Amaranthus tuberculatus*). Wee Sci 58:167-173

Heap I (2020) The international survey of herbicide resistant weeds. www.weedscience.org Accessed: December 1, 2020

Oerke EC, Dehne HW (2004) Safeguarding production—losses in major crops and the role of crop protection. Crop Prot 23:275-285

Rasmusson DD, Dexter AG, Warren H (1980) The use of electricity to control weeds. Sugarbeet Res and Ext Rep 10:70-71

Schweizer EE, Dexter AG (1987) Weed control in sugarbeets (*Beta vulgaris*) in north America. Weed Sci 3:113-133

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 replications.

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 determination 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

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.

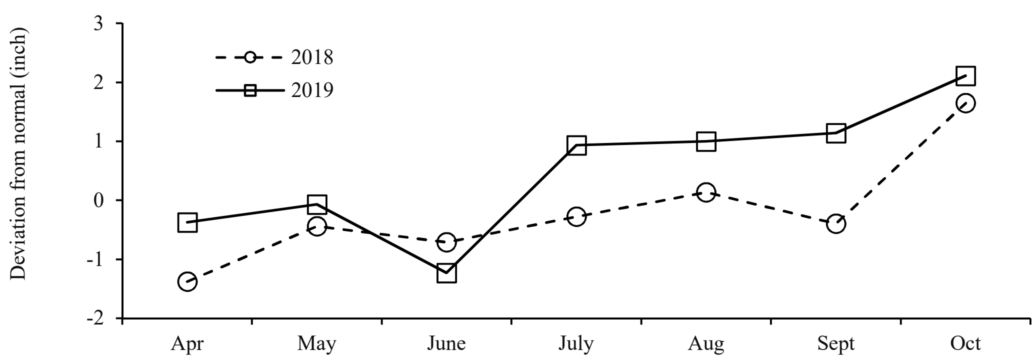

Figure 1: Deviation from normal precipitation for 2018 and 2019.

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.

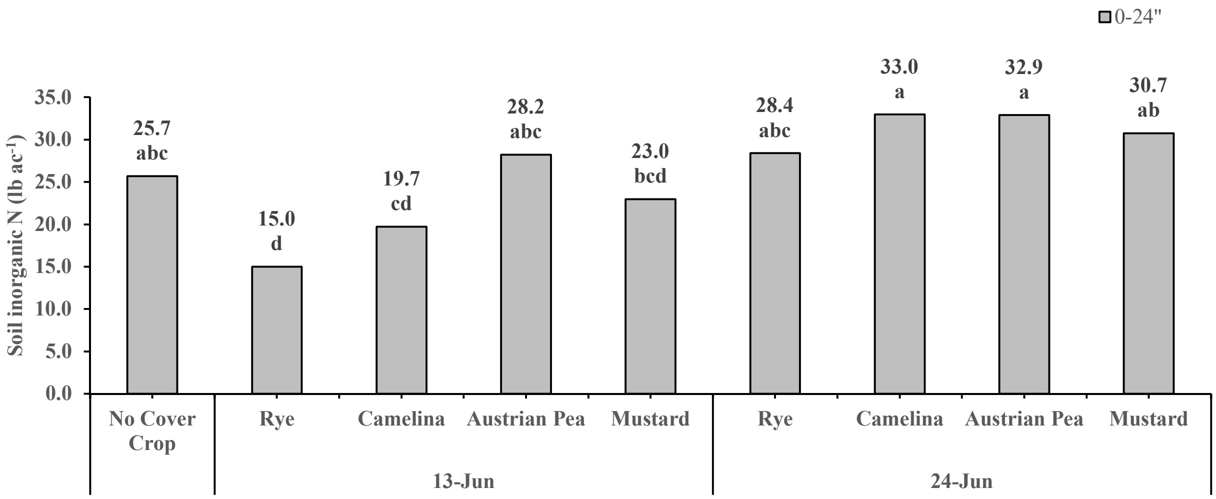

Figure 1: Effect of cover crop interseeding on residual soil inorganic N (lb ac^{-1}) after harvest at 0-24" depth during 2019 at Ada.

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

INFLUENCE OF PLANT POPULATION ON SUGARBEET PRODUCTION

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INTRODUCTION

Achieving optimum plant population with uniform stands is the foundation in establishing the potential for high yield and quality of sugarbeet. For high tonnage, increasing plant population has potential to increase the sugar content, the opposite trend is true for high sugar content. Optimizing plant population will help growers to optimize plant population based on the cultivar selection. Research objectives were to determine changes in root yield and sugar content with the selection of plant population for high tonnage and high sugar cultivars, and determine the interactions between cultivar selection, and plant population on sugarbeet root yield and quality.

Table 1. 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 0-2 ft (lb ac^{-1})	49	48
Olsen P (ppm)	4	60
K (ppm)	48	495
OM (%)	3.07	3.3

METHODS

Field study was conducted at two sites, Ada, MN and Prosper, ND. For both sites, previous crop was soybean. The experiment was laid out in factorial RCBD which included six population density, 75, 125, 175, 225, 250, and 275 plants per 100 ft, and two cultivars, high tonnage (Beta seed) and high sugar (Crystal). Individual treatment plots measured 11 feet wide and 30 feet long. Recommended NPK fertilizers were applied based on the soil test values (Table 1) in the form of urea, MAP and MOP. At Ada, 81 lb of N, 55 lb of P_2O_5 and 90 lb of K_2O ac^{-1}, were applied. At Prosper, we only applied nitrogen due to high soil test values for phosphorus and potassium. Plots were planted in thick to achieve the highest population of 275 plants per 100 ft. Due to lack of rain, emergence was not uniform at both locations. After emergence, we conducted a stand count and thinned plots to achieve stand density of 175 plants per 100 ft. At harvest, we did another set of stand count. Middle two rows of each plot were harvested to determine the root yield and sugar concentration was analyzed by American Crystal Tare Lab in East Grand Forks, MN. Due to uneven emergence, results were represented as changes in recoverable sugar yield with range of stand density.

RESULTS AND DISCUSSION

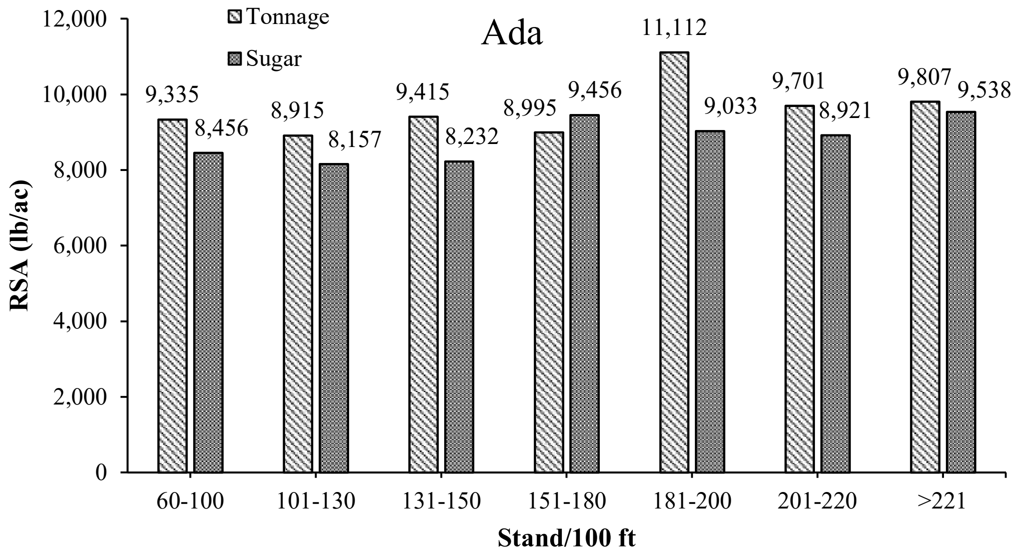
Due to lack of rainfall at planting, stand emergence was irregular. Stand density of middle two rows at harvest was presented in Table 2. For high tonnage cultivar, the highest average root yield was 32.0 ton/ac with stand density at harvest with population of 178 plant/100 ft at Ada, and 31.1 ton/ac with population of 160 plant/100 ft at Prosper, highest sugar concentration was 16.5% at Ada and 15.4% at Prosper. Sugar concentration did not show any response to plant population. Recoverable sugar yield also optimized at plant population of 181-200 plant per 100 ft at both sites (Fig. 1). For high sugar cultivar, highest root yield was 28.1 ton/ac and 29.2 ton/ac and highest sugar concentration was 17.7% and 17.1% at Ada and Prosper, respectively. For high sugar cultivar, recoverable sugar yield was optimized at greater than 221 plant per 100 ft at Ada and at 151-180 plant per 100 ft at Prosper.

CONCLUSION

This trial showed that for high tonnage, root yield and recoverable sugar yield were optimized at 200 plant per 100 ft; but for high sugar, plant population density could be increased to 220 plants per 100 ft depending on site. This experiment needs to be continued to validate results under consistent plant population and other soil characteristics.

Table 2. Average final stand density (plant/60 ft), root yield (t/ac), and sugar concentration (%) in response to plant density and cultivar type conducted at Ada, MN and Prosper, ND during 2020

Density /100 ft	Cultivar	Density at harvest	Root yield (t/ac)	Sugar%	Density at harvest	Root yield (t/ac)	Sugar%
			Ada			Prosper	
75	**Tonnage**	46 (3)	29.3 (3.8)	16.9 (0.3)	71 (27)	28.5 (7.3)	15.1 (0.3)
125		77 (7)	31.1(3.9)	16.4 (0.2)	96 (15)	31.1 (1.2)	15.2 (0.9)
175		107(5)	32.0 (2.1)	16.5 (0.3)	63 (26)	23.5 (6.0)	15.3 (0.8)
225		129 (20)	31.6 (2.4)	16.3 (0.6)	81 (20)	28.2 (3.1)	15.0 (1.0)
250		122 (26)	28.9 (2.3)	16.1 (0.2)	78 (18)	26.5(6.8)	15.4 (0.7)
275		126 (14)	30.3 (5.3)	16.5 (0.3)	95 (32)	30.6 (6.7)	15.2 (0.7)
75	**Sugar**	47 (5)	26.4 (2.2)	17.7 (0.3)	78 (25)	25.9 (2.2)	17.1 (0.8)
125		67 (8)	23.6 (2.2)	17.5 (0.3)	73 (33)	28.4 (1.4)	16.7 (0.8)
175		99 (11)	27.2 (2.6)	17.4 (0.7)	101 (20)	26.8 (5.0)	17.0 (0.5)
225		130 (4)	27.9 (1.7)	17.5 (0.2)	88 (23)	28.8 (2.0)	16.4 (0.9)
250		118 (9)	25.6 (1.8)	17.6 (0.8)	88 (29)	29.2 (1.1)	16.7 (0.5)
275		106 (14)	28.1 (2.4)	17.7 (0.4)	113 (15)	28.2 (2.2)	16.7 (0.9)



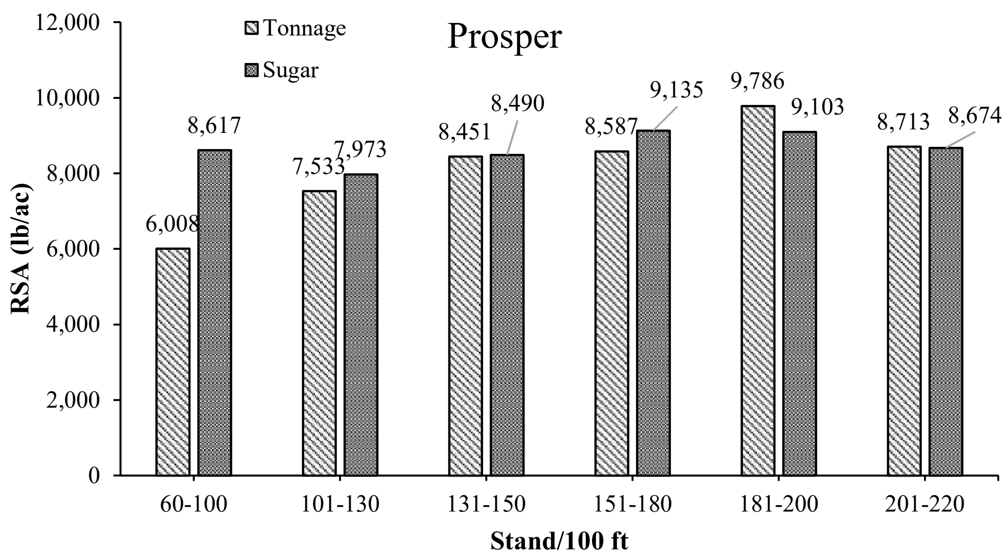


Figure 1. Changes in recoverable sugar yield (lb/ac) due to a range of stand density of high tonnage and sugar cultivars at Ada, MN and Prosper, ND during 2020 growing season

EVALUATION OF NITROGEN FERTILIZER TECHNOLOGIES AND FERTILIZER TIMING FOR SUGAR BEET PRODUCTION

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Justification: Research on biostimulant use in sugar beet production is not widespread. Limited work has been conducted looking at the benefits of chitosans. Eweiss et al. (2005) studied the effect of chitosans on mycelial growth, sporulation, and germination of conidia or sclerotial of *Rhizoctonia solani*, *Sclerotium rolfsii* Sacc., and *Fusarium solani* and noted a limited impact on *R. solani*. More research has been conducted with sugar beet treated with beneficial microbes. Mrkovacki et al. (1995) found increased dry mass of sugar beet treated with Azotobacter chroococcum. Cakmakc et al. (2001) found increased root yield and sugar content for sugar beet seed inoculated with Bacillus and Pseudomonas bacterial strains. Mahmoud et al. (2014) indicated that 60-80 kg N applied with Azobacter and Asospirillum sp produced similar root yield as 100 kg N without treatment. The majority of research has been conducted outside of the U.S. on soils which do not have the same microbial activity as Minnesota soils. A recurring issue with microbial treatments is the ability for the microbe to establish itself when it is not native to the soil and the ability to establish in the presence of high rates of nitrogen. Free living N fixers typically are less active when high rates of N are applied. Some native strains of bacteria are currently being engineered to allow for colonization on plant roots when near optimal rates of N are applied. These bacteria will not likely supply the majority of the N requirement by a crop but may help supplement N to the crop potentially reducing the need for supplemental N application.

Objectives:

1. Evaluate nitrogen fertilizer requirement for sugar beet.

2. Determine whether a biostimulant such as chitosans or beneficial N fixing bacteria can increase sugar beet yield and reduce the amount of N required to maximize root yield and recoverable sugar per acre.

Materials and Methods: Two field locations were established in spring 2020 in Minnesota one located at the Northwest Research and Outreach Center at Crookston and the second on a farmer field near Wood Lake (Table 1). Trials laid out using a strip plot design. Main blocks consisted of six rates of N (0, 40, 80, 120, 160, and 200 lbs of N) at Crookston and eight rates of N (0, 30, 60, 90, 120, 150, 180, 210 lbs of N) at Wood lake. All fertilizer was applied as spring urea (46-0-0) applied to the soil and incorporated prior to planting.

The biostimulant treatment were applied in-furrow across the N rates as strips randomized within each replication. Biostimulant treatments included none, High Tide [chitosan additive manufactured by Tidal Vision and applied at 75 mL/ac (30 mL/gallon of starter)], and a mixture of 60 oz/ac of Bio Red plus 22.5 oz/ac of Bio Mate. Bio Red and Bio Mate contain Azotobacter, Clostridium, and Lactobacillus bacteria which are nitrogen fixing bacteria, plus sugar which acts as a food source for the bacteria. Bio Red and Bio Mate were sourced locally through a Biovante distributor at Grand Meadow, MN and High Tide was sourced through Amazon.com. All biostimulant treatments were mixed with deionized water and the mix was combined 1:1 v/v with 3 gallons per acre of 6-24-6. The combined solution starter/biostimulant mixture was applied at a rate of 6 GPA. The no biostimulant control included 6-24-6 and deionized water only.

Soil samples will be collected from each replication at 0-6, 6-24, and 24-48" as a single composite sample from each trial area. Initial soil test information is summarized in Table 2. Leaf blade and petiole samples were collected in early July (Table 1) by sampling the uppermost fully developed leaf. Extractable nitrate-N was determined following extraction with 2% acetic acid. Petiole and leaf blade samples was analyzed for total N dry combustion.

Plots were harvested at the end of the growing season and root samples will be analyzed for quality parameters. The variety planted at each location was Crystal 796RR at Crookston and SV 863 at Wood Lake. All practices, weed and disease control, planting, and tillage were consistent with common practices for the growing regions. All statistical analysis was conducted using SAS 9.4 assuming fixed effects of Site, N rate, biostimulant treatment and their interaction and random blocking effects. Treatments are considered significant at the $P \leq 0.10$ probability level.

Results

A summary of main effect significant is given in Table 3. Figures 1 through 5 summarize sugar beet response to N at the two trial locations. Data are summarized across all biostimulant treatments when the statistical analysis indicated no N rate by biostimulant interaction for a given locations. The summary of the main effect of the biostimulant treatments are given in Table 4.

Sugar beet emergence was significantly impacted by N rate at both locations and by the biostimulant treatment only at Crookston (Table 3 and Figure 1). In both cases, sugar beet emergence was less as the rate of N applied as spring urea increased. The decrease was quadratic at both locations where the difference in emergence was generally non-significant between no nitrogen and the lowest rate applied at both locations and the effect increased with increasing N application rate. The effect to of the biostimulant treatment at Crookston occurred when emergences was reduced more when the biostimulant products were used but only at higher rates of applied N. When 120 lbs of N or less was applied there was no difference among the biostimulant treatments at Crookston and the greatest different was between the no-biostimulant treatment and the BioRed/BioMate treatment when 200 lbs of N were applied. Overall, the impact of the biostimulant treatment was relatively minor compared to the impact that spring urea had on emergence.

Sugar beet root yield as impacted by N application rate at both locations and was not affected by use of biostimulant (Table 3). The amount of N applied with starter (2 lbs/ac) was combined with the amount of residual nitrate in the top four feet of the soil (Table 2) and related to root yield. Root yield responded to 81 lbs of total N at Crookston. At Wood Lake two models were fit to the data. First, root yield appeared to increase up to the highest total N rate, 242 lbs, fitting a quadratic model. A linear plateau model could also be fit where root yield maximized at 177 lbs total N. In either case sugar beet root yield was more responsive to nitrogen than expected at the Wood Lake location.

The decrease in plant population did not impact sugar beet root yield at either location. The loss of population was compensated by the sugar beet plants which increased the mass of roots per plant (not shown). While higher rates of N as spring urea could reduce yield the effect on root yield should be minimal if the variety planted can compensate by growing larger roots. In fact, at Wood Lake the highest rate of N applied, 210 lbs/ac, reduced emergence by 20% and increased root yield by 40%. This speaks to the ability for sugar beet to compensate for reduced stands by increasing root size.

Nitrogen rate effects on extractable sucrose are summarized in Figures 3 and 4. Nitrogen rate effected extractable sucrose per ton at Crookston but not at Wood Lake (Table 3). At Crookston, extractable sucrose per ton was greatest for 80 lbs total N, similar to the total N which maximized root yield, and decreased as total N increased past 80 lbs. A decrease in extractable sucrose with increasing total N is expected. Extractable sucrose generally increase as total N increased but the effect was more variable, and a statistical model could not be fit to the data. Since root yield was not maximized at the highest amount of total N an increase then decrease in extractable sucrose per ton would not be expected at Wood Lake as the peak would be beyond the greatest rate of N applied. Biostimulant treatments impacted extractable sucrose per ton at Wood Lake. However, neither biostimulant source differed from the no-biostimulant control at Wood Lake. The only difference at Wood Lake was between the High Tide treatment which produced greater, on average, extractable sucrose compared to BioRed/BioMate.

Extractable sucrose per acre followed similar trends as root yield maximizing close to 80 lbs of total N at Crookston while increasing up to the highest total N rate at Wood Lake (Figure 4). No decrease in extractable sucrose on a per acre bases was found at Crookston where extractable sucrose per ton decreased as N was applied beyond the optimal N rate.

Petiole nitrate concentrations were determined following sampling in early to mid-July. Leaf blade nitrate was also analyzed but the data were more variable and are not included in this report. Nitrogen application rate significantly impacted petiole nitrate concentration at both locations while the biostimulant treatments only impacted petiole nitrate at the Wood Lake location (Table 3). The effect of biostimulant at Wood Lake was a reduction in petiole nitrate concentration when BioRed/BioMate was applied. In fact, there was a significant interaction between N rate and biostimulant treatment at Wood Lake where difference in petiole nitrate concentration between the BioRed/BioMate treatment compared to the no biostimulant control or High Tide treatment only occurred at the highest rates of N applied. This difference among the biostimulant sources was not reflected in differences in root yield.

In all cases the effect of N rate on petiole N concentration were curvilinear where petiole nitrate concentrations increased slowly at first then rapidly as total N reached or exceeded the amount of N needed to maximize root yield (Figure 5). Data from Crookston and Wood Lake were combined with data from a separate N rate trial established near Lake Lillian, MN also in 2020 (yield data for the Lake Lillian trial are not included in this report). Yield data were converted at each location to a relative basis (deviation from maximum site yield) by dividing root yield for each plot in all locations by the maximum yield produced for a given location. For Crookston and Wood Lake the maximum yield was assumed to be the yield produced at the plateau as identified by the quadratic- or linear plateau models.

Petiole nitrate concentration was regressed with relative yield and the data are given in Figure 6. Data indicate that 100% of maximum root yield was achieved with a petiole nitrate concentration near 850 ppm. However, relative root yield for plots ranged from 50-110% for petiole nitrate concentration less than 850 ppm. The high range in relative yield levels for petiole nitrate concentration does present some issues for using petiole nitrate concentration to assess nitrate sufficiency to direct supplemental application of N for sugar beet. The range in relative yield values is similar to what is seen with other tests such as the corn basal stalk N test. While we could say that 850 ppm would be a sufficient petiole nitrate concentration for sugar beet what to do if you concentration is below that level is more difficult to determine. As we continue the nitrogen work, we will add more data to the dataset. One item of note is that root yield at Lake Lillian did not respond to nitrogen and yield levels were 40+ tons similar to Wood Lake, yet many of the petiole nitrate concentration were less than 850 ppm. Past research has also not been able to calibrate the petiole nitrate test. The petiole nitrate test may work to help manage nitrogen at specific locations, but it may not be possible to determine which locations it may work until yield data is available at a given location.

Conclusions

Based on the 2020 data the biostimulant products did not provide any nitrogen or enhance yield for sugar beet. It should be noted that research was conducted at only two locations and it cannot be determined whether a response might occur given a specific circumstance. However, the amount of data available does not indicate widespread benefits for the use of biostimulant for sugar beet production. Sugar beet response to N was greater than expected at one location but the data at that location does not mean the amount of N applied to all sugar beet fields in the southern growing region need to be adjusted. The data will be added to additional current data on sugar beet response to nitrogen. The current suggested rates of N to achieve optimal extractable sucrose per acre is 123 lbs of N in the southern growing region and 130 lbs of N in the northern growing region (applied N plus nitrate-N in a two-foot soil sample). Petiole nitrate concentration did respond to the addition of nitrogen fertilizer but could not be accurately calibrated to determine how much fertilizer to apply if petiole nitrate concentration is less than 850 ppm.

Acknowledgments

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Literature Cited

Cakmacr, Ramazan., Faik Kantar, and Fikrettin Sahin. 2001. Effect of N2-fixing bacterial inoculations on yield of sugar beet and barley. J. Plant Nutr. Soil Sci. 164: 527-531.

Chatterjee, A., N. Cattanach, and H. Mickelson. 2018. Fall vs. spring nitrogen application on sugar beet production. In sugar beet reports [Online] https://www.sbreb.org/wp-content/uploads/2018/08/FALL-VS-1.pdf.

Eweis, M., S.S. Elkholy, and M.Z. Elsabee. 2006. Antifugal efficacy of chitosan and its thiourea derivatives upon the growth of some sugar-beet pathogens. Int. J. of Biostimulant Macromolecules 38: 1-8.

Lamb, J.A., and A.L. Sims. 2011. Fertilizing sugar beet in Southern Minnesota. Ext. Publ FO-3814-S. Univ. of MN. Ext., St. Paul.

Mahmoud, E.A., B.S.H. Ramadan. I.E. El-Geddayw, and Samah F. Korany. 2014. Effect of mineral and bio-fertilization on productivity of sugar beet. J. Plant Production, Mansoura Univ. 5: 699-710.

Mrkovacki, N., S Mezei, I Veresbaranji, M. Popovic, Z. Saric, and L. Kovacev. 1997. Associations of sugar beet and nitrogen-fixing bacteria in vitro. Biologia Plantarum 39: 419-425.

Rehm, G.W., J.A. Lamb. J.D Hughes, and G.W. Randall. 2008. Best management practices for nitrogen use in Southwester and West-Central Minnesota. Ext publ 08558. Univ. of MN Ext. St. Paul.

Sims, A.L., 2013. Nitrogen management in sugar beet grown in finer textured soils of the RRV. In sugar beet reports [Online] https://www.sbreb.org/wp-content/uploads/2018/03/SimsNitrogenRRV.pdf.

Sims, A.L., 2009. Challenging Current Nitrogen Recommendations: Sugar beet Response to Nitrogen in Different RRV Locations and Soils-Report 3. In sugar beet reports [online] https://www.sbreb.org/wp-content/uploads/2018/03/ChallengingNitrogen2009.pdf.

Table 1. Location, planting and sampling information and dominant soil series for each location.

	Date of				Soil		
Location	Urea Application	Planting	Tissue Sampling	Harvest	Series	Texture†	Classification‡
Crookston	18-May	18-May	14-Jul.	15-Sept.	Wheatville	FSL	Ae. Calciaquoll
Wood Lake	22-Apr.	22-Apr.	9-Jul.	5-Oct.	Canisteo	CL	T. Endoaquoll

† CL, clay loam; FSL, fine sandy loam.

‡Ae, aeric; T, typic

Table 2. Summary of soil test results for 2020 locations.

	0-6" Soil Test				Soil Test Nitrate-N	
Location	Olsen P	Ammonium Acetate K	pH	SOM	0-2'	2-4'
	----------ppm----------			----%----	--------------------lb/ac--------------------	
Crookston	75	185	8.1	4.1	15	12
Wood Lake	69	274	7.5	4.5	22	8

Table 3. Summary of analysis of variance for main effects of nitrogen application rate (N rate) and biostimulant (Bio.) and their interaction at Crookston (CRX) and Wood Lake (WL), MN in 2020.

	Emergence		Petiole N		Yield		Recoverable Sugar (ton)	
Effect	CRX	WL	CRX	WL	CRX	WL	CRX	WL
	--*P*>F--							
N rate	***	***	***	***	*	***	**	0.32
Bio.	0.88	0.44	0.48	**	0.40	0.16	0.13	0.08
N rate x Bio.	*	0.71	0.75	*	0.46	0.37	0.13	0.51

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

Table 4. Summary of the main effect of in-furrow biostimulant source for selected variable at Crookston (CRX) and Wood Lake (WL), MN in 2020. Letters indicating least significant difference are only listed in the table when the main effect of biostimulant was significant.

	Emergence		Petiole N		Yield		Rec. Sugar (ton)		Rec Sugar (acre)	
Biostimulant	CRX	WL	CRX	WL	CRX	WL	CRX	WL	CRX	WL
	------%------		----ppm----		--tons/ac--		---lb/ton---		----lb/ac----	
None	71	72	2766	905a	23.9	35.9	306	299ab	7314	10670
BioRed/Mate	69	75	3058	621b	22.9	34.6	308	295b	7093	10227
High Tide	71	72	2745	852a	25.3	34.7	304	301a	7701	10474

†Numbers followed by the same letter are not significantly different at the *P*≤0.10 probability level.

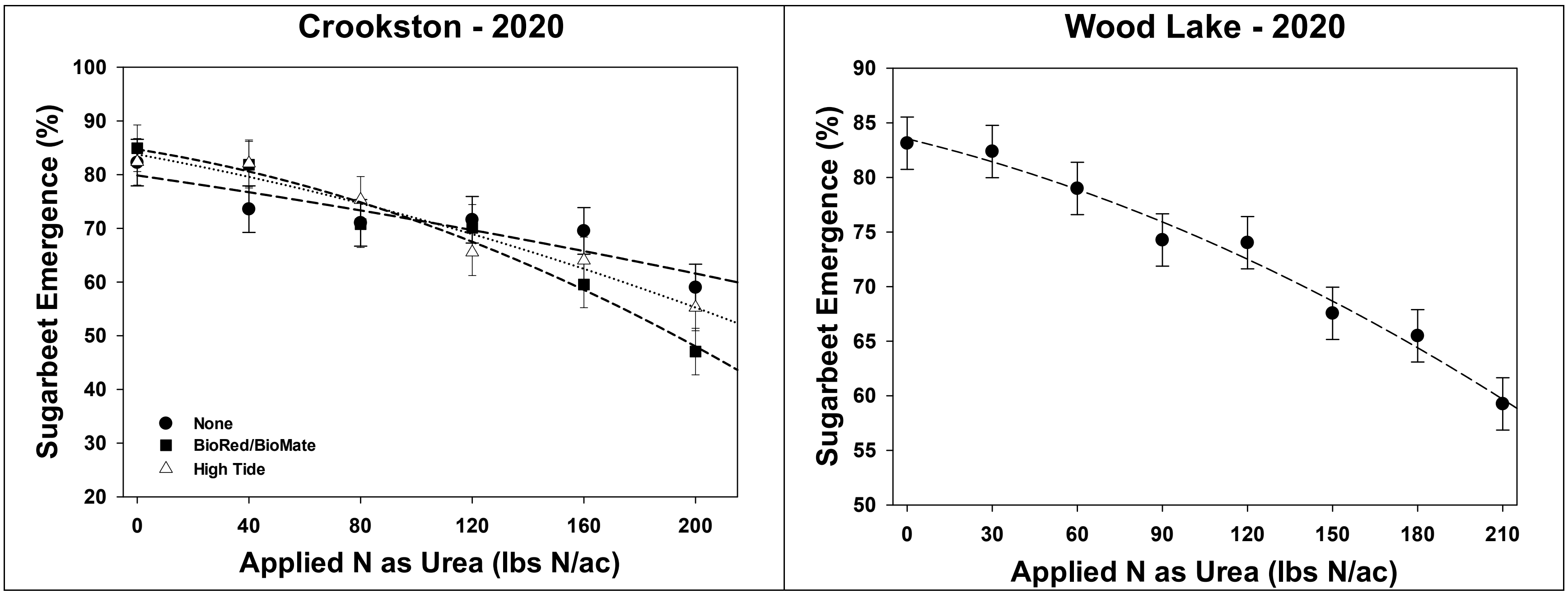

Figure 1. Effect of nitrogen applied as spring urea on sugar beet emergence at two Minnesota locations during the 2020 growing season.

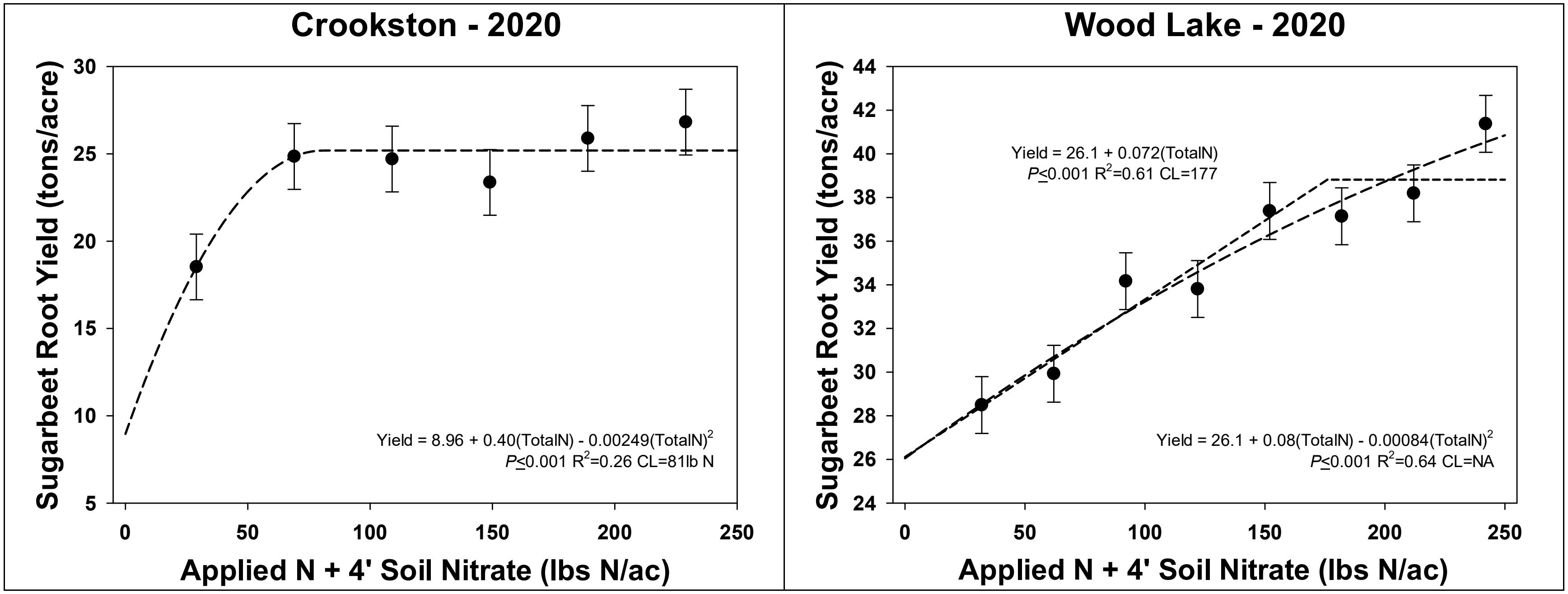

Figure 2. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet root yield at two Minnesota locations during the 2020 growing season.

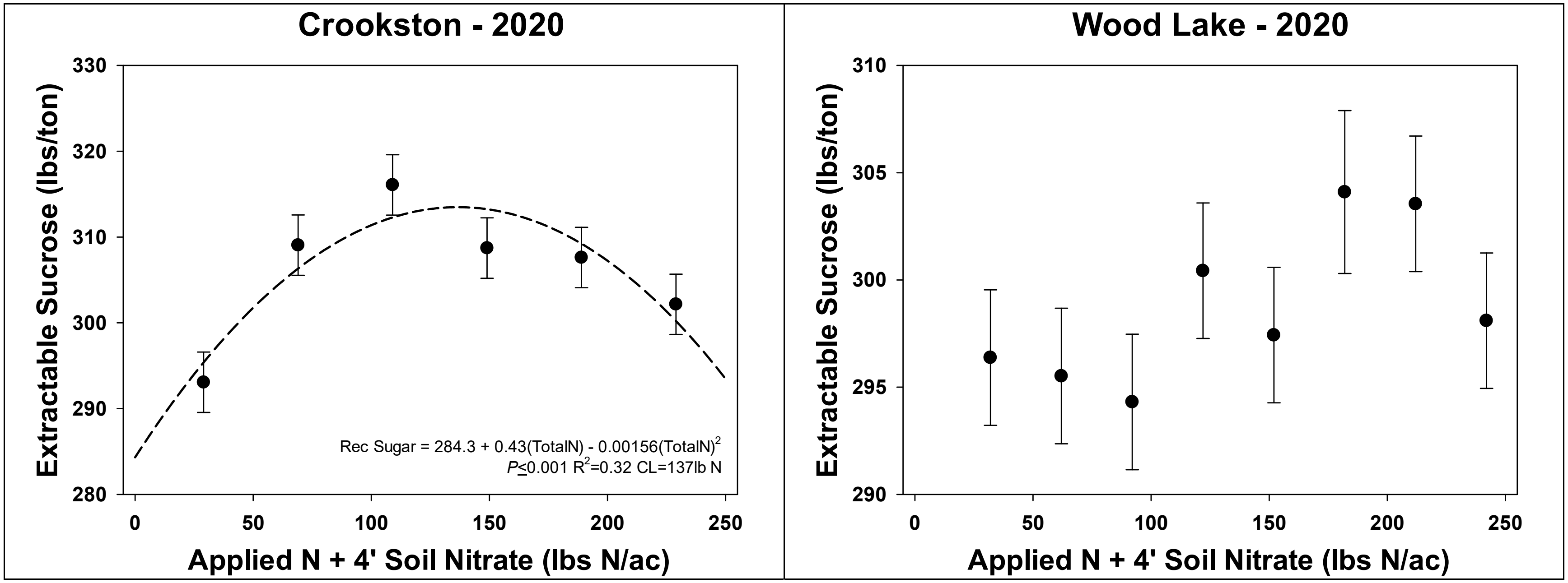

Figure 3. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet extractable sucrose per ton at two Minnesota locations during the 2020 growing season.

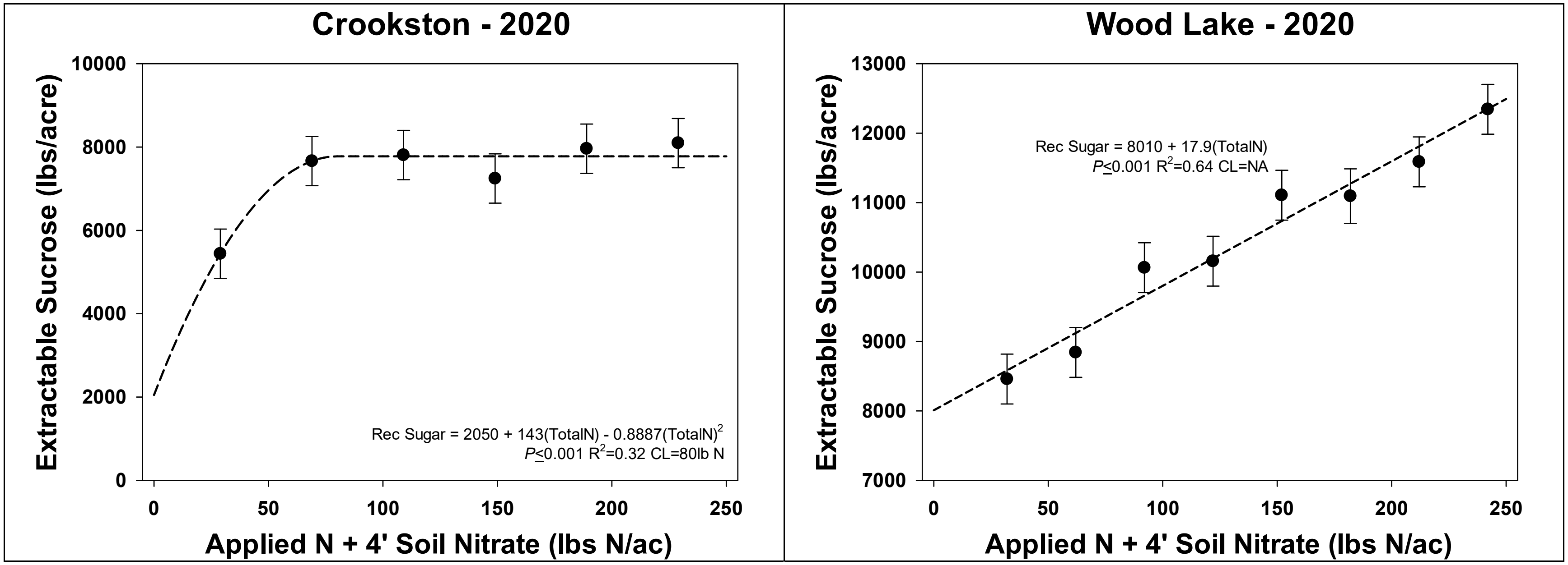

Figure 4. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet total extractable sucrose per acre at two Minnesota locations during the 2020 growing season.

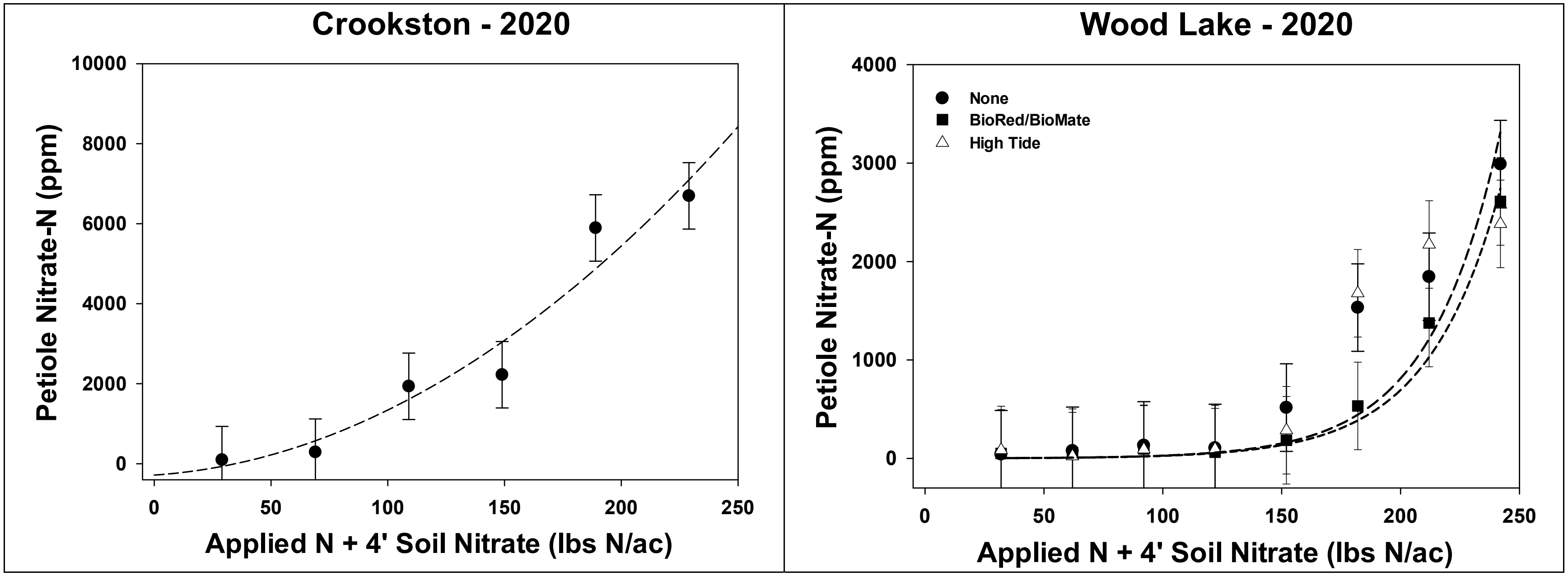

Figure 5. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet early to mid-July petiole nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2020 growing season.

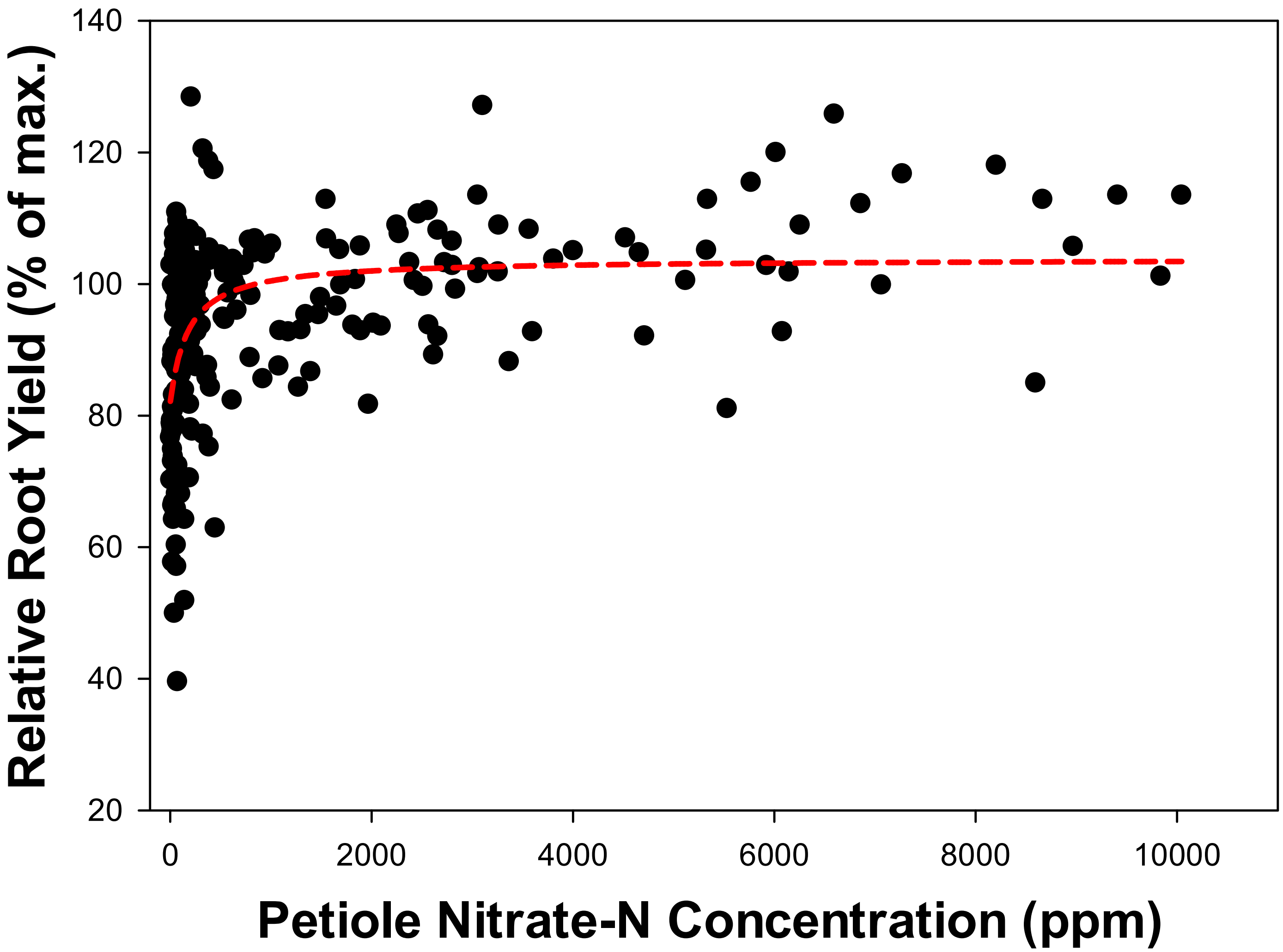

Figure 6. Relationship between relative sugar beet root yield (% of site maximum yield) and nitrate concentration in the uppermost fully developed petiole sampled in early- to mid-July.

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.

Project 1. 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 Murdock, MN and Nashua, MN - 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 and 15,400 gallons per acre at the Murdock and Nashua sites, respectively), a low application rate (about 9,500 and 10,300 gallons per acre at the Murdock and Nashua sites, respectively), 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. Subplot treatments.

Treatment	Year 1	Year 2	Year 3
a	Fertilizers	Fertilizers	Fertilizers
b	Manure low rate (fertilizers if needed to balance crop nutrient needs)	Fertilizers w/ second year manure N credit	Fertilizers w/ third year manure N credit
c	Manure high rate (fertilizers if needed to balance crop nutrient needs)	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 began in the fall of 2019 at a farm site near Murdock, MN following corn. Manure was surface applied and incorporated within 24 hours of application. Fertilizers were applied as appropriate in the spring prior to planting crops. Initial soil samples and manure samples were collected and analyzed (Table 3). Corn (Enesvedt E-696RR), soybean (Stine Liberty Link GT27), and sugarbeet (SESVDH 863) were planted and maintained according to typical practices in the region.

Table 3. Soil and manure test results for Murdock site in fall 2019.

Initial soil test results		Manure characteristics		Manure as-applied (lb/acre)†		
		Nutrient	(lb/1000 gal)	Nutrient	High rate	Low rate
pH	8.0	Total N	16-22	Total N	321	155
Nitrate – 0-24" (lb/ac)	40	Ammonium-N	12-13.5	First year N‡	177	85
Olsen P (ppm)	7	Total P_2O_5	6-13	Total P_2O_5	196	62
K (ppm)	190	Total K_2O	20-21	Total K_2O	300	187

†Note that the high and low manure rates were balanced with spring-applied fertilizers to meet crop nutrient needs as appropriate. ‡First year availability was assumed to be 55% of total N.

Plant and soil samples were collected during the growing season to better understand nutrient cycling between the different nutrient sources. We collected soil samples (0-1 ft) twice during the growing season for nitrate analysis (tests are being completed this winter). Early in the growing season we noted some issues with the soybean in the manured plots; growth was stunted and the plants were yellow, indicative of iron chlorosis deficiency. When corn reached maturity (around the R6 growth stage) we collected plant samples (stalk, cob, and grain) to evaluate nitrogen uptake. These samples will be sent to a lab for analyses this winter as well. Post-harvest soil samples were also collected from each plot but have yet to be analyzed.

Sugarbeets were harvested on September 30, 2020. There were no significant differences between treatments on yield or extractable sucrose (per ton or per acre). The fertilized plots tended to result in lower overall yield but higher sucrose per ton than the manured plots. Sucrose purity was significantly affected by treatments, with fertilizer having a higher percent purity than the high dairy manure application rate, though the low manure application rate was not significantly different than the fertilizer or high manure rate (Table 4). Soybean were harvested on October 2, 2020, with few plants in the manured plots (Figure 1). As expected, based on what we saw earlier in the growing season, soybean yield was significantly reduced by manure application in this field. Corn was harvested on November 4, 2020. Both treatments with manure tended to have higher yield than the fertilizer only plot (Figure 1), but differences were not significant.

Table 4. Yield, extractable sucrose (per ton and per acre), and sucrose percent purity

Nutrient Source	Yield (tons/acre)	Extractable Sucrose (lbs/ton)	Extractable Sucrose (lbs/acre)	Sucrose Purity (%)
Fertilizer only	32.7a	297a	9,710a	91.2a
Low dairy manure rate	35.8a	286a	10,266a	90.85ab
High dairy manure rate	35.6a	292a	10,380a	90.78b

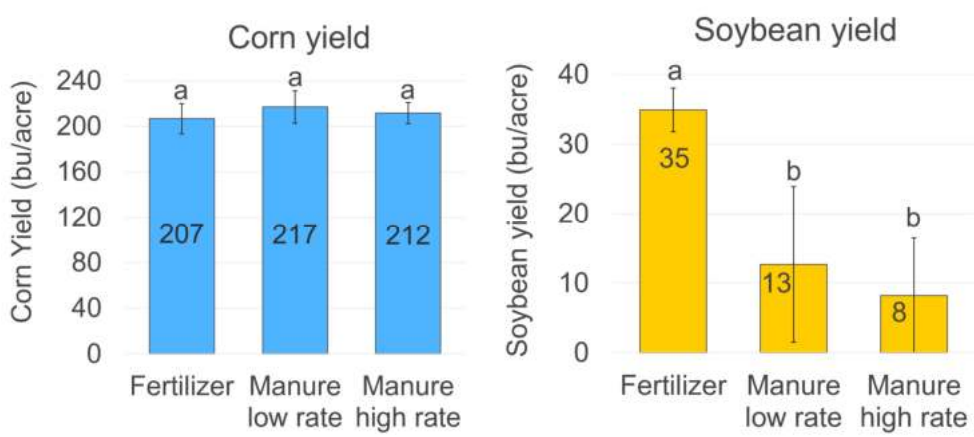

Figure 1. Corn (adjusted to 15.5% moisture) and soybean (adjusted to 13% moisture) yield at Murdock site in 2020. Manure was fall applied at 14,400 gallons per acre (high rate) or 9,500 gallons per acre (low rate) and fertilizer was spring applied. Different letters above a bar within a graph indicate a significant difference (*P*<0.05).

The second trial near Nashua, MN began in fall 2020 with the application of manure to a field that previously had corn in it. The plots were set up similarly to the Murdock site. Initial manure and soil samples (0-6”) were collected and will be analyzed this winter.

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.

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, the disease has been controlled using fungicides. However, with developing tolerance of *C. beticola* to several classes of fungicides, it is increasingly likely 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 to determine the impact of different levels of CLS disease severity on sugarbeet root storage properties after short-term and long-term storage. In a three-year study, roots with varying levels of CLS disease severity were obtained from field plots that were inoculated with *C. beticola* and received different fungicide treatments, and the storage properties of these roots were evaluated during storage. In studies initiated in 2018 and 2019, roots from plots with very low, low, moderate, and severe CLS disease ratings were used for evaluating storage properties after 30, 90 and 120 days in storage. In 2020, roots from plots with low, moderate, moderately-severe and severe CLS disease ratings were used in this study due to higher CLS disease incidence in the field. A summary of the 2018 storage study can be found in last year's Sugarbeet Research and Extension Report (Fugate et al., 2020). A summary of the 2019 storage study and initial results from the ongoing 2020 storage study are presented here.

MATERIALS AND METHODS

Sugarbeet plants were produced in 2019 and 2020 in fields near Foxhome, MN using a randomized complete block design with four replicates. 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 2019, plots were planted with Seedex Cruze hybrid seed on 14 May. In 2020, plots were planted with Hilleshög HM4448RR on 4 May. Plants were produced using recommended agronomic practices (Khan, 2019). On 12 July and 6 July in 2019 and 2020, respectively, field plots were inoculated with 5 lb ac^{-1} dried *C.*

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

/Disease Severity	2019 Production Year		2020 Production Year	
	Fungicide Treatment	Application Date	Fungicide Treatment	Application Date
Group 1 (lowest severity)	Super Tin + Proline + NIS	07/22	Super Tin + Proline + NIS	07/20
	Super Tin + Proline + NIS	08/01	Super Tin + Proline + NIS	07/31
	Super Tin + Proline + NIS	08/14	Super Tin + Proline + NIS	08/12
	Super Tin + Proline + NIS	08/28	Super Tin + Proline + NIS	08/24
Group 2	Super Tin + Manzate Max + Topsin	07/22	Proline + NIS + Badge SC	07/20
	Super Tin + Manzate Max + Topsin	08/01	Proline + NIS + Badge SC	07/31

	Super Tin + Manzate Max + Topsin	08/14	Proline + NIS + Badge SC	08/12
	Super Tin + Manzate Max + Topsin	08/28	Proline + NIS + Badge SC	08/24
Group 3	Gem	07/22	Inspire XT + Badge SC	07/20
	Gem	08/01	Inspire XT + Badge SC	07/31
	Gem	08/14	Inspire XT + Badge SC	08/12
	Gem	08/28	Inspire XT + Badge SC	08/24
Group 4 (highest severity)	untreated		Topsin	07/20
			Topsin	07/31
			Topsin	08/12
			Topsin	08/24

beticola-infected leaves. Plots were treated with the fungicide treatments described in **Table 1** to achieve different levels of disease symptom severities, with all fungicides applied at their full rate to the middle four rows of each plot. CLS disease severity was rated using a 1 – 10 scale with 1 indicative of an absence of disease symptoms and 10 describing plants that experienced complete defoliation and leaf regrowth.

The middle two rows of each plot were harvested on 10 September and 11 September in 2019 and 2020, respectively. 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 determining sucrose content, loss to molasses, invert sugar concentration, impurity concentrations, and recoverable sugar per ton prior to storage. The remaining 10-root samples were stored at 5°C (41°F) and 95% humidity. Respiration rates of samples were determined after 30, 90, and 120 days in storage using a Licor infrared CO_2 analyzer (Campbell et al., 2011). Samples were then ground into brei for determining sucrose content, loss to molasses, invert sugar concentration, impurity concentrations, and recoverable sugar per ton.

PROGRESS REPORT

2019-2020 Storage Study

At harvest, root yield and recoverable sugar per acre were significantly reduced in plots with moderate or severe CLS disease symptoms (**Table 2**). Sucrose concentration was also reduced in these plots although the reduction was only statistically significant for roots harvested from plants with severe disease symptoms (**Table 3**). Impurities that cause sucrose loss during processing were also greater in roots from plots with moderate to severe CLS symptoms as evidenced by higher values for sucrose loss to molasses and lower values for recoverable sugar per ton for these roots (**Table 3**).

Table 2: Root yield and recoverable sugar per acre for plants with varying levels of disease symptoms due to Cercospora leaf spot in 2019. 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})
Group 1 (lowest)	3.0 c	31.7 a	8709 a
Group 2 (low)	3.5 c	30.3 a	8171 a
Group 3 (moderate)	5.8 b	25.9 b	6753 b
Group 4 (severe)	8.8 a	21.5 c	5467 b

After storage for 30, 90 or 120 days, sucrose concentration and recoverable sugar per ton (RST) were lower in roots from plants with moderate and severe CLS relative to roots from plants with the lowest CLS ratings (**Table 3**). Some, but not all of these reductions were statistically significant. The reductions in sucrose concentration and RST in stored roots, however, were reflections of the lower values for these traits at harvest and were not the product of accelerated sucrose loss in roots with either disease ratings. Similarly, disease severity had no significant effect on root respiration rate after 30, 90, or 120 days in storage (**Table 4**) or invert sugar concentration at harvest or after 30, 90 or 120 days in storage (**Table 3**).

2020-2021 Storage Study

The severity of Cercospora leaf spot was greater in 2020 than in 2018 or 2019. Because of this, no roots with low levels of CLS were available and all roots had moderate to severe disease symptoms. Within the four CLS severity classes used for the 2020 storage study, disease ratings ranged from 5.5 to 10 (**Table 5**). For these roots, no significant differences in root yield, sucrose content, sucrose loss to molasses or recoverable sugar per acre at harvest were found (**Table 5**). At the writing of this report, only respiration rate determinations for roots stored for 30 and 90 days are available, as roots have yet to be stored for 120 days. Data for sucrose concentration, invert sugar concentration, and impurity concentrations will be determined after 120 d when all tissue samples have been collected. For roots stored for 30 and 90 days, however, CLS disease severity had no significant effect on root respiration rate (**Table 6**).

ation, sucrose loss to molasses, recoverable sugar per ton, and invert sugar concentration at harvest and during storage for roots obtained evels of disease symptoms due to Cercospora leaf spot in 2019. Roots were stored at 5°C and 95% relative humidity. Means within a ent letters are significantly different based upon Fisher's LSD, with α = 0.05 (n = 4). DIS = days in storage.

concentration			Sucrose loss to molasses				Recoverable sugar per ton				Invert sugar concentration			
S	90 DIS	120 DIS	0 DIS	30 DIS	90 DIS	120 DIS	0 DIS	30 DIS	90 DIS	120 DIS	0 DIS	30 DIS	90 DIS	120 DIS
- - - (%) - - - - - - - - - - - - -			- - - - - - - - - - (%) - - - - - - - - - -				- - - - - - - (lbs ton^{-1}) - - - - - - -				- - - (g per 100 g sucrose) - - -			
.4 a	14.2 a	14.5 a	0.90 b	0.80 b	0.77 b	1.18 a	271 a	271 a	269 a	267 a	0.77 a	0.88 a	1.03 a	2.14 a
.0 ab	13.9 a	14.1 a	0.87 b	0.92 ab	0.88 ab	1.20 a	254 ab	262 ab	261 ab	258 a	0.87 a	1.04 a	1.09 a	1.18 a
.6 b	13.7 a	13.8 ab	1.17 a	0.86 ab	1.01 ab	1.33 a	247 b	255 b	253 b	250 ab	0.80 a	0.84 a	0.90 a	1.30 a
.1 c	12.7 a	13.2 b	1.16 a	1.04 a	1.03 a	1.37 a	232 b	241 c	233 c	237 b	0.84 a	0.88 a	1.22 a	1.22 a

during storage for roots obtained from plants ase symptoms due to Cercospora leaf spot in red at 5°C and 95% relative humidity. Means by different letters are significantly different with α = 0.05 (n = 4). DIS = days in storage.

Respiration rate		
30 DIS	90 DIS	120 DIS
- - - - - - - - - - (mg kg^{-1} h^{-1}) - - - - - - - - - - -		
2.18 a	3.66 a	4.16 a
2.55 a	3.55 a	3.70 a
2.72 a	3.39 a	3.64 a
2.94 a	3.48 a	4.22 a

Table 5: Root yield and recoverable sugar per acre for plants with varying levels of disease symptoms due to Cercospora leaf spot in 2020. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with $\alpha = 0.05$ ($n = 4$).

CLS severity class	Disease rating	Sucrose content (%)	Loss to molasses (%)	Yield (tons acre^{-1})	Recoverable sugar (lbs acre^{-1})	Recoverable sugar (lbs ton^{-1})
Group 1 (lowest/moderate)	5.5 c	15.3 a	0.91 a	14.9 a	4281 a	287 a
Group 2 (moderate)	6.5 bc	14.7 a	0.91 a	10.5 a	2864 a	276 a
Group 3 (moderately severe)	8.0 b	15.0 a	0.94 a	12.7 a	3530 a	282 a
Group 4 (severe)	10.0 a	14.1 a	0.90 a	14.3 a	3800 a	264 a

Table 6: Respiration rate after 30 and 90 days in storage for roots obtained from plants with varying levels of disease symptoms due to Cercospora leaf spot in 2020. Roots were stored at 5°C and 95% relative humidity. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with $\alpha = 0.05$ (n = 4). DIS = days in storage.

CLS severity class	Respiration rate (mg kg^{-1} h^{-1})	
	30 DIS	90 DIS
Group 1 (lowest/moderate)	2.85 a	2.38 a
Group 2 (moderate)	2.94 a	3.14 a
Group 3 (moderately severe)	2.79 a	2.41 a
Group 4 (severe)	3.08 a	2.87 a

CONCLUSIONS

Data from the 2019-2020 storage study and the ongoing 2020-2021 storage study suggest that Cercospora leaf spot, at any severity level, has no effect on sugarbeet root storage properties. This is consistent with results from the 2018-2019 storage study (Fugate et al., 2020). These conclusions, however, should be considered preliminary until all data from the 2020-2021 storage study are collected and analyzed, and a multiyear analysis of data is completed.

ACKNOWLEDGEMENTS

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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.

Fugate, K.K., Eide, J.D., Lafta, A.M., Khan, M.F.R. (2020). Impact of Cercospora leaf spot disease severity on sugarbeet root storage. Sugarbeet Res. Ext. Rep., Coop. Ext. Serv., North Dakota State Univ., 50:76-81.

Khan, M., Ed. (2019). 2019 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 2019

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Attendees of the 2020 Winter Sugarbeet Grower Seminars were asked about their 2019 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 2019 (Tables 1, 2, 3, and 4).

Table 1. 2020 Fargo Grower Seminar – county in which sugarbeet was grown in 2019

County	Number of Responses	Percent of Responses
Becker	1	3
Cass	4	11
Clay	15	41
Norman/Mahnomen	10	28
Richland	1	3
Traill	1	11
Wilkin/Otter Tail	1	3
Totals	36	100

Table 2. 2020 Grafton Grower Seminar – county in which sugarbeet was grown in 2019

County	Number of Responses	Percent of Responses
Kittson	10	20
Marshall	2	4
Pembina	14	27
Polk	4	8
Walsh	21	41
Other	0	0
Totals	51	100

Table 3. 2020 Grand Forks Grower Seminar – county in which sugarbeet was grown in 2019

County	Number of Responses	Percent of Responses
Grand Forks	10	15
Mahnomen	0	0
Marshall	11	16
Pennington/Red Lake	0	0
Polk	36	54
Traill	4	6
Walsh	4	6
Other	2	3
Totals	67	100

Table 4. 2020 Wahpeton Grower Seminar – county in which sugarbeet was grown in 2019

County	Number of Responses	Percent of Responses
Clay	0	0
Grant	2	18
Richland	1	9
Traverse	0	0
Wilkin	8	73
Totals	11	100

This report is based on an estimated 110,950 acres of sugarbeet grown in 2019 by 155 survey respondents that attended the 2020 Fargo, Grafton, Grand Forks, and Wahpeton Winter Sugarbeet Grower seminars (Table 5). The majority (37%) of respondents reported growing sugarbeet on between 400 and 799 acres during the 2019 production season. An additional 12% grew sugarbeet on between 1,000 and 1,499 acres, whereas 10% produced sugarbeet on less than 99 acres. Similar to previous years, 12% of respondents reported growing sugarbeet on over 1,500 acres in 2019.

Table 5. Ranges of sugarbeet acreage operated by respondents in 2019

		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	32	16	9	9	6	25	9	6	3	3	13
Grafton	49	10	6	8	12	16	18	6	14	0	8
Grand Forks	66	9	6	6	5	26	15	6	17	9	1
Wahpeton	8	0	12	12	25	12	12	0	0	25	0
Totals	155	10	7	8	8	22	15	6	12	6	6

From a combined total of 171 respondents at the Fargo, Grafton, Grand Forks, and Wahpeton seminars, 41% reported that the sugarbeet root maggot was their worst insect pest problem during the 2019 growing season (Table 6). That was a significant increase from 2017 and 2018, for which only 27 and 36% of growers, respectively, viewed the root maggot as their worst insect pest problem. The majority of respondents at both Grafton (62% of respondents) and Grand Forks (45% of respondents) identified the sugarbeet root maggot as their worst insect pest problem in 2019. Other significant insect pest problems reported included Lygus bugs (30% of respondents at Wahpeton), grasshoppers (16, and 17% of respondents at Fargo and Grafton, respectively), and springtails (8, 15, and 10% of respective respondents at Fargo, Grand Forks, and Wahpeton).

Table 6. Worst insect pest problem in sugarbeet in 2019

Location	Number of Responses	Springtails	Cutworms	Lygus bugs	Wireworms	Root maggot	White grubs	Grass-hoppers	None
		---% of responses---							
Fargo	38	8	11	3	5	16	0	16	42
Grafton	52	2	0	2	0	62	0	17	17
Grand Forks	71	15	3	0	3	45	0	4	30
Wahpeton	10	10	10	30	0	0	0	10	40
Totals	171	9	4	3	2	41	0	11	29

The majority (67%) of grower respondents, averaged across all four seminar locations, indicated that they planted seed treated with Poncho Beta insecticidal seed treatment in 2019, whereas Cruiser- and NipsIt Inside-treated seed were used by 7 and 4% of respondents, respectively (Table 7). Growers at the Fargo, Grafton, and Grand Forks seminars accounted for most of the seed treatment use for the production area in 2019. The highest use of Poncho Beta in 2019 was reported by seminar attendees at Fargo (71%), Grafton (71%), and Grand Forks (72%); whereas, Wahpeton seminar attendees reported the highest use of Cruiser-treated seed (20% of producers) and the highest use of seed treated with NipsIt Inside (10%). Averaged across seminar locations, 22% of respondents reported not using an insecticidal seed treatment. Wahpeton seminar attendees significantly influenced this figure, with 90% at that location reporting no seed treatment insecticide use in 2019.

Table 7. *Seed treatment* insecticide use for sugarbeet insect pest management in 2019

Location	Number of Responses	Poncho Beta	Cruiser	NipsIt Inside	None
		---% of responses---			
Fargo	35	71	6	3	20
Grafton	49	71	6	2	20
Grand Forks	67	72	6	6	16
Wahpeton	7	0	20	10	70
Totals	161	67	7	4	22

Planting-time granular insecticides were used in 2019 by an average of 31% of grower attendees of the Fargo, Grafton, Grand Forks, and Wahpeton seminars (Table 8). An overall average of 29% of growers at these meetings reported using Counter 20G at planting time, whereas only 1% 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 50 and 28%; whereas only 20 and 10% of growers at the Grafton and Wahpeton locations, respectively, reported using Counter 20G at planting to protect their sugarbeet crop. Overall, 69% of respondents across all four grower seminars reported that they did not use a granular insecticide at planting in 2019.

Table 8. *Planting-time granular* insecticides used for insect pest management in sugarbeet during 2019

Location	Number of Responses	Counter 20G	Lorsban 15G	Thimet 20G	Other	None
		---% of responses---				
Fargo	38	50	0	0	0	50
Grafton	51	20	2		2	76
Grand Forks	65	28	0	0	1	71
Wahpeton	9	10	0	0	0	90
Totals	164	29	1	0	1	69

Averaged across all seminar locations, Counter 20G was most commonly (15% of all grower seminar attendees) applied at its moderate rate of 7.5 lb product/ac (Table 9). An additional 7% used Counter 20G at its highest labeled application rate (9 lb/ac), and another 8% applied it at the low labeled rate of 5.25 lb/ac.

The majority (53%) of Fargo respondents reported no use of Counter 20G, but 22% reported using it at its moderate (7.5-lb) rate, and 19% used the low rate (5.25 lb product/ac). The majority of growers surveyed at Grafton and Wahpeton (76 and 90%, respectively) reported no granular insecticide use at planting. Similarly, 64% of Grand Forks attendees reported opting to not use a planting-time granular insecticide. However, a total of 33% of Grand Forks attendees used Counter 20G, and most (23%) reported using it at the 7.5-lb application rate.

Table 9. Application rates of *planting-time granular* insecticides used for sugarbeet insect pest management in 2019

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	36	6	22	19	0	0	0	0	53
Grafton	50	14	4	0	4	0	0	2	76
Grand Forks	61	3	23	7	0	0	0	3	64
Wahpeton	10	0	0	10	0	0	0	0	90
Totals	157	7	15	8	1	0	0	2	67

As presented in Table 9 above, just 10% of Wahpeton seminar attendees reported using Counter 20G for planting-time-applied protection from insect pests; however, all reported use of Counter by Wahpeton attendees was at the 5.25-lb rate. A small number (4%) of growers at the Grafton seminar reported using Lorsban 15G (or a generic granular chlorpyrifos product) for planting-time insecticide protection, and all applied it at the highest labeled rate of 13.4 lb of product per acre.

Averaged across all seminar locations, 55% of grower respondents reported using a postemergence insecticide for root maggot control in 2019 (Table 10). That was a 17% increase over what was reported for 2018. The majority (33%) of postemergence insecticide use for root maggot control in 2019 involved applications of Lorsban 4E, Lorsban Advanced, or a similar chlorpyrifos-containing sprayable liquid insecticide. Mustang Maxx, Lorsban 15G, and Thimet were also used for this purpose, but only 6, 6, and 5% of respondents, respectively.

At the Fargo grower seminar, 18% of respondents reported using Mustang Maxx and 10% used a sprayable liquid formulation of chlorpyrifos, whereas just 5% of respondents applied Counter 20G for postemergence root maggot management in 2019. In contrast, 50 and 35% of the Grafton and Grand Forks seminar attendees, respectively, reported using postemergence applications of sprayable liquid chlorpyrifos products for root maggot control. Lorsban 15G was reported as being used for this purpose by 8, 7, and 11% of the seminar attendees as Grafton, Grand Forks, and Wahpeton attendees. Grafton seminar attendees indicated the highest incidence of using Thimet 20G for postemergence root maggot control (13% of respondents), whereas just 3% of Fargo seminar attendees used Thimet.

An average of 45% of survey respondents across all locations indicated that they did not apply a postemergence insecticide to manage the sugarbeet root maggot in 2019. The majority of those respondents were attendees of the Fargo and Wahpeton locations, where a respective 60 and 89% of respondents reported no use of a postemergence insecticide for root maggot control.

Table 10. *Postemergence* insecticide use for *sugarbeet root maggot* management in 2019

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	40	10	18	2		5	2	3	60
Grafton	62	50	0	0	2	2	8	13	26
Grand Forks	74	35	7	0	0	3	7	0	49
Wahpeton	9	0	0	0	0	0	11	0	89
Totals	185	33	6	1	1	3	6	5	45

Overall satisfaction with insecticide applications made for root maggot management was rated as good to excellent by 81% of respondents when averaged across the Fargo, Grafton, Grand Forks, and Wahpeton seminar locations (Table 11). That was a 5% reduction in growers' rating of insecticide performance for root maggot control during 2018. At the Fargo location, 91% of respondents rated their satisfaction with root maggot control tools as being good to excellent. Similarly, 80% of respondents at the Grafton seminar rated their satisfaction with root maggot management practices as being good to excellent. The majority (81%) of Grand Forks seminar attendees also rated their insecticide performance as good to excellent.

Table 11. *Satisfaction* with insecticide treatments for sugarbeet root maggot management in 2019

Location	Number of Responses	Excellent	Good	Fair	Poor	Unsure
		---% of responses---				
Fargo	22	50	41	4	0	4
Grafton	40	22	48	25	0	5
Grand Forks	46	35	52	11	0	2
Wahpeton	0	-	-	-	-	-
Totals	108	33	48	15	0	4

Averaged across all locations, 52% of all growers used some form of insecticide to protect their sugarbeet crop from springtails in 2019 (Table 12). Poncho Beta was relied on by 31% of respondents for springtail control, which was a 24% increase in comparison to use of that product in 2018. . Counter 20G was used by 15% of all survey respondents, whereas both Mustang Maxx and Lorsban 15G were used by 2% each of the attendees across all four seminar locations. About 48% of all growers surveyed at the four seminar locations reported not using any insecticide for springtail control.

At the Fargo seminar, Counter 20G and Poncho Beta were used by 20% and 28% of respondents, respectively, with only 3% reporting Mustang Maxx as their choice for springtail control in 2019. Insecticide use for springtail management by Grafton seminar attendees was split between Poncho Beta, Lorsban 15G, and Counter 20G (17, 6, and 4%, respectively). Small proportions (i.e., 2% each) of growers at the Grafton seminar reported using Mustang Maxx and Cruiser seed treatment for their springtail control, whereas 69% of respondents at Grafton indicated no insecticide use for this purpose in 2019. The majority (48%) of respondents at Grand Forks reported using Poncho Beta for springtail control, and an additional 22% used Counter 20G for this purpose. Only 2% of Grand Forks attendees reported using Mustang Maxx for springtail management, and 29% of them reported not using an insecticide to control springtails in 2019. The majority (70%) of attendees at the Wahpeton seminar indicated that they did not use an insecticide to control springtails; however, NipsIt Inside seed treatment, Counter 20G, and Lorsban 15G each used by 10% of respondents for this purpose. **NOTE:** Lorsban 15G is not recommended for springtail management in sugarbeet because NDSU performance trial data indicates that it does not provide adequate control of these early-season pests.

Table 12. Insecticide use for *springtail* management in 2019

Location	Number of Responses	Cruiser	NipsIt Inside	Poncho Beta	Mustang Maxx	Counter 20G	Lorsban 15G	Other	None
		---% of responses---							
Fargo	35	0	3	28	3	20	0	0	46
Grafton	52	2	0	17	2	4	6	0	69
Grand Forks	65	0	0	48	2	22	0	0	29
Wahpeton	10	0	10	0	0	10	10	0	70
Totals	162	1	1	31	2	15	2	0	48

As presented in Table 13, 70% of grower respondents across all four seminar locations rated their insecticide performance for springtail management as good to excellent, and only 5% rated insecticide performance as poor. Satisfaction among growers with regard to insecticide performance for springtail control was fairly similar across locations, with ratings of good to excellent by 72% of respondents at both Fargo and Grand Forks. Assessments of insecticide performance for springtail control were slightly lower from growers at Grafton and Wahpeton (66 and 50% good to excellent, respectively); however, respondent ratings of poor performance averaged only 5% across seminar locations.

Table 13. *Satisfaction* with insecticide treatments for springtail management in 2019

Location	Number of Responses	Excellent	Good	Fair	Poor	Unsure
		--% of responses--				
Fargo	18	44	28	11	6	11
Grafton	18	33	33	0	6	28
Grand Forks	49	29	43	12	4	12
Wahpeton	2	0	50	50	0	0
Totals	87	32	38	10	5	15

Only 13% of respondents surveyed across all seminar locations reported using an insecticide for Lygus bug management in 2019 (Table 14). The majority (i.e., 6% averaged across locations) of growers applied a liquid formulation of chlorpyrifos (i.e., Lorsban 4E, Lorsban Advanced, or a generic equivalent) for this purpose. Those producers comprised 18, 4, and 20% of surveyed producers at Fargo, Grafton, and Wahpeton, respectively. Mustang Maxx was used for this purpose by 6% of grower respondents that attended the Fargo seminar, and only 2% of respondents at Grand Forks. Interestingly, although variable across locations, between 3 and 10% of respondents reported using an insecticidal option that was not included as a choice in the survey for Lygus bug management.

Table 14. Insecticide use for *Lygus bug* management in 2019

Location	Number of Responses	Asana	Lannate	Lorsban (4E, Advanced, or generic)	Movento	Mustang Maxx	Other	None
		---% of responses---						
Fargo	34	0	0	18	0	6	3	73
Grafton	44	0	0	4	0	0	6	90
Grand Forks	63	0	0	0	0	2	3	95
Wahpeton	10	0	0	20	0	0	10	70
Totals	156	0	0	6	0	2	4	87

Although a relatively small number of growers (i.e., 21 across all locations) responded to the question regarding satisfaction with insecticide performance for Lygus bug control, 52% rated it as good to excellent (Table 15). Satisfaction levels of good to excellent ranged from 50% at the Fargo seminar to 100% at Wahpeton, although it should be noted that only two respondents answered this question at the Wahpeton seminar. No respondents rated their insecticide performance as poor at any of the locations; however, 33 and 83% of respective attendees at Grafton and Grand Forks responded as being unsure of the level of their insecticide performance.

Table 15. *Satisfaction* with insecticide treatments for Lygus bug management in 2019

Location	Number of Responses	Excellent	Good	Fair	Poor	Unsure
		--% of responses--				
Fargo	10	50	20	10	0	20
Grafton	3	33	0	33	0	33
Grand Forks	6	17	0	0	0	83
Wahpeton	2	0	100	0	0	0
Totals	21	33	19	10	0	38

The majority (60%) of respondents, averaged across all grower seminar locations, reported that they applied postemergence liquid insecticides in a total spray output volume of between six and 10 gallons per acre (GPA), and 29% reported using output volumes ranging between 11 and 15GPA. At individual locations, the percentage of producers using the 6- to 10 GPA rate ranged from 56 to 63% at Fargo, Grafton, and Grand Forks up to 100% of the Wahpeton respondents. Responses to this question at Wahpeton should be considered with discretion, as only three individuals at that seminar location provided input on this question.

Table 16. Spray volume output used for ground-applied postemergence insecticide applications in 2019

Location	Number of Responses	1–5 GPA	6–10 GPA	11–15 GPA	16–20 GPA	> 20 GPA
		-----------------------------------% of responses------------------------------------				
Fargo	16	13	56	31	0	0
Grafton	34	9	56	35	0	0
Grand Forks	32	9	63	25	3	0
Wahpeton	3	0	100	0	0	0
Totals	85	9	60	29	1	0

At the Fargo seminar, 31% of respondents reported applying postemergence insecticide sprays in a volume of 11 to 15 GPA, and survey results at Grafton and Grand Forks indicated that 35 and 25% of growers used this higher output volume. These responses were significant increases in use of the 11-15 GPA spray volume when compared to those reported for the previous (2018) crop year. Smaller numbers (9 to 13%) of attendees at the Fargo, Grafton, 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 (3%) of respondents at Grand Forks also reported applying postemergence insecticides at an even higher output volume range of 16 to 20 GPA, however, that amounted to just 1% of respondents when averaged across all four seminar locations.

Overall, 76% of all respondents at the 2019 Winter Sugarbeet Grower Seminars (all locations combined) reported that their insecticide use in 2019 was not different from what it had been during the previous five years (Table 17). At the Fargo Growers Seminar, 14% of respondents indicated that their insecticide use in sugarbeet had decreased, and 75% of respondents at that location reported no change in insecticide use in comparison to the past five years. However, 18, 11, and 11% of grower respondents at Grafton, Grand Forks, and Wahpeton, respectively, 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 2019 in areas that typically experience lower root maggot infestations. At the Wahpeton seminar location, 33% of attendees reported that they did not use an insecticide on their sugarbeet crop in 2019. That was a 15% reduction from 2018, suggesting an overall increase in insecticide use by growers within the MinnDak Farmers Cooperative growing area in 2019.

Table 17. Insecticide use in sugarbeet during 2019 compared to the previous 5 years

Location	Number of Responses	Increased	Decreased	No Change	No Insecticide Use
		------------------------------------% of responses----------------------------------			
Fargo	36	3	14	75	8
Grafton	51	18	2	74	6
Grand Forks	65	11	3	81	5
Wahpeton	9	11	11	44	33
Totals	161	11	6	76	7

Averaged across all four grower seminar locations, 62% of respondents indicated that they used some form of online or cellular-enabled information source for information regarding sugarbeet insect management during the 2019 growing season (Table 18). The most commonly used online/electronic decision-making tools used by attendees for pest management in 2019, as averaged across locations, included NDSU's online posting of sugarbeet root maggot fly counts (18%), the NDSU Crop & Pest report (14%), cellular text alerts (12%), and the NDSU root maggot model application on the North Dakota Agricultural Weather Network (NDAWN) (12%).

Table 18. Use of online decision-making tools for sugarbeet insect management in 2019

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	47	15	0	30	6	9	2	34	4
Grafton	70	11	1	9	14	21	1	41	0
Grand Forks	100	12	5	8	28	9	7	30	1
Wahpeton	11	0	0	27	0	0	0	45	27
Totals	228	12	3	14	18	12	4	35	3

At the Fargo seminar, about 62% of respondents indicated using some form of online information, with most use involving the NDSU Crop & Pest Report (30%) and the cellular text-alert system (15%). The majority (21%) of respondents at Grafton reported using the NDAWN root maggot model, and 14% of Grafton attendees also reported using NDSU's online posting of root maggot fly counts for guidance with management decisions. Attendees of the Grand Forks seminar location reported substantially greater use of NDSU's web-posted root maggot fly counts (28%) than the respondents at any other seminar location. Twelve percent of Grand Forks attendees also reported using the cellular text-alert system for guidance on their pest management decision-making in 2019. The highest proportion (27%) of Wahpeton seminar respondents reported getting most of their insect pest management information from the NDSU Crop & Pest Report in 2019.

SUGARBEET ROOT MAGGOT FLY MONITORING IN THE RED RIVER VALLEY IN 2020

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Sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), fly activity was monitored at 150 grower field sites throughout the Red River Valley during the 2019 growing season. This effort was carried out as a collaborative effort between the NDSU Department of Entomology and American Crystal Sugar Company..

For the third consecutive year, root maggot fly activity was at exceptionally high levels throughout much of the Valley. Fly activity levels in 2020 were the second-highest recorded in the past 14 years for the growing area (Figure 1). This suggests that control efforts between 2017 and 2020 were unsuccessful in reducing overall population levels for many producers.

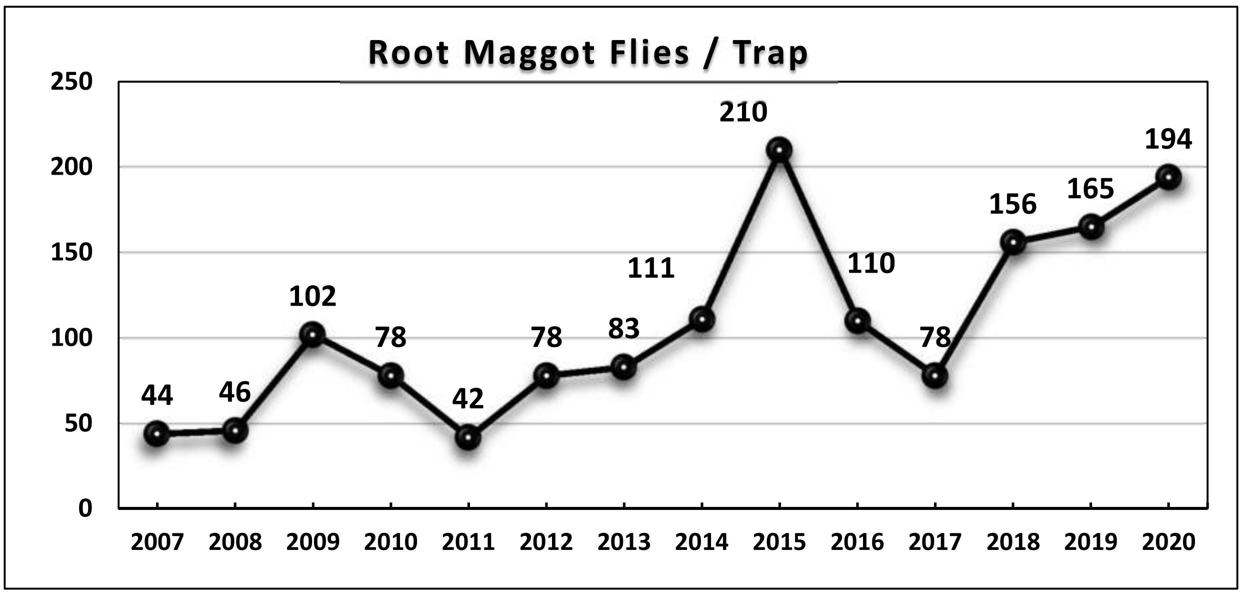
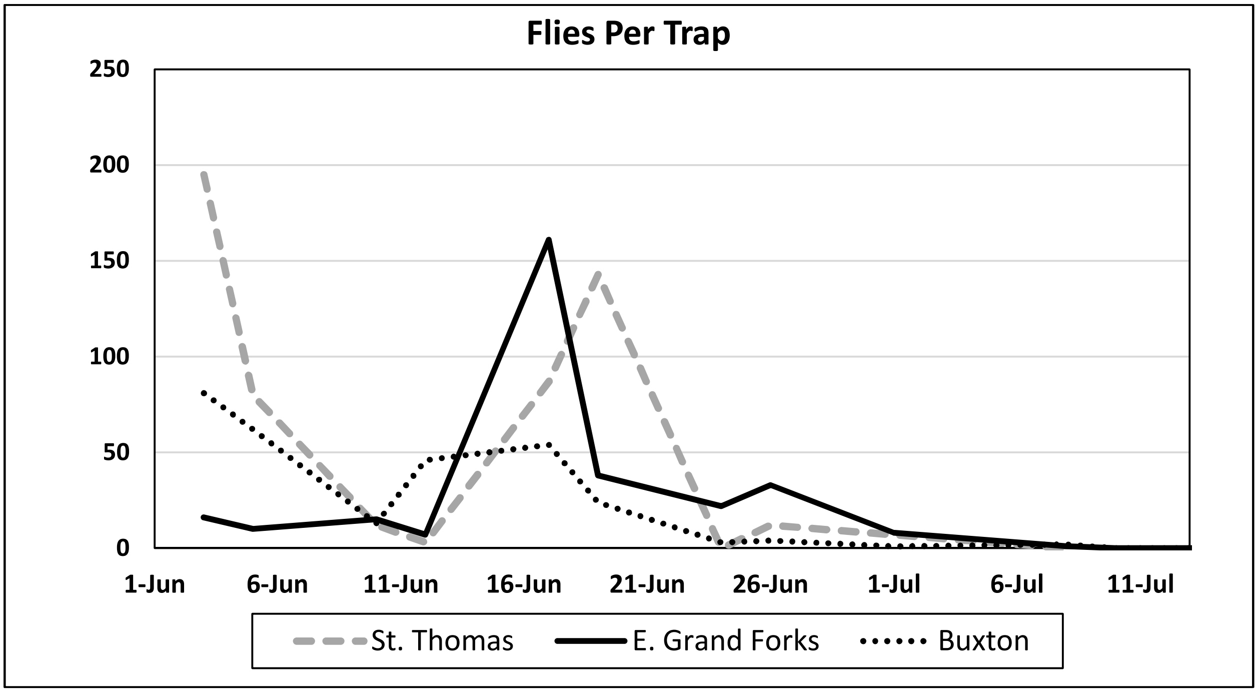


Figure 1. Yearly averages of sugarbeet root maggot flies captured on sticky-stake traps (Blickenstaff and Peckenpaugh, 1976) in the Red River Valley from 2007 to 2020.

The highest levels of SBRM fly activity observed in 2020 occurred near Auburn, Bathgate, Buxton, Cavalier, Crystal, Drayton, Glasston, Grafton, Hamilton, Hoople, Leroy, Reynolds, St. Thomas, and Thompson, ND, as well as near Argyle, Crookston, Donaldson, East Grand Forks, Fisher, Kennedy, Stephen, and Warren, MN. Moderately high levels of activity were recorded near Emerado, Forest River, Grand Forks, Merrifield, Minto, Neche, and Voss, ND, and near Ada, Angus, Sabin, and Sherack, 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 2020 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 2020



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 Red River Valley sites, 2020.

In late-summer, after the larval feeding period had ended, 58 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 SBRM risk forecast for next year is presented in the report that immediately follows this one).

Root maggot feeding injury, averaged across all RRV fields that exceeded the generalized economic threshold (43 cumulative flies per trap), was 2.14 on the 0 to 9 rating scale. That amounted to a 128% increase over the same figure recorded in 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 70 flies/trap near Forest River, ND to 634 flies/trap near Crystal, ND.

Table 1. Sugarbeet root maggot fly activity and larval feeding injury in Red River Valley commercial sugarbeet fields where injury exceeded 2.5, 2020				
Nearest City	**Township**	**State**	**Flies/stake**	**Average Root Injury Rating[a]**
Crystal	Crystal	ND	225	4.10
Crystal	Elora	ND	364	3.78
Cavalier	S. Cavalier	ND	237	3.48
Hoople	Dundee	ND	194.5	3.45
Hamilton	Hamilton	ND	88	3.38
St. Thomas	Lodema	ND	172.5	3.30
Grafton	Martin	ND	280	3.28
St. Thomas	S. St. Thomas	ND	634	3.20
Buxton	Belmont	ND	377	2.98
Bathgate	Bathgate	ND	252	2.85
Forest River	Ops	ND	70	2.70
Glasston	N. Midland	ND	476	2.55

[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).

The comparatively high root injury ratings observed at the locations listed in Table 1 suggest that control practices in those areas were not as successful as growers may have hoped. As also indicated in Table 1, average root injury ratings in fields in eight townships near Cavalier, Crystal, Grafton, Hamilton, Hoople, and St. Thomas, ND ranged between 3.20 and 4.1 on the 0 to 9 scale. Also, average root injury ratings in four additional fields in the vicinity of Bathgate, Buxton, Forest River, and Glasston, ND exceeded 2.5. As noted in 2019, this is very concerning because it is rare for SBRM feeding injury ratings in grower-managed fields to exceed 3.0.

As such, the risk of damaging SBRM infestations in those areas for the 2021 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 2021. 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.

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The authors extend sincere appreciation to the following American Crystal agriculturists for monitoring several additional fields for sugarbeet root maggot fly activity (in alphabetical order): Clay Altepeter, Andrew Clark, Todd Cymbaluk, Mike Doeden, Tyler Driscoll, Curtis Funk, Tom Hermann, Austin Holy, Bob Joerger, Tim Kenyon, Holly Kowalski, Brock Larson, Kyle Lindberg, Curt Meyer, Chris Motteberg, Travis Pederson, Eric Ptacek, Nolan Rockstad, John Samdahl, Aaron Sawatzsky, Nick Shores, Dan Vagle, and Chad Wheeler. Thanks are also due to the following NDSU summer aides for providing assistance with fly monitoring activities: Zane Miller, Brett Skarda, Claire Stoltenow, and Kenan Stoltenow. We also thank the Sugarbeet Research and Education Board of Minnesota and North Dakota, and American Crystal Sugar Company for providing significant funding support for this project. This work was also partially supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Hatch project number ND02398.

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 2021 GROWING SEASON

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The 2021 sugarbeet root maggot (SBRM) risk map for the Red River Valley appears in the figure below. Valley-wide, SBRM fly activity was significantly greater in 2020 than in the three previous years. The 2020 infestations were the second highest in the past 14 years. Root injury surveys suggest that some areas will have higher populations in 2021.

Areas at highest risk of damaging SBRM infestations include rural Auburn, Bathgate, Buxton, Cavalier, Crystal, Drayton, Glasston, Hamilton, Hoople, Reynolds, St. Thomas, and Thompson, N.D., and Argyle, Crookston, Donaldson, East Grand Forks, and Warren, Minn. Moderate risk is expected in areas bordering high-risk zones, as well as fields near Emerado, Forest River, Grand Forks, Leroy, Merrifield, Minto, Neche, and Voss, N.D., and near Ada, Angus, Fisher, Kennedy, Sabin, Sherack, and Stephen, Minn. The rest of the area is at lower risk.

Proximity to previous-year beet fields where populations were high and/or control was unsatisfactory can increase risk. Areas where high fly activity occurred in 2020 should be monitored closely in 2021. Growers in high-risk areas should use an aggressive form of at-plant insecticide treatment (granular insecticide) and expect the need for a postemergence rescue insecticide.

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. 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 https://tinyurl.com/SBRM-FlyCounts.

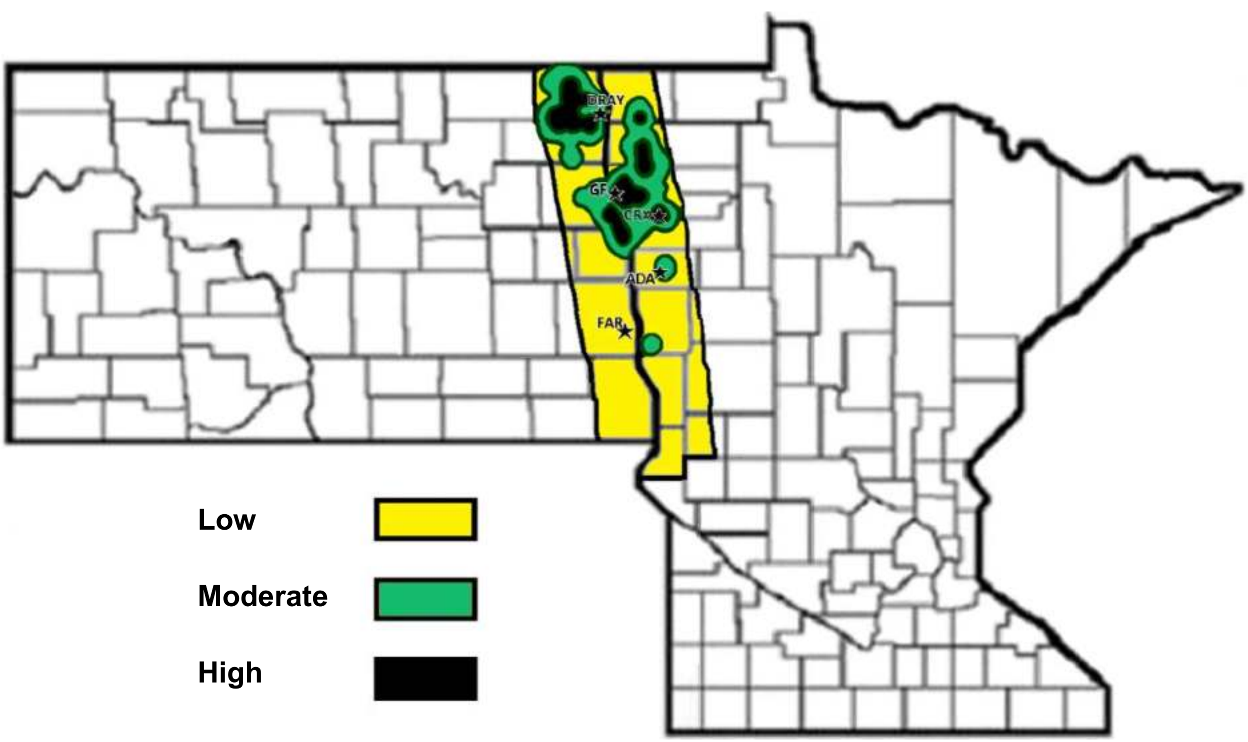

Fig. 1. Anticipated risk of SBRM fly activity and damaging larval infestations in the Red River Valley.

Acknowledgments:

We appreciate the efforts of the following sugar cooperative agriculturists in monitoring several grower fields for sugarbeet root maggot fly activity, which we believe has added precision to this forecast (presented in alphabetical order): Clay Altepeter, Andrew Clark, Todd Cymbaluk, Mike Doeden, Tyler Driscoll, Curtis Funk, Tom Hermann, Austin Holy, Bob Joerger, Tim Kenyon, Holly Kowalski, Brock Larson, Kyle Lindberg, Curt Meyer, Chris Motteberg, Travis Pederson, Eric Ptacek, Nolan Rockstad, John Samdahl, Aaron Sawatzsky, Nick Shores, Dan Vagle, and Chad Wheeler. Thanks are also due to the following NDSU summer aides for providing assistance with fly monitoring activities: Zane Miller, Brett Skarda, Claire Stoltenow, and Kenan Stoltenow. We also thank the Sugarbeet Research and Education Board of Minnesota and North Dakota, and American Crystal Sugar Company for providing significant funding support for this project. This work was also partially supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Hatch project number ND02398.

MOVENTO HL® AS A POSTEMERGENCE RESCUE INSECTICIDE FOR SUGARBEET ROOT MAGGOT CONTROL

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) is a major insect pest of sugarbeet in the Red River Valley (RRV) growing area. Most RRV sugarbeet producers in high-risk areas for economic loss from this pest use a two-pronged approach to control it. This typically involves beginning the season with a prophylactic insecticide application, which involves either a planting-time granular insecticide or an insecticidal seed treatment. That initial measure of protection is usually followed by the application of a postemergence insecticide, in either a granular or sprayable liquid form. Organophosphate insecticides, which kill insects through acetylcholinesterase (ACHE) inhibition, have been the predominate choice of Red River Valley sugarbeet growers for both planting-time and postemergence insecticides in SBRM control programs for well over four decades. This means that a single mode of action has been widely used for SBRM control for an exceptionally long time. This long-term, repeated use of ACHE inhibitor insecticides suggests that it is only a matter of time before SBRM populations develop insecticide resistance to this insecticide class.

In July of 2017, the U.S. Environmental Protection Agency approved the registration of Movento HL insecticide for use in sugarbeet. The addition of this product is encouraging from an insect resistance management perspective because spirotetramat, the active ingredient in Movento, belongs to the lipid biosynthesis inhibitors (LBIs), a completely different insecticide mode of action from the ACHE inhibitors. This project was carried out to evaluate the efficacy of Movento HL as a postemergence insecticide for sugarbeet root maggot control. A secondary objective was to assess the performance of dual-insecticide programs for SBRM management that include Poncho Beta as the planting-time insecticide component and Movento HL as the postemergence rescue component.

Materials and Methods:

This experiment was conducted during the 2020 growing season on a commercial sugarbeet field site near St. Thomas in rural Pembina County, ND. Plots were planted on 18 May using Betaseed 8524 glyphosate-resistant seed. 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 was used to plant the trial. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. The outer "guard" row on each side of the plot served as an untreated buffer. 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.

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.

Postemergence insecticide applications. Additive postemergence insecticides applied in this trial included Movento HL, Mustang Maxx, and Yuma 4E (a generic chlorpyrifos formulation, similar to Lorsban 4E). Treatment timings evaluated included the following: 1) Yuma 4E and Mustang Maxx were applied at two days before peak SBRM fly activity; and 2) Movento HL was applied at three days pre-peak. Liquid insecticide solutions were delivered with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ 110015VS AIXR nozzles, and the system was calibrated to deliver a finished output volume of 10 GPA. Both postemergence Movento spray treatments included methylated seed oil at the recommended rate of 0.25% v/v.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this experiment on 28 July, 2020. 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: Treatment performance was also compared on the basis of sugarbeet yield. Plots were harvested on 23 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). Treatment means were compared by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

Sugarbeet root maggot feeding injury results from this trial are presented in Table 1. The feeding injury rating mean for the untreated check (5.24 on the 0 to 9 scale of Campbell et al. [2000]) indicated the presence of a moderately high SBRM infestation for the trial. All insecticide-treated entries in the trial provided significant reductions in SBRM feeding injury when compared to the untreated check. The lowest level of SBRM feeding injury (i.e., the highest level of protection) was observed in plots treated with the single planting-time application of Counter 20G at its moderate labeled rate (7.5 lb product/ac); however, that entry was not statistically superior to any of the dual (i.e., planting-time plus postemergence) insecticide entries in the trial that included Poncho Beta insecticidal seed treatment plus a postemergence foliar spray of either Movento HL, Mustang Maxx, or Yuma 4E. The planting-time treatment of Counter 20G at its moderate rate was the only insecticide treatment that provided significantly greater root protection than the Poncho Beta-only treatment. There were no significant differences in SBRM feeding injury sustained between any of the treatments that included both Poncho Beta and a postemergence rescue insecticide application, irrespective of which post-applied product was used, or at which rate it was applied.

Table 1. ***Larval feeding injury*** **in a comparison of Movento HL with other commonly used postemergence rescue insecticides for sugarbeet root maggot control, St. Thomas, ND, 2020**

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G	B	7.5 lb	1.5	4.33 c
Poncho Beta + Mustang Maxx	Seed 2 d Pre-peak Broadcast	 4 fl oz	68 g a.i./ unit seed 0.025	4.38 bc
Poncho Beta + Movento HL + MSO	Seed 3 d Pre-peak Broadcast	 4.5 fl oz	68 g a.i./ unit seed 0.156	4.65 bc
Poncho Beta + Yuma 4E	Seed 2 d Pre-peak Broadcast	 2.0 pts	68 g a.i./ unit seed 1.0	5.15 bc
Poncho Beta + Yuma 4E	Seed 2 d Pre-peak Broadcast	 1.0 pts	68 g a.i./ unit seed 0.5	5.18 bc
Poncho Beta + Movento HL + MSO	Seed 3 d Pre-peak Broadcast	 2.5 fl oz	68 g a.i./ unit seed 0.078	5.23 bc
Poncho Beta	Seed		68 g a.i./ unit seed	5.33 b
Check	-----	----	-----	6.35 a
LSD (0.05)				0.964

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 at-plant band; Seed = insecticidal seed treatment

Yield data from this experiment are shown in Table 2. The top-performing treatment, with regard to recoverable sucrose and root yield was the combination of Poncho Beta seed treatment plus a postemergence application of Yuma 4E at its high labeled rate for a single application (2 pts product/ac). When compared to the untreated check, that entry produced 1,814 lb more recoverable sucrose and 7.6 additional tons per acre in root yield, and generated a revenue increase of $137/ac above that recorded for the check.

The only other treatment that was not significantly different from the top treatment, with regard to both recoverable sucrose yield and root tonnage, was the combination of Poncho Beta seed treatment plus Mustang Maxx. Interestingly, in plots initially protected with Poncho Beta-treated seed, applying a postemergence application of Movento HL at its highest labeled rate (4.5 fl oz/ac) produced significantly greater recoverable sucrose yield than when the Movento was applied at the lower rate of 2.5 fl oz/ac. Also, plots that received the higher rate of Movento HL generated $214/ac more revenue than similar plots treated with the lower (2.5-oz) rate of that product. Similarly, plots treated with the higher (2-pt) rate of Yuma generated $61/ac more revenue than those that received the 1-pt rate of Yuma.

Table 2. *Yield parameters* from a comparison of Movento HL with other commonly used postemergence rescue insecticides for sugarbeet root maggot control, St. Thomas, ND, 2020

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Poncho Beta + Yuma 4E	Seed 2 d Pre-peak Broadcast	2.0 pts	68 g a.i./ unit seed 1.0	10,259 a	33.8 a	16.33 a	1,297
Poncho Beta + Mustang Maxx	Seed 2 d Pre-peak Broadcast	4 fl oz	68 g a.i./ unit seed 0.025	9,758 ab	31.0 ab	16.95 a	1,300
Counter 20G	B	7.5 lb	1.5	9,577 ab	29.3 bcd	17.44 a	1,334
Poncho Beta + Movento HL + MSO	Seed 3 d Pre-peak Broadcast	4.5 fl oz	68 g a.i./ unit seed 0.156	9,514 ab	29.6 bc	17.19 a	1,334
Poncho Beta	Seed		68 g a.i./ unit seed	9,392 abc	29.6 bc	16.99 a	1,261
Poncho Beta + Yuma 4E	Seed 2 d Pre-peak Broadcast	1.0 pts	68 g a.i./ unit seed 0.5	9,225 bc	29.2 bcd	16.79 a	1,236
Poncho Beta + Movento HL + MSO	Seed 3 d Pre-peak Broadcast	2.5 fl oz	68 g a.i./ unit seed 0.078	8,511 c	27.3 cd	17.28 a	1,120
Check	-----	----	-----	8,445 c	26.2 d	15.10 a	1,160
LSD (0.10)				970.2	3.30	NS	

Means within a column sharing a letter are not significantly (P = 0.10) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch at-plant band; Seed = insecticidal seed treatment

Overall, results from this study demonstrate that major yield and revenue benefits can be achieved by using insecticide-based control programs that combine a neonicotinoid seed treatment insecticide and a postemergence sprayable insecticide such as Yuma 4E or Mustang Maxx. Results also suggest that the higher rate (4.5 fl oz/ac) of Movento HL may be needed under moderately high to severe SBRM feeding pressure situations.

It should be pointed out that, due to equipment- and weather-related complications, the Movento HL applications could not be applied at the planned pre-peak interval. Movento is a systemic insecticide. As such, if the Movento treatments could have been applied at a more appropriate time (7 to 14 days ahead of peak SBRM fly activity), they would have likely resulted in higher concentrations of insecticide active ingredient in roots when SBRM larval feeding injury was occurring and, thus, would have been more likely to provide greater levels of control.

Further research is needed to evaluate Movento HL under higher SBRM infestation levels to determine its ability to effectively control this pest. Research should also focus on optimizing the application timing and use rate for this product. The EPA-approved label allows for applying Movento HL at 4.5 fl oz/ac; however, it is uncertain at this time as to whether that rate, if more effective, would be economically viable for sugarbeet producers.

Acknowledgments:

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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.

CONCURRENT AND TANK-MIXED INSECTICIDE AND FUNGICIDE APPLICATIONS IN SUGARBEET: IMPACTS ON ROOT MAGGOT CONTROL AND YIELD

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Introduction:

Red River Valley (RRV) sugarbeet producers, especially those in central and northern portions of the growing area, can realize significant economic benefits from insecticide, fungicide, and starter fertilizer applications. Insecticide protection is needed by many RRV producers to protect against losses associated with the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), a perennial pest of sugarbeet in the RRV. Producers typically manage this pest through prophylactic insecticide application during sugarbeet planting. At-plant insecticide options include granular or sprayable liquid formulations, or the use of insecticide-treated seed. In situations where high SBRM fly activity and associated larval feeding pressure are expected, most producers complement their at-plant protection with a postemergence insecticide, which can involve either granular or sprayable liquid formulations.

Fungicides are often needed to manage soil-borne root diseases such as Rhizoctonia damping off, as well as Rhizoctonia crown and root rot, which are all caused by the pathogen *Rhizoctonia solani* Kühn. Similar to the insecticides used for SBRM management, fungicides targeting Rhizoctonia management in sugarbeet also can be delivered as planting-time and postemergence applications. Starter fertilizer applications are also commonly used by RRV sugarbeet producers. If demonstrated to be safe for the crop, consolidating insecticide, fungicide, and/or starter fertilizer treatments into either tank-mixed or independent, but concurrent, delivery systems during planting or postemergence spray operations would provide time savings and significant application-associated input costs.

This experiment was carried out to evaluate the impact of such multicomponent application systems on sugarbeet root maggot control. A secondary objective was to monitor for any potential symptoms of phytotoxic effects of the treatment combinations, including impacts on plant emergence and survival. Several treatment combinations, based on the following application groupings, were evaluated:

1) Counter 20G insecticide at planting time with a concurrent (i.e., at same time through a separate application system) application of 10-34-0 starter fertilizer;

2) Counter 20G at planting time with a concurrently applied tank mixture of 10-34-0 starter fertilizer plus AZteroid (i.e., azoxystrobin) fungicide;

3) Yuma 4E insecticide applied postemergence in a tank mixture with Quadris (i.e., azoxystrobin) fungicide; and

4) Thimet 20G insecticide applied postemergence with a concurrent application of azoxystrobin (i.e., Quadris) fungicide.

Materials and Methods:

This experiment was planted on May 19, 2020 in a commercial sugarbeet field site near St. Thomas in rural Pembina County, ND. Betaseed 8524 glyphosate-resistant seed was used for all treatments. 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 was used to plant the trial. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. The outer “guard” row on each side of the plot served as an untreated buffer. 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. AZteroid was used as the azoxystrobin-based fungicide for planting-time treatment combinations, and Quadris was chosen as the postemergence version of an azoxystrobin-based fungicide. These selections reflect the most common uses of azoxystrobin for respective planting-time and postemergence fungicide applications to manage root diseases in the Red River Valley growing area.

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 spray applications included both T-band and dribble in-furrow (DIF). T-band placement involved delivering spray system output in a 3-inch swath over each open seed furrow by using a planter-mounted, CO_2-propelled spray system equipped with TeeJet™ 450067E nozzles and calibrated to apply a finished spray volume output of 5 GPA. Dribble in-furrow applications were made by orienting a microtube (1/4" outside diam.) directly into the open seed furrow. Inline Teejet™ No. 18 orifice plates were used to stabilize the output rate of the spray solutions from the microtubes.

Postemergence insecticide applications. Additive postemergence insecticides applied in this trial included Yuma 4E (a generic chlorpyrifos formulation, similar to Lorsban 4E) and Thimet 20G, and both materials were applied on June 17, which was just one day before peak SBRM fly activity. That timing, is not recommended for applications of Yuma (recommended for 2-5 days pre-peak), and even more so, Thimet 20G (recommended for 5-14 days pre-peak); however, an equipment failure and long periods of unfavorable weather prevented more timely applications of treatments that included those products.

Liquid insecticide solutions were delivered with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ 110015VS AIXR nozzles, and the system was calibrated to deliver a finished output volume of 10 GPA. Postemergence granular output rates were regulated by using a SmartBox™ system mounted on a tractor-drawn four-row toolbar, and placement of insecticide in 4-inch bands was achieved by using Kinze™ row banders. Granules were incorporated by using two pairs of metal rotary tines that straddled each row. A set of tines was positioned ahead of each bander, and a second pair was mounted behind the granular drop zone.

Plant Stand Counts: To measure relative safety of the various treatment combinations in this trial, plant density (i.e., number of surviving plants per unit row length) assessments were conducted at 37, 49, and 62 days after planting (DAP). This involved counting all surviving plants within each 35-ft plot row, and converting the counts to the commonly understood index of plants per 100 linear row feet.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this experiment on July 27, 2020. 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: Treatment performance was also compared on the basis of sugarbeet yield parameters. Plots were harvested on September 23. 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). Treatment means were compared by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

Results from stand count assessments are presented in Table 1. There were no significant differences among treatments during the first stand count (37 DAP), suggesting that there were no negative or positive impacts from any of the treatments on seedling emergence or survival. Although there were occasional statistically significant differences between treatments at both 49 and 62 DAP, none appeared to be the result of negative interactions from either combining an at-plant application of Counter 20G with either starter fertilizer or AZteroid fungicide, or from combining postemergence applications of Yuma 4E with Quadris fungicide. There also were no significant reductions in plant stands in relation to insecticide application rate for any of the at-plant or postemergence treatment combinations.

Sugarbeet root maggot feeding injury results from this two-year trial are shown in Table 2. This data should be interpreted with the aforementioned fact that an equipment failure and unfavorable weather conditions prevented the applications of Yuma 4E and Thimet 20G at preplanned timings in relation to peak SBRM fly activity. As such, the performance levels of treatments including those products could have been negatively affected.

Table 1. *Plant stand counts* from an evaluation of concurrently applied and tank-mixed combinations of azoxystrobin fungicides with sugarbeet root maggot-targeted insecticides, St. Thomas, ND, 2020

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[c] (plants / 100 ft)		
				37 DAP	**49 DAP**	**62 DAP**
Counter 20G + Thimet 20G	B 4" Post B, 1 d Pre-peak	8.9 lb 7 lb	1.8 1.4	211.4 a	221.8 a	213.6 a
Counter 20G	B	7.5 lb	1.5	184.6 a	212.1 ab	210.9 a
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 2 pt 10 fl oz	1.8 1.0 0.17	187.0 a	174.3 cd	205.5 ab
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 1 pt 10 fl oz	1.8 0.5 0.17	189.1 a	200.9 abc	200.7 ab
Counter 20G + Yuma 4E	B 10" Post B, 1 d Pre-peak	7.5 lb 2 pt	1.5 1.0	185.7 a	205.0 abc	199.1 ab
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	7.5 lb 2 pt 10 fl oz	1.5 1.0 0.17	176.4 a	119.1 abc	198.6 ab
Counter 20G + Thimet 20G + Quadris	B 4" Post B, 1 d Pre-peak 10" Post B, 1 d Pre-peak	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	184.5 a	208.2 abc	196.1 abc
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	187.1 a	192.1 a-d	191.1 abc
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	180.5 a	184.5 a-d	183.9 bc
Counter 20G + AZteroid FC + 10-34-0	B DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15	175.9 a	182.3 bcd	182.5 bc
Counter 20G + AZteroid FC + 10-34-0	B DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.15	163.4 a	186.6 a-d	182.3 bc
Counter 20G	B	8.9 lb	1.8	190.9 a	183.8 bcd	174.3 c
Fertilizer check	DIF	5 GPA		168.8 a	155.7 d	144.6 d
Check	---	----	---	192.5 a	160.4 d	133.4 d
LSD (0.05)				NS	37.40	24.16

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]At-plant sprays were delivered in a 10-34-0 starter fertilizer/water carrier (3:2 gal. H_2O to fertilizer) at an output volume of 5 GPA.
[b]B = 5-inch at-plant band; Post B = postemergence band (i.e., 4-inch width for granular products; 10-inch width for liquid formulations); DIF = dribble in-furrow
[c]Surviving plant stands were counted on 25 June, and on 7 and 20 July, 2020 (i.e., 37, 49, and 62 days after planting [DAP], respectively).

The average SBRM feeding injury sustained in the true untreated check and the fertilizer-only check plots (7.63 and 6.45, respectively, on the 0 to 9 scale of Campbell et al. [2000]) indicated the presence of a relatively high larval infestation for the experiment. All insecticide-treated entries in the trial provided significant reductions in SBRM feeding injury when compared to the untreated check. The lowest level of SBRM feeding injury (i.e., the highest level of protection) was observed in plots that received the combination of a planting-time application of Counter 20G at its moderate labeled rate (7.5 lb product/ac) plus a tank-mixed postemergence combination of Yuma 4E (2 pts/ac) plus Quadris fungicide; however, that entry was not statistically superior to any of the dual (i.e., planting-time plus postemergence) insecticide entries in the trial. Root protection from SBRM feeding injury was not significantly impaired by applying starter fertilizer and/or AZteroid fungicide at the same time as banded applications of Counter 20G at planting time. Similarly, there were no significant reductions in SBRM control when Quadris was applied concurrently with Thimet 20G or when it was tank mixed with Yuma 4E, irrespective of the rate at which the insecticides were applied.

Table 2. *Larval feeding injury* from an evaluation of concurrently applied and tank-mixed combinations of azoxystrobin fungicides with sugarbeet root maggot-targeted insecticides, St. Thomas, ND, 2020

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	7.5 lb 2 pt 10 fl oz	1.5 1.0 0.17	2.55 e
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 2 pt 10 fl oz	1.8 1.0 0.17	2.88 e
Counter 20G + Thimet 20G + Quadris	B 4" Post B, 1 d Pre-peak 10" Post B, 1 d Pre-peak	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	3.20 de
Counter 20G + Yuma 4E	B 10" Post B, 1 d Pre-peak	7.5 lb 2 pt	1.5 1.0	3.20 de
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 1 pt 10 fl oz	1.8 0.5 0.17	3.33 cde
Counter 20G + Thimet 20G	B 4" Post B, 1 d Pre-peak	8.9 lb 7 lb	1.8 1.4	3.63 cde
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	4.45 bcd
Counter 20G	B	7.5 lb	1.5	4.63 bc
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	4.63 bc
Counter 20G + AZteroid FC + 10-34-0	B DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15	4.63 bc
Counter 20G + AZteroid FC + 10-34-0	B DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.15	4.63 bc
Counter 20G	B	8.9 lb	1.8	4.98 b
Fertilizer check	DIF	5 GPA		6.45 a
Check	-----	----	-----	7.63 a
LSD (0.05)				1.350

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]At-plant sprays were delivered in a 10-34-0 starter fertilizer/water carrier (3:2 gal. H_2O to fertilizer) at an output volume of 5 GPA.
[b]B = 5-inch at-plant band; Post B = postemergence band (i.e., 4-inch width for granular products; 10-inch width for liquid formulations); DIF = dribble in-furrow

Yield data from this experiment are presented in Table 3. As noted with SBRM feeding injury results, the interpretation of yield results from this trial should be interpreted carefully and with the understanding that postemergence applications of Yuma 4E and Thimet 20G were both applied later than planned. Overall performance patterns indicated that treatment combinations including dual (planting-time plus postemergence) insecticide applications provided greater recoverable sucrose and root yields, and higher gross economic returns.

The treatment combination comprised of Counter 20G at its high labeled rate (8.9 lb product/ac) plus a postemergence tank mixture of Yuma 4E (high labeled rate of 2 pts product/ac) and Quadris fungicide at its recommended rate (10 fl oz product/ac) produced greatest recoverable sucrose yield, root tonnage, and gross revenue in this trial. However, a similar treatment, only differing by a reduced rate of Yuma (1 pt/ac), produced comparable sucrose and root yields, and a nearly identical gross economic return as when the Yuma component was applied at its full 2-pt labeled rate.

Although not statistically significant, percent sucrose content and resulting recoverable sucrose yield were numerically reduced by tank mixing Quadris fungicide with the full labeled rate (2 pts product/ac) of Yuma 4E in plots initially treated at planting with Counter at its moderate labeled rate (7.5 lb/ac). The resulting revenue reduction by including Quadris with 2 pts of Yuma was $120.

Table 3. Impacts of concurrently applied and tank-mixed combinations of azoxystrobin fungicides and sugarbeet root maggot-targeted insecticides on *yield parameters*, St. Thomas, ND, 2020

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 2 pt 10 fl oz	1.8 1.0 0.17	10,394 a	33.8 a	17.80 a	1,342
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 1 pt 10 fl oz	1.8 0.5 0.17	10,218 a	32.8 ab	17.00 a	1,341
Counter 20G + Yuma 4E	B 10" Post B, 1 d Pre-peak	7.5 lb 2 pt	1.5 1.0	10,009 a	31.8 abc	16.93 a	1,331
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	7.5 lb 2 pt 10 fl oz	1.5 1.0 0.17	9,683 ab	32.1 ab	16.49 a	1,211
Counter 20G + Thimet 20G	B 4" Post B, 1 d Pre-peak	8.9 lb 7 lb	1.8 1.4	9,397 ab	29.2 bcd	17.33 a	1,286
Counter 20G + Thimet 20G + Quadris	B 4" Post B, 1 d Pre-peak 10" Post B, 1 d Pre-peak	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	9,247 abc	27.8 cde	16.67 a	1,320
Counter 20G + AZteroid FC + 10-34-0	B DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.15	8,988 a-d	27.3 de	17.63 a	1,266
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	8,506 bcd	27.3 de	16.91 a	1,116
Counter 20G + AZteroid FC + 10-34-0	B DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.15	8,473 bcd	25.9 def	17.60 a	1,187
Counter 20G	B	8.9 lb	1.8	8,429 bcd	25.9 def	17.50 a	1,171
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	7,964 de	24.9 ef	17.48 a	1,082
Counter 20G	B	7.5 lb	1.5	7,639 de	24.1 ef	17.10 a	1,025
Fertilizer check	DIF	5 GPA		6,986 e	21.8 f	17.34 a	951
Check	-----	----	-----	6,673 e	22.3 f	16.40 a	824
LSD (0.05)				1,408.6	4.10	NS	

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

[a]At-plant sprays were delivered in a 10-34-0 starter fertilizer/water carrier (3:2 gal. H_2O to fertilizer) at an output volume of 5 GPA.

[b]B = 5-inch at-plant band; Post B = postemergence band (i.e., 4-inch width for granular products; 10-inch width for liquid formulations); DIF = dribble in-furrow

In plots that received the planting-time combination of a banded application of Counter 20G at 7.5 lb product per acre plus a concurrently applied (i.e., dribbled in-furrow) application of 10-34-0 starter fertilizer, the inclusion of the fertilizer resulted in numerical, but not statistically significant, increases in both recoverable sucrose yield and root tonnage per acre. Additionally, in plots that received the same (7.5 lb) rate of Counter, adding AZteriod fungicide to the planting-time fertilizer application resulted in even larger, albeit not statistically significant, increases in both recoverable sucrose and root yield. Plots treated with that combination (i.e., Counter 20G at 7.5 lb/ac plus a tank mixture of 10-34-0 starter fertilizer and AZteroid fungicide) generated $150/ac more revenue than similar plots that excluded AZteroid, and $241 more revenue than plots that did not include fungicide or fertilizer. However, when Counter was applied at its high labeled rate (8.9 lb product/ac), slight, non-significant reductions in recoverable sucrose yield, root tonnage, and gross revenue were observed when 10-34-0 starter fertilizer was applied in furrow ahead of the insecticide bands at planting time. The triple-component planting-time combination of Counter, AZteroid, and 10-34-0 starter fertilizer produced greater recoverable sucrose, root yield, and gross revenue when Counter was applied at the moderate rate of 7.5 lb product/ac. That treatment program generated $79 more revenue than when Counter was applied at 8.9 lb/ac in combination with a concurrent application of AZteroid with starter fertilizer.

The overall findings of this experiment suggest that combining 10-34-0 starter fertilizer and/or azoxystrobin-based fungicide applications with SBRM-targeted insecticides, through either tank-mixed or concurrent delivery systems, is not likely to result in reduced root maggot control or negative impacts on sugarbeet yield or quality. However, two concerning observations included the following: 1) applying 10-34-0 starter fertilizer into the seed furrow during planting while concurrently applying Counter 20G at its high rate (8.9 lb product/ac) rate resulted in a slight (not statistically significant) yield reductions and reduced revenue by $89/ac when compared to similar plots that did not include the fertilizer application; and 2) in plots initially protected by the lower (7.5-lb) rate of Counter 20G, a gross revenue loss of $120 occurred when Quadris fungicide was combined with a full labeled rate of Yuma 4E at postemergence. These concerns strongly suggest further study of these combinations.
It also should be noted that this trial was conducted in an environment that included high SBRM feeding pressure. As such, the net impacts of the treatment combinations on plant health (i.e., excluding SBRM control) cannot be accurately measured. Therefore, this research should be continued under both pest-free and SBRM-infested scenarios to more fully characterize the safety as well as SBRM control efficacy of these treatment combinations.

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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. Sugarbeet Res. 37: 57–69.

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

COMBINING MIDAC FC® AND PONCHO BETA WITH AZTEROID FUNGICIDE AND STARTER FERTILIZER: IMPACTS ON ROOT MAGGOT CONTROL AND YIELD

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is one of the most serious economic insect pests of sugarbeet in the Red River Valley (RRV) growing area. In central and northern portions of the Valley, sugarbeet producers typically manage this pest by initially using either a granular, liquid, or seed-applied insecticide during planting operations. In localities where moderately high to severe SBRM fly infestations develop, growers often choose to complement their planting-time protection measure with at least one postemergence insecticide application to protect the crop from major yield and revenue loss.

Since the mid-1970s, most of these applications have involved the use of insecticides involving the same mode of action, which is acetylcholinesterase (ACHE) inhibition. Grower dependence on this single mode of action for SBRM control in the Red River Valley has mostly been due to the fact that a limited number of insecticide products have been commercially available for use in the crop for several decades. 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 Midac FC for registered 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 Midac for SBRM control. The 2(ee) 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 is an entirely 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, insecticides belonging to this class have been widely used as seed treatments for insect management in sugarbeet since 2008.

One purported positive aspect of Midac FC is its compatibility for being tank-mixed with starter fertilizer formulations. That characteristic is beneficial to producers, as it allows for including fertilizer with planting operations. Starter fertilizer is commonly practiced by sugarbeet producers in the Red River Valley growing area, but little is known about its potential impacts, either positive or negative, on agronomic responses such as insecticide performance, plant safety, and resulting crop yield.

The key objective of this experiment was to evaluate the efficacy of Midac FC as an insecticide for sugarbeet root maggot control. Secondarily, this research was conducted to also determine the impacts of combining Midac with 10-34-0 starter fertilizer, and also integrating it with Poncho Beta insecticidal seed treatment and AZteroid fungicide for single-pass insect and disease management in sugarbeet. A third objective was to monitor for potential negative impacts (e.g., phytotoxicity) of dual- and multiple-component combinations of Midac, Poncho Beta, AZteroid, and 10-34-0 starter fertilizer.

Materials and Methods:

This experiment was conducted in a grower-owned field near St. Thomas in rural Pembina County, ND during the 2020 growing season. Betaseed 8524 glyphosate-resistant seed was used for all treatments in the trial. All plots were planted on May 20, 2020 by 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.

Midac FC was applied by both dribble-in-furrow (DIF) and T-band placement. T-bands were achieved by orienting the output fan of each nozzle (TeeJet™ 450067E) 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. 18 orifice plates were used to stabilize the output rate of the spray solutions from the microtubes. Most at-plant treatments included 10-34-0 fertilizer (i.e., 10, 34, and 0% nitrogen, phosphorus, and potassium, respectively), which was diluted to a 3:2 gallon ratio of fertilizer to water. Water used for these solutions was adjusted to pH 6.0 several weeks before use. All planting-time liquid applications were delivered in a finished spray volume output of 5 GPA.

Non-fertilizer entries included Counter 20G at two application rates (i.e., 7.5 and 8.9 lb product/ac), and a true untreated check. However, each of those entries were compared with treatments that included the same base application (i.e., either Counter or a check) with a concurrent application of the fertilizer/water solution. Counter 20G was 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 a planter-mounted SmartBox™ insecticide delivery system that had been calibrated on the planter before all applications.

Plant Stand Counts: To determine treatment impacts on seedling emergence and survival throughout the growing season, surviving plant stands were conducted on June 25, July 7, and July 20, 2020, which were 37, 49, and 62 days after planting (DAP), respectively. Plant stand assessments involved counting all living plants within each 35-ft-long row. Raw stand counts were then converted to plants per 100 linear row feet for the analysis.

Root injury ratings: Sugarbeet root maggot feeding injury ratings were conducted on July 28. 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 September 22. Immediately (i.e., within one hour) before harvest, 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. A 0.05 level of significance was used for root injury rating and yield data; however, due to the occurrence of slightly more variability in plant stands within and among replicates in this trial, all stand count data was analyzed and at the 0.10 of significance.

Results and Discussion:

Table 1 includes plant stand counts from three dates. Treatments are listed in descending order of surviving plant stand at the final count. Thus, careful attention is required to assess stand count comparisons from the first two count dates. The highest plant densities at the first stand count (i.e., 37 DAP) were observed in plots protected by Poncho Beta-treated seed and a 3" T-banded application of 10-34-0 starter fertilizer. Most other entries had comparable plant densities, and were not significantly different from that treatment. However, the following had significantly lower plant stands than the treatment that included Poncho Beta and starter fertilizer alone:

1) Poncho Beta-treated seed + a T-banded tank mixture of Midac FC, AZteroid, and 10-34-0;
2) Untreated check (i.e., no insecticide and no fertilizer)
3) Counter 20G banded at 8.9 lb product/ac + a concurrent T-banded application of 10-34-0;
4) 10-34-0 starter fertilizer, 3" T-band; and
5) 10-34-0 starter fertilizer, applied DIF.

Table 1. ***Plant stand counts*** **from from an evaluation of tank-mixed and concurrent applications of planting-time granular, liquid, and seed treatment insecticides with starter fertilizer and azoxystrobin for sugarbeet root maggot control, St. Thomas, ND, 2020**

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[c] (plants / 100 ft)		
				37 DAP	49 DAP	62 DAP
Poncho Beta + Midac FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5 GPA	68 g a.i./ unit seed	190.2 a-d	205.5 abc	209.5 a
Poncho Beta + Midac FC + AZteroid FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5.7 fl oz 5 GPA	68 g a.i./ unit seed 0.18 0.15	183.0 b-e	200.4 abc	200.2 ab
Midac FC + 10-34-0	3" TB	13.6 fl oz 5 GPA	0.18	199.3 ab	209.3 ab	198.2 ab
Poncho Beta + 10-34-0	Seed 3" TB	 5 GPA	68 g a.i./ unit seed	201.1 a	202.3 abc	196.8 ab
Counter 20G	B	8.9 lb	1.8	191.6 abc	213.6 a	191.3 ab
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	188.0 a-e	194.5 bcd	189.6 bc
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	184.1 a-e	190.5 cd	189.3 bc
Counter 20G	B	7.5 lb	1.5	185.4 a-e	205.4 abc	187.0 bcd
10-34-0	DIF	5 GPA		171.4 e	189.3 cd	184.1 bcd
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	173.9 de	178.9 d	182.5 bcd
10-34-0	3" TB	5 GPA		172.3 e	189.6 cd	170.9 cd
Check	---	---	---	175.0 cde	181.3 d	169.1 d
LSD (0.10)				17.48	17.82	19.77

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

[a]Carrier for at-plant treatments that included starter fertilizer involved a 3:2 gal. ratio of H_2O to liquid 10-34-0 fertilizer. Output volume was 5 GPA.

[b]Seed = insecticidal seed treatment; B = 5-inch band at planting; 3" TB = 3-inch T-band over open seed furrow at planting; DIF = dribble in-furrow at planting

[c]Surviving plant stands were counted on June 25, and on 7 and 20 July, 2020 (i.e., 37, 49, and 62 days after planting [DAP], respectively).

These early plant stand counts suggest a few concerns. First, these results suggest that combining Midac FC insecticide with azoxystrobin fungicide and 10-34-0 starter fertilizer and using Poncho Beta-treated seed has potential to negatively impact seedling emergence and/or survival. However, further study should be conducted to confirm or rule out this concern. Secondly, the results of this first stand count indicate that banding Counter 20G at its high rate (8.9 lb product/ac) at planting and combining the application with a concurrent (i.e., separate delivery system) application of 10-34-0 could also delay or reduce sugarbeet seedling emergence. Finally, this first series of stand counts suggest that 10-34-0 starter fertilizer itself has potential to reduce or delay sugarbeet seedling emergence, at least under the light-textured soil conditions that characterized this field location.

At the second stand count (49 DAP), the highest surviving plant stand in the trial was observed in plots treated with Counter 20G at 8.9 lb product per acre (without starter fertilizer). The average stand count for that treatment was significantly greater than both Counter treatments (7.5 and 8.9 lb product/ac) when a concurrent application of 10-34-0 starter fertilizer was included at planting. Plots treated with a T-banded application of Midac plus 10-34-0 had the second-highest plant densities at 49 DAP, with an average stand count of 209.3 plants per 100 row ft. Although not significantly different, plots receiving the same Midac FC/10-34-0 tank mixture, but applied via DIF placement, had about 7% fewer plants per 100 row ft than when the mixture was T-banded. Similarly, a slight numerical (i.e., not statistically significant) reduction in stand was observed when AZteroid was tank mixed with Midac and starter fertilizer and applied to plots planted with Poncho Beta-treated seed. However, the difference was only a 3% reduction in plant stand, suggesting that this disparity could have simply been a result of natural variability within and/or between replicates in the experiment.

The third stand count (i.e., 62 DAP) was carried out on July 20, which should have been after nearly all SBRM larvae had ceased feeding behavior. As such, this data should be interpreted for treatment impacts on both crop safety and efficacy at protecting plants from mortality resulting from SBRM feeding injury. At this last count, excellent stands were achieved by using the following treatments, which were not significantly different from each other in respect to surviving plant densities:

1) Poncho Beta-treated seed + a T-banded tank mixture of Midac FC and 10-34-0;
2) Poncho Beta-treated seed + a T-banded tank mixture of Midac FC, AZteroid, and 10-34-0;
3) Midac FC + 10-34-0, T-band;
4) Poncho Beta seed + 10-34-0, T-band; and
5) Counter 20G banded at 8.9 lb product/ac (no fertilizer).

In comparing the tank mixtures that included Midac FC and 10-34-0 starter fertilizer, the trend suggested a slight reduction in surviving stand by adding AZteroid fungicide was also evident at this final count; however, that amounted to a decrease of only 4.5%, and it was not statistically significant. Similarly, in plots treated at planting with Counter 20G at the high labeled rate (8.9 lb/ac), plant densities were reduced by about 5% when a concurrent application of starter fertilizer was included, but the difference was not significant. In comparing placement methods for applying Midac plus starter fertilizer, stands were numerically greater when the mixture was applied by T-band, but the slight difference (4.4%) was not statistically significant.

Results from sugarbeet root maggot feeding injury ratings in this experiment are presented in Table 2. A moderate SBRM infestation was present for the study. This was indicated by the average SBRM feeding injury ratings in the untreated check and the fertilizer-treated controls, which ranged between 5.78 and 5.92 on the 0 to 9 scale of Campbell et al. (2000). Most insecticide treatments provided significant reductions in SBRM feeding injury when compared to that recorded for the untreated check plots. However, the following treatments incurred SBRM feeding injury that was not statistically reduced in comparison to the untreated check: 1) Poncho Beta + 10-34-0 starter fertilizer; 2) Midac FC + 10-34-0 applied in a 3” T-band; and 3) Midac FC + 10-34-0 applied in a 3” T-band.

Table 2. ***Larval feeding injury ratings*** **from an evaluation of tank-mixed and concurrent applications of planting-time granular, liquid, and seed treatment insecticides with starter fertilizer and azoxystrobin for sugarbeet root maggot control, St. Thomas, ND, 2020**				
Treatment/form.[a]	**Placement[b]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	3.03 e
Counter 20G	B	7.5 lb	1.5	3.08 e
Poncho Beta + Midac FC + AZteroid FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5.7 fl oz 5 GPA	68 g a.i./ unit seed 0.18 0.15	3.65 e
Counter 20G	B	8.9 lb	1.8	3.95 de
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	4.20 cde
Poncho Beta + Midac FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	4.25 cde
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	4.40 b-e
Midac FC + 10-34-0	3" TB	13.6 fl oz 5 GPA	0.18	5.35 a-d
Poncho Beta + 10-34-0	Seed 3" TB	 5 GPA	68 g a.i./ unit seed	5.50 abc
Check	---	---	---	5.78 ab
10-34-0 fertilizer check	DIF	5 GPA		5.83 ab
10-34-0 fertilizer check	3" TB	5 GPA		5.93 a
LSD (0.05)				1.432

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

[a]Carrier for at-plant treatments that included starter fertilizer involved a 3:2 gal. ratio of H_2O to liquid 10-34-0 fertilizer. Output volume was 5 GPA.

[b]Seed = insecticidal seed treatment; B = 5-inch band at planting; 3" TB = 3-inch T-band over open seed furrow at planting; DIF = dribble in-furrow at planting

It should be noted, however, that the DIF application of Midac with starter fertilizer also was not statistically different from the best-performing treatment in the trial with regard to protection from SBRM feeding injury (i.e., Counter 20G applied at its high labeled rate of 8.9 lb product/ac with a concurrent application of 10-34-0 starter fertilizer. Other treatments that provided excellent levels of protection from SBRM feeding injury included the following:

1) Counter 20G banded at 7.5 lb product/ac (no fertilizer);
2) Poncho Beta-treated seed + a T-banded tank mixture of Midac, AZteroid, and 10-34-0 starter fertilizer;
3) Counter 20G banded at 8.9 lb product/ac (no fertilizer);
4) Counter 20G banded at 7.5 lb product/ac + a concurrent application of 10-34-0; and
5) Poncho Beta-treated seed + a T-banded tank mixture of Midac and 10-34-0

These results suggest that combining at-plant insecticide applications, such as Counter 20G, Poncho Beta seed treatment, or Midac sprayable liquid insecticide, with 10-34-0 starter fertilizer or AZteroid fungicide are not likely to reduce efficacy of the SBRM insecticides evaluated in this trial.

Yield data from this experiment are shown in Table 3. The top-yielding treatment in the trial, with regard to both recoverable sucrose yield and root tonnage, was the planting-time application of Counter 20G, applied at its high labeled rate of 8.9 lb product per acre. Excellent yield was also produced by using a similar treatment involving the same rate of Counter and combining it with a concurrent application of 10-34-0 starter fertilizer.

Table 3. *Yield parameters* from an evaluation of tank-mixed and concurrent applications of planting-time granular, liquid, and seed treatment insecticides with starter fertilizer and azoxystrobin for sugarbeet root maggot control,, St. Thomas, ND, 2020							
Treatment/form.[a]	**Placement[b]**	**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	10,085 a	29.6 a	18.17 a	1,478
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	9,768 a	29.3 a	17.89 a	1,397
Poncho Beta + Midac FC + AZteroid FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5.7 fl oz 5 GPA	68 g a.i./ unit seed 0.18 0.15	9,709 ab	28.7 a	18.05 a	1,412
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	9,577 ab	27.9 ab	18.33 a	1,416
Counter 20G	B	7.5 lb	1.5	9,458 abc	29.2 a	17.38 a	1,303
Poncho Beta + Midac FC + 10-34-0	Seed 3" TB	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	9,088 abc	28.1 ab	17.50 a	1,251
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	8,986 abc	26.9 a-d	17.96 a	1,289
Poncho Beta + 10-34-0	Seed 3" TB	 5 GPA	68 g a.i./ unit seed	8,713 a-d	27.4 abc	17.19 a	1,177
Midac FC + 10-34-0	3" TB	13.6 fl oz 5 GPA	0.18	8,378 bcd	24.8 bcd	17.91 a	1,216
10-34-0 fertilizer check	DIF	5 GPA		8,345 bcd	27.2 abc	16.81 a	1,073
Check	---	---	---	8,198 cd	23.7 cd	18.42 a	1,223
10-34-0 fertilizer check	3" TB	5 GPA		7,580 d	23.4 d	17.47 a	1,046
LSD (0.05)				1,373.0	3.69	NS	

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

[a]Carrier for at-plant treatments that included starter fertilizer involved a 3:2 gal. ratio of H_2O to liquid 10-34-0 fertilizer. Output volume was 5 GPA.

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

Although the recoverable sucrose yield, root tonnage, and percent sucrose recorded for those plots were slightly lower when the starter fertilizer application was included, none of those yield response variables were significantly reduced in comparison to those recorded for the Counter-only plots. Most other treatments in the trial also produced sucrose and root yields that were not significantly different from the top treatment in the study (Counter 20G only, at the high rate). Exceptions to that, which also failed to provide significant recoverable sucrose and root yield improvements over the unfertilized untreated check, included the following:

1) Counter 20G at 7.5 lb product/ac + a concurrent application of 10-34-0 starter fertilizer;
2) Poncho Beta + 10-34-0 applied in a 3" T-band; and
3) Midac FC tank mixed with 10-34-0 and applied in a 3" T-band;

Despite the fact that few significant yield differences were observed among insecticide-treated plots in this trial, a few general performance patterns suggest careful consideration on deploying the products tested. For instance, in plots treated with Counter 20G, the inclusion of a concurrent application of 10-34-0 starter fertilizer consistently resulted in numerical (i.e., not statistically significant) reductions in recoverable sucrose yield and root tonnage when a concurrent application of 10-34-0 starter fertilizer was included. This was the case for both application rates of Counter (i.e., 7.5 and 8.9 lb product/ac); however, the resulting negative impact on gross revenue was most notable in the case of the high labeled rate of Counter 20G (8.9 lb), which generated $81 less revenue when the starter fertilizer application was included during planting.

One very positive finding was that including AZteroid fungicide in a T-banded tank mixture with Midac FC and 10-34-0 starter fertilizer, and combining the mix with Poncho Beta-treated seed, had no deleterious impact on any of the measured yield parameters. Plots that received that multi-component treatment produced numerically greater recoverable sucrose yield and root yield, and had a numerically greater percent sucrose than comparative plots that included individual or paired components from that combination (i.e., plots protected by only Poncho Beta-treated seed with T-banded 10-34-0 or the T-banded application of the Midac FC plus 10-34-0 tank mixture).

Another helpful result from this trial was that, although placement (i.e., 3” T-band vs. DIF) did not have a significant impact on performance of Midac FC, plots that received this product via DIF placement produced numerically greater recoverable sucrose yield and root tonnage, and roots from DIF-treated Midac plots had numerically greater sucrose content. This is a very positive result, because sugarbeet planters are commonly equipped with DIF delivery technology, and it is also fairly simple to add to a planter.

Overall results of this trial suggest that, for growers intending on applying Counter 20G at planting and also including a concurrent application of 10-34-0 starter fertilizer, it is advisable to at least dilute the fertilizer to the 3:2 gallon (i.e., 3 gallons of fertilizer to 2 gallons of water) ratio if they choose to use the full 8.9-lb rate of Counter. Results also suggest that combining Poncho Beta-treated seed with an application of Midac FC plus 10-34-0 starter fertilizer can improve SBRM control and resulting yield and gross revenue. Additionally, it appears that including AZteroid in a tank mixture with Midac FC and 10-34-0 starter fertilizer, and applying while planting Poncho Beta-treated seed is safe for the crop and is not likely to reduce SBRM control efficacy. Also, growers intending on using Midac FC for SBRM control are advised to apply it by using dribble in-furrow placement. However, it should be noted that data from previous NDSU research suggests that Midac FC performs at a comparable level to that of the moderate rate of Counter 20G (i.e., 7.5 lb product/ac). Thus, if planting-time insecticide protection is limited to Midac FC, the grower should expect the need to add a postemergence rescue insecticide application to augment SBRM control, especially in areas of moderate to high risk of economically damaging root maggot populations.

Finally, it should be noted that most of the treatments tested in this trial need further testing to determine the validity and repeatability of these results. This is especially so for the multi-component treatments tested, for the inclusion of AZteroid fungicide with Midac/10-34-0 tank mixtures, and for the safety of combining Counter 20G applications with concurrent applications of starter fertilizer.

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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.

SPRINGTAIL CONTROL IN SUGARBEET ALONG THE MONTANA/NORTH DAKOTA BORDER: EFFICACY OF GRANULAR, SPRAYABLE LIQUID, AND SEED-APPLIED INSECTICIDES

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Introduction:

Subterranean (soil-dwelling) springtails are tiny, nearly microscopic, blind, and wingless insects that spend their entire lives below the soil surface (Boetel et al. 2001). These organisms belong to the Collembola, a primitive order of Arthropods, and most species resemble insects; however, due to some unusual anatomical features, they are technically not true insects. In sugarbeet production systems, 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 sugarbeet stand and yield losses if conditions are conducive to their development and reproduction.

These pests have been recognized as a serious threat to sugarbeet production 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, Midac FC, and Bifender liquid insecticides; 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 planting-time applications of Midac and Mustang Maxx with Poncho Beta-treated seed.

Materials & Methods:

This experiment was established in a grower-owned sugarbeet field near Fairview (Richland County) in northeastern, MT. Plots were planted on 7 May, 2020 using a four-row John Deere 71 Flex 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 (24-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 (i.e., Cruiser, NipsIt Inside, and Poncho Beta) 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^{TM} row banders. Planting granular output rates were regulated by using a planter-mounted SmartBox^{TM} computer-controlled insecticide delivery system that was calibrated on the planter immediately before all applications.

Planting-time sprayable liquid insecticides (i.e., Bifender FC, Midac FC, and Mustang Maxx were applied as either 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^{TM} 450067E) 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. 18 orifice plates were used to provide backpressure for stabilizing the output rate of 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 June 1, 9, and 15, 2020, which were 25, 33, and 39 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, 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:

Plant stand count data for this trial appear in Table 1. The treatments are presented in descending order of performance as observed at the last stand count (39 DAP). As such, the best-performing treatment, with regard to surviving sugarbeet plant stand, is listed in the top row. At the initial stand count (25 DAP), the highest stand counts were recorded in plots protected by the following treatment combinations: 1) Poncho Beta-treated seed plus a T-banded application of Mustang Maxx (4 fl oz/ac); and 2) Poncho Beta-treated seed plus a T-banded application of Midac FC (13.6 fl oz/ac). Plots treated with a banded application of Counter 20G at the moderate rate of 5.9 lb product/ac also had plant densities that were not statistically different from Poncho Beta plus T-banded Mustang or Poncho Beta plus T-banded Midac FC, and all of the aforementioned treatments provided significant levels of stand protection when compared to the untreated check.

Other treatments that were not statistically different from all of the aforementioned treatments, but were also not different from the check, included the following (listed in descending order of recorded stand count):

1) Poncho Beta-treated seed;
2) Mustang Maxx T-banded at 4 fl oz/ac (maximum labeled rate per application);
3) NipsIt Inside-treated seed;
4) Poncho Beta-treated seed plus Mustang Maxx, applied DIF at 4 fl oz/ac; and
5) Bifender T-banded at 10.97 fl oz/ac.

Table 1. ***Plant stand counts*** **from an evaluation of planting-time granular, liquid, and seed treatment insecticides for springtail control, Fairview, MT, 2020**						
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Stand count[b] (plants / 100 ft)**		
				25 DAP[c]	**33 DAP[c]**	**39 DAP[c]**
Poncho Beta + Mustang Maxx	Seed 3" TB	4 fl oz	68 g a.i./ unit seed 0.025	135.0 a	161.0 a	164.0 a
Poncho Beta + Mustang Maxx	Seed DIF	4 fl oz	68 g a.i./ unit seed 0.025	114.0 a-e	152.0 a-d	163.0 ab
Poncho Beta	Seed		68 g a.i./ unit seed	127.0 abc	150.0 a-e	158.0 ab
Poncho Beta + Midac FC	Seed 3" TB	13.6 fl oz	68 g a.i./ unit seed 0.18	135.0 a	157.0 ab	158.0 ab
Counter 20G	B	5.9 lb	1.2	133.0 ab	154.0 abc	153.0 abc
Cruiser 5FS	Seed		60 g a.i./ unit seed	109.0 a-e	143.0 a-f	152.0 abc
Nipslt Inside	Seed		60 g a.i./ unit seed	118.0 a-e	131.0 a-g	150.0 a-d
Midac FC	DIF	13.6 fl oz	0.18	101.0 b-e	120.0 a-g	136.0 a-e
Bifender FC	3" TB	10.97 fl oz	0.15	102.0 a-e	132.0 a-g	127.0 a-e
Mustang Maxx	3" TB	4 fl oz	0.025	122.0 a-d	123.0 a-g	126.0 a-e
Counter 20G	B	7.5 lb	1.5	85.0 e	115.0 b-g	122.0 b-e
Midac FC	3" TB	13.6 fl oz	0.18	93.0 de	105.0 fg	114.0 cde
Mustang Maxx	DIF	4 fl oz	0.025	99.0 cde	113.0 c-g	109.0 de
Bifender FC	3" TB	6.6 fl oz	0.09	99.0 cde	107.0 efg	107.0 e
Counter 20G	B	4.5 lb	0.9	96.0 cde	109.0 d-g	102.0 e
Check	---	----	---	99.0 cde	96.0 g	102.0 e
LSD (0.05)				33.57	43.83	41.68

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 June 1, 9, and 15, 2020 (i.e., 25, 33, and 39 days after planting, respectively).
[c]DAP = Days after planting

Interestingly, at 25 DAP, plots treated with the moderate rate of Counter 20G (5.9 lb product/ac) had significantly greater plant stand densities than those treated with Counter at either 4.5 or 7.5 lb product/ac. This could have been a product of two independent causal factors. First, the lower rate may not provide sufficient control of the springtail species present in this field. Second, the higher rate may have had a negative impact on seedling emergence timing or possibly seedling survival that was independent of springtail feeding injury.

Results from the second series of plant stand counts, conducted at 33 DAP, were somewhat similar to the first stand counts. The following treatment plots had the highest average stand counts, and all had significantly greater stands than those recorded in the untreated check plots (listed in descending order of recorded stand count):

1) Poncho Beta-treated seed Mustang Maxx T-banded at 4 fl oz/ac;
2) Poncho Beta-treated seed Midac FC T-banded at 13.6 fl oz/ac;
3) Counter 20G banded at 5.9 lb product/ac;
4) Poncho Beta-treated seed Mustang Maxx applied DIF at 4 fl oz/ac;
5) Poncho Beta-treated seed; and
6) Cruiser-treated seed.

A performance pattern at 33 DAP that was similar to that at 25 DAP was that surviving plant stands in plots treated at planting with the moderate (i.e., 5.9-lb) rate of Counter 20G were significantly greater than those in plots that received Counter 20G at the low labeled rate of 4.5 lb product per acre. Plant stands in plots treated with Counter 20G at the higher rate of 7.5 lb product per acre were intermediate between those recorded for plots treated at 4.5 and 5.9, but were not significantly different from either of the other two rates.

At the final stand count date (39 DAP), plant densities had increased in most treatment plots. Similar to the results from the earlier stand assessments, the following treatments resulted in the highest plant densities, and all had significantly greater stands than those recorded in the untreated check plots (listed in descending order of recorded stand count):

1) Poncho Beta-treated seed Mustang Maxx T-banded at 4 fl oz/ac;
2) Poncho Beta-treated seed Mustang Maxx applied DIF at 4 fl oz/ac;
3) Poncho Beta-treated seed;
4) Poncho Beta-treated seed Midac FC T-banded at 13.6 fl oz/ac;
5) Counter 20G banded at 5.9 lb product/ac;
6) Cruiser-treated seed; and
7) NipsIt Inside-treated seed.

Plots in which surviving plant stands were not statistically different from stands in the untreated check plots at 39 DAP included those treated with the following single-component insecticide treatments: Midac FC (i.e., both T-banded and DIF applications), T-banded applications of Bifender (i.e., both 6.6 and 10.97 fl oz/ac), Mustang Maxx (i.e., both T-banded and DIF applications), and Counter 20G when it was applied at either 4.5 or 7.5 lb product per acre.

Yield data from this experiment appear in Table 2. Unfortunately, despite large numerical differences between treatments, no significant differences could be detected in the yield analyses. This was probably due to a large amount of variability in springtail infestations and potentially other unidentified agronomic factors among and within replicates in the plot area.

Despite a lack of statistically significant differences in yield parameters among treatments, several general performance patterns were evident, with some corresponding to and reinforcing the stand count results. A few of the yield responses appeared to contradict some of the stand count results. For example, in comparing the three application rates of Counter 20G, plots treated at the intermediate rate (i.e., 5.9 lb product/ac) had greater plant stands than those treated with the lower and higher rates (i.e., 4.5 and 7.5) of the insecticide. However, plots treated with the 7.5-lb rate of Counter 20G produced considerably more recoverable sucrose and root tonnage than those treated with either the moderate or low rate of that product. Also, plots treated with the 7.5-lb rate of Counter 20G generated $250 and $359 more in gross revenue than those treated with Counter at 5.9 and 4.5 lb product per acre, respectively. At a minimum, these results suggest that producers choosing to use Counter 20G for springtail management in the MonDak growing area should avoid using the 4.5-lb rate of this product.

Table 2. ***Yield parameters*** **from evaluation of planting-time granular, liquid, and seed treatment insecticides for springtail control, Fairview, MT, 2020**							
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	9,469 a	27.6 a	17.08 a	1397
Midac FC	3" TB	13.6 fl oz	0.18	8,916 a	26.2 a	17.03 a	1304
Poncho Beta + Midac FC	Seed 3" TB	13.6 fl oz	68 g a.i./ unit seed 0.18	8,767 a	25.0 a	17.48 a	1324
Poncho Beta + Mustang Maxx	Seed 3" TB	4 fl oz	68 g a.i./ unit seed 0.025	8,459 a	23.7 a	17.81 a	1302
Cruiser 5FS	Seed		60 g a.i./ unit seed	8,327 a	23.6 a	17.62 a	1265
Poncho Beta	Seed		68 g a.i./ unit seed	8,271 a	23.4 a	17.68 a	1260
Poncho Beta + Mustang Maxx	Seed DIF	4 fl oz	68 g a.i./ unit seed 0.025	8,173 a	23.6 a	17.39 a	1219
Nipslt Inside	Seed		60 g a.i./ unit seed	8,012 a	22.8 a	17.66 a	1215
Mustang Maxx	3" TB	4 fl oz	0.025	7,962 a	23.2 a	17.43 a	1176
Counter 20G	B	5.9 lb	1.2	7,904 a	21.7 a	17.54 a	1147
Midac FC	DIF	13.6 fl oz	0.15	7,538 a	22.0 a	17.14 a	1110
Mustang Maxx	DIF	4 fl oz	0.025	7,262 a	20.2 a	18.00 a	1126
Bifender FC	3" TB	10.97 fl oz	0.15	7,074 a	19.9 a	17.64 a	1086
Counter 20G	B	4.5 lb	0.9	6,737 a	18.9 a	17.97 a	1038
Bifender FC	3" TB	6.6 fl oz	0.09	6,660 b	19.3 a	17.38 a	992
Check	---	----	---	6,633 b	18.6 a	17.89 a	1022
LSD (0.05)				NS	NS	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; T-band = 3" swath over open seed furrow at planting; Seed = insecticidal seed treatment

Another surprising result in the yield data was that plots protected by the T-banded application of Midac FC produced the second-highest recoverable sucrose yield and root yield in the trial. This also is somewhat contrary to the stand count data, in which plots treated with Midac that was delivered via DIF placement had numerically, but not significantly, lower surviving plant stands than those in which the Midac was delivered in 3" T-bands.

Yield-related findings that corresponded well with stand count data involved the use of Mustang Maxx. First of all, the general trend was that plots that received Mustang Maxx tended to yield better when the insecticide was delivered as a 3" T-band than when it was applied by using DIF placement. This was the case for Mustang-only treatments and for those that involved an integrated combination of Poncho Beta-treated seed plus Mustang Maxx. A very positive finding was that combining Poncho Beta-treated seed with Mustang Maxx resulted in numerically greater recoverable sucrose yield and root tonnage than sole reliance on either Poncho Beta-treated seed or Mustang Maxx alone.

At a minimum, it should be noted that the highest-yielding entry in the trial, Counter 20G banded at 7.5 lb product per acre, produced a yield increase of more than 2,800 lb in recoverable sucrose above the untreated check. Also, the five best-yielding entries in this trial generated between $243 and $375/ac in gross economic return when compared with the revenue generated by the untreated check. Therefore, despite a lack of significant yield differences among treatments in this study, the 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, and apply the insecticide at a minimum of 5.9 lb product per acre. Growers interested in using Midac FC for springtail control in the MonDak growing area should probably integrate it with a neonicotinoid-treated seed treatment until its efficacy against these pests is better understood and characterized. This research should be continued to pursue consistently effective springtail management tools in this growing area. Finally, it should be noted that Bifender FC, a sprayable liquid insecticide product, was not registered for use in sugarbeet at the time this research was conducted or published.

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

Entomology Appendix A.: Agronomic, Rainfall, and Plot Maintenance Information

Location:	St. Thomas (Pembina County), ND – Wayne Lessard Farm – *Sugarbeet Root Maggot Trials*	
Seed variety:	Betaseed BTS 8524 RP	
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 = 3.0%	pH = 8.0
Soil texture:	29.1% sand 48.5% silt	22.4% clay
Previous crop:	Wheat (2019)	
Soil preparation:	Field cultivator (2x)	
Planting depth:	1.25"	
Herbicides applied:	June 12	Cornerstone 5 Plus (1.5 pt/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)
	June 29	Cornerstone 5 Plus (1.5 pt/ac) + Outlook (17 fl oz/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)
Fungicides applied:	Aug 13	Agri Tin (8 fl oz/ac) + Topsin (10 fl oz/ac)
	Aug 31	Priaxor Xemium (6.7 fl oz/ac) + Badge SC (1 pt/ac)
Rainfall (after seedbed preparation):	May 24	0.07"
	Total/May	**0.07"**
	June 3	0.11"
	June 4	0.01"
	June 6	0.07"
	June 7	1.58"
	June 8	0.91"
	June 9	0.01"
	June 10	0.03"
	June 11	0.01"
	June 17	0.16"
	June 20	0.72"
	June 25	0.15"
	June 26	0.20"
	June 30	2.5"
	Total/June	**6.46"**
	July 1	0.05"
	July 6	0.11"
	July 8	0.60"
	July 9	0.08"
	July 13	0.62"
	July 17	1.50"
	July 24	0.20"

July 25	0.36"
Total/July	**3.52"**
August 9	0.20"
August 14	0.22”
August 20	0.01”
August 30	0.10”
Total/August	**0.53"**
September 2	0.08”
September 3	0.13”
Total/September	**0.21"**

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

Location: Fairview (Richland County), MT – Pat Asbeck Farm – *Springtail Trial*

Seed variety: Betaseed BTS 8524 RP

Plot size: Two 25-ft long rows

Design: Randomized complete block, 4 replications

Soil name: Turner-Beaverton complex

Soil texture: 48.2% sand 36.6% silt 15.2% clay

Soil test: Organic matter = 3.0% pH = 8.0

Previous crop: Wheat (2019)

Soil preparation: Disc ripped (1x)
Surface leveled (1x)
Ridged (1x)

Planting depth: 1.25"

Planting date: May 7

Herbicides applied:

May 14	Roundup PowerMAX (32 fl oz/ac) + Hel-fire (1 qt/100 gal)
June 8	Roundup PowerMAX (32 fl oz/ac) + Hel-fire (1 qt/100 gal)
July 22	Roundup PowerMAX (22 fl oz/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)

Fungicides applied: August 20 Minerva (13 fl oz/ac)

Rainfall: (after seedbed preparation)**:**

May 8	0.05"
May 9	0.01"
May 12	0.07"
May 13	0.08”
May 23	0.64”
May 24	0.32”
May 26	0.01”
Total/May	**1.18"**
June 6	0.01"
June 7	0.01"

June 18	0.01"
June 19	0.05"
June 25	0.01"
June 27	0.05"
June 28	0.50"
June 29	0.09”
June 30	0.32”
Total/June	**1.05"**
July 3	0.17”
July 7	0.45”
July 8	0.01”
July 10	0.04”
July 18	0.32”
July 23	0.22”
July 25	0.01
Total/July	**1.22"**
August	0.02”
August	0.13”
August	0.07”
August	0.69”
Total/August	**0.91"**
September 7	0.29”
Total/September	**0.29"**

Stand counts: 25-ft of row, counted on June 1 (25 DAP), 9 (33 DAP), and 15 (39 DAP)
Harvest date: September 24
Yield sample size: One 10.9 linear row ft sample collected from each row of each two-row plot.

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 2019

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The fifth annual fungicide practices live polling questionnaire was conducted using Turning Point Technology at the 2020 Winter Sugarbeet Growers' Seminars held during January and February 2020. Responses are based on production practices from the 2019 growing season. The survey focuses on responses from growers in attendance at the Fargo, Grafton, Wahpeton, ND and Willmar, MN Grower Seminars. Respondents from each seminar indicated the county in which the majority of their sugarbeets were produced (Table 1-5). The average sugarbeet acreage per respondent grown in 2019 was calculated from Table 6 at between 400 and 599 acres.

Survey respondents were asked about soilborne disease and control practices. Sixty-six percent said their fields were affected by Rhizoctonia, 11% said Aphanomyces was the biggest issue, 11% said they had issues with multiple disease including Rhizoctonia, Aphanomyces, Fusarium and Rhizomania, six percent said they had no soilborne disease issues and three percent each listed either Fusarium or Rhizomania as their biggest issue (Table 8). 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. Fourteen percent reported more Rhizoctonia following dry beans, 11% saw more Rhizoctonia following any crop, &% said field corn, 3% said potatoes, 2% each stated small grains or other as the crop preceding sugarbeets they saw the most Rhizoctonia develop and less than 1% said sweet corn (Table 9). Of the respondents to the question regarding whether a specialty variety was used for Rhizoctonia, 67% respondents said yes they did use a specialty variety for Rhizoctonia while 33% said no (Table 10).

Participants were asked what methods were used to control Rhizoctonia and 39% said they used a seed treatment only, 27% used a seed treatment and a POST fungicide, 22% used a seed treatment plus an in-furrow fungicide while 11% 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 11). Seventy eight percent of respondents used a Kabina seed treatment while 10% used Systiva, 6% used Metlock Suite + Kabina, 4% used Vibrance, and 2% used Metlock Suite and Vibrance (Table 12). Ninety percent used an in-furrow starter fertilizer and 10% did not (Table 13). Of the respondents who applied an in-furrow fungicide, 38% used Azteroid, 11% used Quadris or generic and 4% used other; 48% of respondents used no fungicide in-furrow (Table 14).

Respondents were asked what POST fungicides were used to control Rhizoctonia and 44% did not use a POST fungicide to control Rhizoctonia. Forty two percent used Quadris or generic, 10% used Proline, 2% used Priaxor, 2% used Azteroid and 1% used other (Table 15). Participants were then asked to grade the effectiveness of the POST fungicides that were used. Thirty nine percent were unsure of their results, 37% said they had good results, 16% reported fair results, 7% said the fungicides performed excellently and 1% said they performed poorly (Table 16). Respondents were also asked how they applied POST fungicide and 57% stated they used a broadcast application and 43% used a band application (Table 17).

Participants were also asked about use of waste lime to control Aphanomyces. Seventy one percent of participants did not use waste lime in their fields while 19% used between 5 and 10 tons/acre while 10% used less than 5 tons/acre (Table 18). Respondents were also asked about their soil pH. Forty one percent said it was between 8.0 and

8.5, 33% said between 7.5 and 8.0, 18% between 7.0 and 7.5, 7% 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 19). The growers were asked how effective their waste lime application was. Sixty seven percent of respondents did not apply lime, 15% said they had good results, 9% said excellent, 6% were unsure, 2% 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 2019. Fifty eight percent of respondents said yes and 42% said no (Table 21).

Survey participants were then asked a series of questions regarding their CLS fungicide practices on sugarbeet in 2019. Twenty-five percent said that they used 4 sprays to control CLS, 19% used three applications, 16% used two applications, 14% used five applications, 11% used six applications, 8% used one application, 6% used seven applications, 1% applied more than seven application and less than 1% applied no CLS applications (Table 22). Respondents were then asked about the effectiveness of their CLS sprays. Sixty percent said they had good results, 22% said they had excellent results, 13% reported fair results, 3% reported poor results, 1% of respondents were unsure and less than 1% had no CLS applications (Table 23).

Respondents were asked about when their CLS application started and ended. Forty percent of participants said that they began their applications between July 1 and 10, 32% said it started between July 11 and 20, 16% said it was between July 21 and 31, 6% said before July 1, 6% said that CLS sprays started between August 1 and 10 and 1% said after August 10 (Table 24). Fifty two percent of respondents said that their last CLS spray was between September 1 and 10, 22% said between August 21 and 31, 16% said between September 11 and 20, 4% said they only made one or zero CLS applications, 2% said after September 20, 2% said between August 11 and 20, 2% said between August 1-10 and >1% before August 1 (Table 25).

Of the total fungicide applications for CLS, 52% did not use an aerial applicator, 30% used an aerial applicator for 1-20% of their applications, 8% used an aerial applicator for 21-40% of their fungicide applications, 5% said they used an aerial applicator for 100% of applications, 4% fell in the 41-60% range, 1% in the 61-80% range, and <1% in the 81-99% range (Table 26).

Regarding water usage in gallons per acre as applied by tractor, 49% of respondents used 16-20 gallons per acre, 36% used 11-15 gallons per acre, 10% used more than 20 gallons per acre, 4% used 6-10 gallons per acre and 1% used 1-5 gallons per acre (Table 27).

Fifty seven percent of survey respondents made 100% of their CLS applications by ground application. Nineteen percent made 81-99% of their application from the ground, another 10% made between 61 and 80% from the ground. Seven percent made between 41 and 60 percent of their CLS applications from the ground, five percent had all of their application made by air, two percent had between 21 and 40% of their applications made on the ground and 1% had between 1 and 20% of their applications made by ground application rig (Table 28). Survey respondents were also asked if they used mixtures in all of their CLS applications. Eighty seven percent said they used mixtures for all of their applications and 13% said they did not (Table 29).

Table 1. 2020 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2019.

County	Number of Responses	Percent of Responses
Barnes	-	-
Becker	1	3
Cass	4	11
Clay	15	42
Norman[1]	10	28
Ransom	-	-
Richland	1	3
Steele	-	0
Trail	4	11
Wilkin[2]	1	3
Total	36	101

Table 2. 2020 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2019.

County	Number of Responses	Percent of Responses
Cavalier	-	-
Grand Forks	-	-
Kittson	10	20
Marshall	2	4
Nelson	-	-
Pembina	14	27
Polk	4	8
Ramsey	-	-
Walsh	21	41
Other	-	-
Total	51	100

Table 3. 2020 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2019.

County	Number of Responses	Percent of Responses
Grand Forks	10	15
Mahnomen	-	-
Marshall	11	16
Nelson	-	-
Pennington/Red Lake	-	-
Polk	36	54
Steele	-	-
Traill	4	6
Walsh	4	6
Other	2	3
Total	67	100

Table 4. 2020 Wahpeton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2019.

County	Number of Responses	Percent of Responses
Cass	-	-
Clay	-	-
Grant	2	18
Otter Tail	-	-
Ransom	-	-
Richland	1	9
Roberts	-	-
Stevens	-	-
Traverse	-	-
Wilkin	8	73
Total	11	100

Table 5. 2020 Willmar Grower Seminar - Number of survey respondents by county growing sugarbeet in 2019.

County		Number of Responses	Percent of Responses
Chippewa		31	34
Kandiyohi		10	11
Pope		-	-
Redwood		3	3
Renville		29	32
Stearns		-	-
Stevens		4	4
Swift		9	10
Other		5	6
	Total	91	100

Table 6. Total sugarbeet acreage operated by respondents in 2019.

		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	32	16	9	9	6	25	9	6	3	3	13
Grafton	49	10	6	8	12	16	19	6	14	-	8
Grand Forks	66	9	6	6	5	26	15	6	17	9	2
Wahpeton	8	-	12	13	25	13	13	-	-	25	-
Willmar	90	8	10	13	12	16	20	3	12	4	1
Total	247	9	8	10	10	20	17	5	12	5	4

Table 7. What crop preceded most of your sugarbeet acres?

Location	Respondents	Corn	Sweet Corn	Soybean	Dry edible beans	Potatoes	wheat	other
			--------------------% respondents--------------------					
Fargo	32	3	3	16	-	-	78	-
Grafton	55	-	-	2	4	7	82	5
Grand Forks	66	-	-	5	2	2	92	-
Wahpeton	10	20	-	10	-	-	70	-
Willmar	90	72	10	14	1	-	1	1
Total	253	27	4	9	2	2	55	2

Table 8. What soil-borne diseases affected your sugarbeet production in 2019?

		Root disease					
Location	Respondents	Rhizoctonia	Aphanomyces	Fusarium	Rhizomania	All	Neither
		----------------------------% of respondents------------------------					
Fargo	33	45	9	6	-	24	15
Grafton	49	90	10	-	-	-	-
Grand Forks	69	59	16	-	3	16	6
Wahpeton	10	80	10	-	-	10	-
Willmar	88	64	9	6	6	9	7
Total	249	66	11	3	3	11	6

Table 9. With which of the preceeding crops do you see more Rhizoctonia in sugarbeet? **

Location	Respon dents	Field Corn	Sweet Corn	Soybean	Dry edible beans	Potatoes	Small grains	other	Any crop
		---------------------% respondents---------------------							
Fargo	27	7	-	81	4	-	4	-	4
Grafton	49	-	-	47	27	12	4	2	8
Grand Forks	58	3	-	53	21	2	2	5	14
Wahpeton	8	13	-	75	-	-	-	-	13
Willmar	77	14	1	66	5	-	-	-	13
Total	219	7	<1	61	14	3	2	2	11

Table 10. Have you used a specialty variety for Rhizoctonia in 2019?

Location	Respondents	Yes	No
		---------------------% respondents---------------------	
Fargo	34	71	29
Grafton	49	67	33
Grand Forks	67	61	39
Wahpeton	10	50	50
Wilmar	87	72	28
Total	247	67	33

Table 11. What methods were used to control *Rhizoctonia solani* in 2019?

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	32	38	31	28	3	-
Grafton	50	20	22	30	26	2
Grand Forks	65	32	26	34	5	3
Wahpeton	10	100	-	-	-	-
Willmar	88	48	19	23	10	-
Total	245	39	22	27	11	1

Table 12. Which seed treatment did you use to control Rhizoctonia solani in 2019?

		Seed treatment				
Location	Respondents	Kabina	Metlock Suite + Kabina	Vibrance	Systiva	Metlock Suite + Vibrance
		------------------------------% of respondents----------------------------				
Fargo	30	79	6	2	11	2
Grafton	48	75	2	6	15	2
Grand Forks	63	79	6	2	11	2
Wahpeton	10	80	10	10	-	-
Total	151	78	6	4	10	2

Table 13. Did you apply any in-furrow starter fertilizer in 2019?

Location	Respondents	Variety type	
		Yes	No
		---------------------% respondents---------------------	
Fargo	35	94	6
Grafton	49	88	12
Grand Forks	70	97	3
Wahpeton	10	30	70
Total	164	90	10

Table 14. Which fungicide did you apply in-furrow to control R. solani in 2019?

Location	Respondents	In-furrow fungicide use			
		AZteroid	Quadris or generic	Other	None
		------------------------------% of respondents----------------------------			
Fargo	33	30	15	-	55
Grafton	51	65	10	-	25
Grand Forks	69	49	7	6	38
Wahpeton	10	-	-	-	100
Willmar	87	20	14	6	61
Total	250	38	11	4	48

Table 15. Which POST fungicide did you use to control R. solani in 2019?

Location	Respondents	POST fungicide					
		AZteroid	Quadris or Generic	Proline	Priaxor	Other	None
		------------------------------% of respondents----------------------------					
Fargo	33	-	39	3	3	3	52
Grafton	53	4	57	15	2	-	23
Grand Forks	68	4	50	6	-	-	40
Wahpeton	10	-	-	10	-	-	90
Willmar	86	-	30	14	2	1	52
Total	250	2	42	10	2	1	44

Table 16. How effective were your POST fungicides at controlling Rhizoctonia solani in 2019?

Location	Respondents	Effectiveness of fungicides				
		Excellent	Good	Fair	Poor	Unsure
		------------------------------% of respondents----------------------------				
Fargo	29	7	24	31	-	38
Grafton	48	6	54	25	-	15
Grand Forks	63	13	46	2	-	40
Wahpeton	8	-	-	13	-	88
Willmar	78	3	27	18	3	50
Total	226	7	37	16	1	39

Table 17. How did you apply POST fungicide for controlling Rhizoctonia Solani?

Location	Respondents	Band	Broadcast
		------------------------% of respondents------------------------	
Fargo	27	41	59
Grafton	45	20	80
Grand Forks	54	56	44
Wahpeton	1	-	100
Willmar	54	52	48
Total	181	43	57

Table 18. What rate of precipitated calcium carbonate (waste lime) did you use in 2019?

		Lime use rate		
Location	Respondents	None	<5 T/A	5-10 T/A
		------------------------------% of respondents----------------------------		
Fargo	36	61	3	36
Grafton	52	75	-	25
Grand Forks	69	77	-	23
Wahpeton	9	44	-	56
Willmar	88	70	27	2
Total	254	71	10	19

Table 19. What is your soil pH?

Location	Respondents	Soil pH					
		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	36	-	3	8	47	42	-
Grafton	51	-	12	27	22	35	4
Grand Forks	68	3	4	15	34	44	-
Wahpeton	10	-	10	20	30	40	-
Total	165	1	7	18	33	41	1

Table 20. How effective was waste lime at controlling Aphanomyces in 2019?

Location	Respondents	Waste lime effectiveness					
		Excellent	Good	Fair	Poor	Unsure	No Lime
		------------------------------% of respondents----------------------------					
Fargo	36	11	25	-	-	6	58
Grafton	52	13	8	4	-	4	71
Grand Forks	67	9	12	1	-	4	73
Wahpeton	10	40	20	-	-	10	30
Wilmar	87	2	18	3	2	7	67
Total	252	9	15	2	1	6	67

Table 21. Did you use a specialty variety for Aphanomyces in 2019?

Location	Respondents	Variety type	
		Yes	No
		---------------------% respondents---------------------	
Fargo	34	56	44
Grafton	47	49	51
Grand Forks	66	47	53
Wahpeton	10	30	70
Willmar	87	30	70
Total	244	42	58

Table 22. How many fungicide applications did you make to control CLS in 2019?

Location	Respondents	Number of applications								
		0	1	2	3	4	5	6	7	>7
		-----------------------------% of respondents-------------------------								
Fargo	39	-	-	5	23	56	13	3	-	-
Grafton	47	2	28	47	21	2	-	-	-	-
Grand Forks	70	-	11	22	34	31	1	-	-	-
Wahpeton	10	-	-	-	-	30	50	20	-	-
Willmar	87	-	-	1	6	17	28	30	16	2
Total	253	0	8	16	19	25	14	11	6	1

Table 23. How effective were your fungicide applications on CLS in 2019?

Location	Respondents	Effectiveness of CLS sprays					
		Excellent	Good	Fair	Poor	Unsure	No applications
		------------------------------% of respondents-------------------------					
Fargo	40	13	75	10	3	-	-
Grafton	51	25	57	14	-	2	2
Grand Forks	71	31	62	6	-	1	-
Wahpeton	10	10	20	60	10	-	-
Willmar	83	18	59	14	7	1	-
Total	255	22	60	13	3	1	0

Table 24. What date was your first CLS application?

		Date of first CLS application					
Location	Respondents	Before July 1	July 1-10	July 11-20	July 21-31	August 1-10	After August 10
		-----------------------------% of respondents-----------------------------					
Fargo	36	3	47	39	8	3	-
Grafton	51	-	14	31	31	20	4
Grand Forks	68	-	12	57	28	3	-
Wahpeton	10	-	80	20	-	-	-
Willmar	85	15	69	11	1	2	1
Total	250	6	40	32	16	6	1

Table 25. What date was your last CLS application in 2019?

		Date of last CLS application							
Location	Respondents	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	38	-	-	-	26	55	16	3	-
Grafton	49	2	6	-	27	47	4	2	12
Grand Forks	69	-	1	3	26	55	12	-	3
Wahpeton	10	-	-	-	10	50	40	-	-
Willmar	86	-	-	4	16	52	23	4	1
Total	252	0	2	2	22	52	16	2	4

Table 26. 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	38	29	34	26	5	3	-	3
Grafton	50	78	8	-	2	2	-	10
Grand Forks	68	56	26	4	6	-	-	7
Wahpeton	10	60	30	10	-	-	-	-
Willmar	88	44	43	8	2	-	1	1
Total	254	52	30	8	4	1	0	5

Table 27. 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	38	-	-	63	32	5
Grafton	48	2	13	46	38	2
Grand Forks	68	3	7	54	32	3
Wahpeton	10	-	-	20	80	-
Willmar	86	-	-	5	72	23
Total	250	1	4	36	49	10

Table 28. What percent of total fungicide applications for CLS were made by ground application?

		Percentages						
		0%	1-20%	21-40%	41-60%	61-80%	81-99%	100%
Location	Respondents							
		------------------------------% of respondents------------------------------						
Fargo	38	3	3	8	13	16	21	37
Grafton	50	8	-	-	2	2	10	78
Grand Forks	69	6	-	-	7	13	19	55
Wahpeton	10	-	-	-	-	10	50	40
Total	167	5	1	2	7	10	19	57

Table 29. Did you use fungicide mixtures for all of your CLS applications?

Location	Respondents	Yes	No
		---------------------% respondents---------------------	
Fargo	36	86	14
Grafton	49	82	18
Grand Forks	66	94	6
Wahpeton	9	100	-
Wilmar	88	84	16
Total	248	87	13

EVALUATION OF AT-PLANTING FUNGICIDE TREATMENTS FOR CONTROL OF *RHIZOCTONIA SOLANI* ON SUGARBEET, 2020

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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, 6-8). 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 574RR) with a 2-year average Rhizoctonia rating of 4.4 (10) 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 (50 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 12 at 4.5-inch seed spacing. Counter 20G (8.9 lb A^{-1}) was applied at planting and Lorsban 4E (2 pt A^{-1}) was applied June 5 for control of sugarbeet root maggot. Glyphosate (4.5 lb product ae/gallon, 28 oz A^{-1}) was applied on June 2 and July 29 and Sequence (glyphosate + S-metolachlor, 2.5 pt A^{-1}) with additional glyphosate (8 oz A^{-1}) was applied on June 19 for control of weeds. Cercospora leafspot was controlled by Minerva Duo (16 fl oz A^{-1}) on August 4 and Proline 480 SC + Supertin (5 + 8 oz A^{-1}) on August 24 applied in 20 gallons water A^{-1} at 100 psi.

Stand counts were done beginning 9 days after planting through 13 weeks after planting. Plots were defoliated mechanically and harvested using a mechanical harvest on September 17. The middle two rows of each plot were weighed for root yield and ten representative roots from each plot were analyzed for quality at the American Crystal Sugar Company Quality Tare Lab, East Grand Forks, MN. The number of harvested roots were counted per plot and twenty roots were rated for severity of RCRR using a 0 to 10 scale (0 = healthy root, 10 = 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	0.015 + 0.031 + 7 g a.i./unit seed
Seed	Metlock Suite + Vibrance	Metconazole + Rizolex + Sedaxane	0.015 + 0.031 + 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	Elatus[Z]	Azoxystrobin + Benzovindiflupyr	7.1 oz product A^{-1}
In-furrow	Priaxor	Pyraclostrobin + fluxapyroxad	6.7 fl 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}
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	Priaxor	Pyraclostrobin + fluxapyroxad	6.7 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; 6.7 fl oz priaxor contains 66 g pyraclostrobin and 33 g fluxapyroxad; 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 & DISCUSSION

Monthly rainfall (in inches) at Crookston was as follows: April (1.92), May (1.0), June (4.52), July (7.52), and August (3.02) with 30-year averages of 1.2, 2.4, 4.0, 3.3, and 2.81, respectively. By 2 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 and untreated control plots was higher compared with the seed treatments at 2 weeks after planting (Fig. 1). Stands were significantly lower during the 13-week stand count period for seed treatments compared with in-furrow treatments based on a contrast analysis. It is unusual for stand establishment to be reduced for seed treatments compared to in-furrow fungicides at this location if planting was followed by dry soil conditions. From 3 to 5 WAP there was no difference among seed treatments and in-furrow treatments for stands ($p \leq 0.05$). Until 9 WAP, the stand counts were steady for most treatments and similar to stands at 2 WAP indicating very low disease pressure during this time period. However, by 13 WAP, untreated control lost 14%, seed treatments lost 10 % and in-furrow treatments lost about 6% of stands compared to stands at 9 WAP, indicating the efficacy of in-furrow treatments could last a little longer compared to seed treatments. The SDHI fungicides that are currently labeled for Rhizoctonia provide excellent stand protection for 4 to 5 WAP depending on individual field conditions.

Rainfall in July helped some root rot development later in the season and resulted in statistical differences among treatments for root rot incidence and severity, root yield, % sucrose and recoverable sucrose per acre (RSA). Performance of individual treatments compared to untreated control is presented in Table 2. The in-furrow fungicides resulted in higher number of harvestable roots, lower root rot severity and incidence, higher root yield, and higher RSA. Even though the treatment including 6 fl oz rate of Quadris with Kabina (14 g per unit) could provide stand protection as well as higher RSA at the end of the season (Table 2), it is recommended to use 9.5 fl oz rate for Quadris in-furrow application. It is also important to know that certain isolates of *R. solani* AG 2-2 have low sensitivity to Quadris on artificial media (1,9), but) but could be managed with labeled field rates of Quadris under greenhouse conditions (1). While it is important to note that use of in-furrow fungicides comes with some risk of stand loss under dry and cool soil conditions, the benefits of stand protection and higher RSA will outweigh the risks in fields with severe Rhizoctonia history or risk.

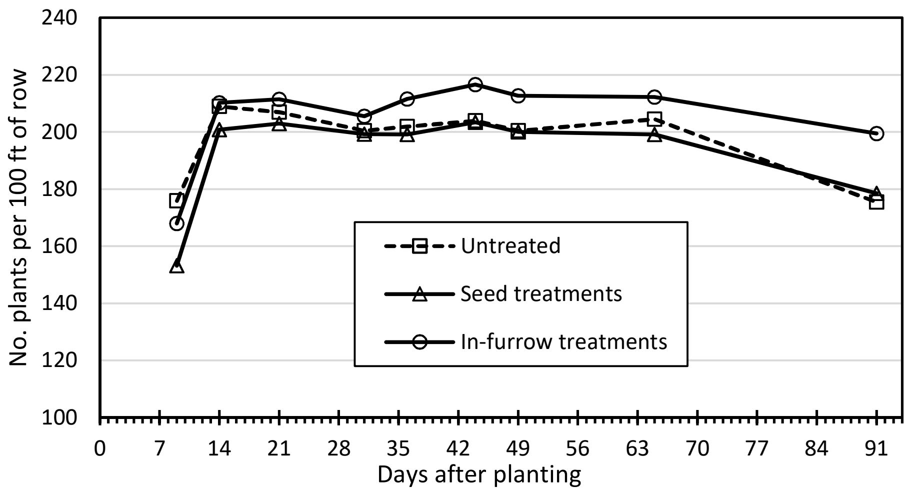

Fig. 1. Emergence and stand establishment for seed treatment and in-furrow fungicides compared to an untreated control in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2. For each stand count date, stands are significantly different (P=0.05) when comparing in-furrow treatments to seed treatments.

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	13-wk stand Plants/100 ft[V]	No. harv. Roots/100 ft[V]	RCRR (0-10)[VW]	RCRR % incidence[VX]	Yield[V]	Sucrose[V] %	Sucrose[V] lb A^{-1}	Sucrose[V] lb ton^{-1}
Untreated control	176 efd	157 e-h	3.0 d-g	55.0 b-f	24.9 def	15.9	7355 def	293
Kabina ST	195 bc	176 b-e	2.9 c-g	57.5 def	25.8 c-f	16.5	7871 b-f	305
Met. Suite + 7 g Kabina	183 b-e	165 c-f	3.3 d-g	61.3 efg	27.1 b-e	15.6	7717 c-f	284
Met. Suite + 1 g Vibrance	173 ef	139 gh	3.9 f-h	75.0 fg	23.3 fg	16.3	7034 fg	300
Systiva	175 efd	150 fgh	3.4 efg	66.3 efg	24.0 ef	16.5	7292 ef	305
Vibrance	182 b-e	161 c-f	4.1 gh	81.3 g	24.6 def	16.1	7287 ef	295
Kabina ST + *Quadris I-F (6 oz A^{-1})	204 ab	193 ab	1.1 ab	35.0 ab	28.9 abc	17.1	9206 a	319
AZteroid in-furrow	194 bc	177 b-e	1.3 ab	38.8 a-d	29.2 abc	16.7	9012 ab	309
Elatus in-furrow[Y]	215 a	203 a	0.9 a	21.3 a	31.3 a	16.1	9248 a	296
Priaxor in-furrow	195 bc	176 b-e	2.3 b-e	56.3 c-f	26.9 b-e	16.3	8075 a-f	300
Proline in-furrow	191 bcde	178 b-e	2.7 c-f	55.0 b-f	27.6 bcd	16.0	8164 a-f	295
Propulse in-furrow	207 ab	184 abc	2.0 abc	47.5 b-e	29.7 ab	16.1	8681 abc	294
Quadris in-furrow	203 ab	183 a-d	1.7 abc	36.3 abc	28.6 abc	16.3	8584 a-d	300
Xanthion in-furrow	193 bcd	165 c-f	2.2 b-e	52.5 b-e	28.1 a-d	16.4	8517 a-e	303
ANOVA P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.7519	<0.0001	0.7891
LSD (P = 0.05)	18.2	22.3	1.3	20.8	3.5	NS	1274.1	NS
Seed vs In-furrow Contrast analysis[Z]								
Mean of seed trmts	179	155	3.8	69.4	24.2	16.1	7176	296
Mean of in-furrow trmts	200	181	1.9	43.9	28.8	16.3	8612	300
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.5282	<0.0001	0.5812

[V] Values represent mean of 4 plots; treatments with the same letter are not significantly different; NS = not significantly different at P = 0.05
[W] RCRR = Rhizoctonia crown and root rot; 0-10 scale, 0 = root clean, no disease, 10 = 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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LITERATURE CITED

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. 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.

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. 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.

9. 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.

10. Niehaus, W.S. 2020. Results of American Crystal's 2019 Official Coded Variety Trials. 2019 Sugarbeet Res. Ext. Rept. 50:195-236.

INTEGRATED MANAGEMENT OF RHIZOCTONIA ON SUGARBEET WITH RESISTANT VARIETIES, AT-PLANTING TREATMENTS, AND POSTEMERGENCE FUNGICIDES, 2020

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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 diseases can occur throughout the growing season and reduce plant stand, root yield, and quality (3-7). 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 (4-7).

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 resistant (R) and moderately susceptible (MS) varieties 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 resistant and moderately susceptible varieties were 3.7 and 4.4, respectively (8).

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 50 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 19 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 05 for control of root maggot. Roundup Power Max (28 oz/A) on Jun 2, Sequence (glyphosate + S-metolachlor, 2.5 pt/A) + Roundup (8 oz/A) was applied on June 19 and Roundup Power Max (28 oz/A) on Jul 29 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 12 (4-leaf stage, ~3.5 weeks after planting) or June 25 (8-leaf stage, ~5 weeks after planting). Cercospora leaf spot (CLS) was controlled by Minerva Duo (16 fl oz/A) on Aug 04 and Super Tin (8 oz) + Proline (5 oz/A) on Aug 24 applied in 20 gallons water/A at 100 psi. The trial was harvested on Sept 21.

MDFC site. Prior to planting, soil was infested with a mixture of four isolates of *R. solani* AG 2-2-infested whole barley (50 kg ha^{-1}). The trial was sown in six-row plots (22-inch row spacing, 25-ft rows) on May 21 at 4.5-inch seed spacing. Dual Magnum (0.5 pt/A) + Ethofumesate 4SC (2 pt/A) was applied PRE on May 21. A tank-mix of Roundup PowerMax (5.5 lb product ae/gallon), N-tense (10 fl oz/A), Outlook (12 fl oz/A), and Ethofumesate 4SC (4 fl oz/A) was applied on June 19 and Outlook (12 fl oz/A) was applied on June 30. Postemergence azoxystrobin was applied in a 7-inch band on June 17 (5-leaf stage, 3 WAP) or June 24 (8-leaf stage, 4 WAP). Cercospora leaf spot was controlled by application of Provysol + Badge SC (5 oz/A+2 pt/A) on Jul 2, AgriTin + Manzate (8 fl oz/A+52 fl oz/A) on Jul 10, Proline 480 SC + Badge SC + Prefer 90 (5.7 fl oz/A+2 pt/A+0.125% v/v) on Jul 20, AgriTin + Manzate (8 fl oz/A+52 fl oz/A) on Jul 27, Inspire + Badge SC (7 fl oz/A+2 pt/A) on Aug 8, AgriTin + Manzate (8 fl oz/A+52 fl oz/A) on Aug 19, and Badge SC (4 pt/A) on Sept 2. All fungicides for CLS control were applied utilizing a 3pt-mounted sprayer dispersing the products in broadcast pattern at a water volume of 20 GPA with TeeJet 11002 air induction nozzles at 40 psi. The trial was harvested on Sept 29.

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 = 3.7) and moderately susceptible (2-year average rating = 4.4) 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 2020 crop season based on weather stations.

	Precipitation in inches		
Month	NWROC	MDFC	SMBSC
April	1.92	2.05	0.19
May	1.00	0.91	0.55
June	4.52	2.98	4.15
July	7.52	6.35	2.94
August	3.02	3.59	4.07
September	0.44	0.88	1.69
October	0.49	0.86	0.99
Total	**18.91**	**17.62**	**14.58**

SMBSC site. Prior to planting, soil was infested with a mixture of four isolates of *R. solani* AG 2-2-infested whole barley (50 kg ha^{-1}). The trial was sown in six-row plots (22-inch row spacing, 35-ft rows) on May 07 at 4.77-inch seed spacing. Inoculum was incorporated using the 8.5 foot field cultivator followed by a drag. Weeds were controlled using a preemergence application of Dual Magnum (0.5 pt/A) plus Norton (2 pt/A) and by postemergence applications of Roundup PowerMax (32 oz/A) on Jun 03 followed by Sequence (2.5 pts/A) on Jun 12 and Jun 23. Postemergence azoxystrobin timings were applied on June 09 (4-leaf, ~5 weeks after planting), or June 22 (8-leaf, ~6.5 weeks after planting) as 7 inch bands using 4001E nozzles at 35 psi. Cercospora leaf spot was managed by fungicide applications of Agritin + Dithane on Jul 03, Inspire XT + Dithane on Jul 13, SuperTin + Dithane on Jul 22, Minerva + Badge on Aug 03, SuperTin + Dithane on Aug 18, and Provysol + Dithane on Aug 27. All fungicides for CLS control were applied in a water volume of 21 GPA with 110025 nozzles at 50 psi. The trial was harvested on Sept 16.

At NWROC stand counts were done beginning 2 weeks after planting through 11 weeks after planting. At MDFC stand counts were done 2, 3.5, 4 and 5 weeks after planting. At SMBSC stand counts were done 3, 5, and 7 weeks after planting (WAP). Data were collected for number of harvested roots (NWROC and SMBSC), yield, and quality. Twenty roots per plot also were arbitrarily selected and rated for severity of RCRR using a 0 to 10 scale with 10% increment for each point (0 = 0%, healthy root; 10 = 100%, root completely rotted). Disease incidence was reported as the percent of rated roots with a root rot rating > 0.

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 2020 growing season was dry at the NWROC during the period of May – early June resulting in lower early season disease pressure. Rainfall at the NWROC was just 1.00 in. during the month of May compared to a 30-year average of 2.44. Resistant (R) and moderately susceptible (MS) varieties had similar stands from 2 to 11 weeks after planting (WAP). AT 2, 3 and 5 WAP, Systiva, Systiva + Quadris in-furrow (I-F) had higher stands followed by untreated + Quadris I-F and lowest for untreated control plots. At 4 and 6 to 11 WAP, Systiva and Systiva + Quadris I-F had higher stands followed by Systiva and untreated + Quadris I-F and lowest for untreated plots. Quadris in-furrow application caused some stand loss whereas Quadris I-F on Systiva treated seed did not show this stand reduction in 2020. Control plants had 165 plants/100 ft. row at 4.5 WAP indicating low early season disease pressure. Stand reduction with Quadris was also observed in 2017 to 2019 (4-6). Very low root rot severity and incidence were observed for both varieties at harvest. Moderately susceptible variety had significantly lower percent sucrose and higher recoverable sucrose A^{-1} (RSA) (Table 3). Significant variety by postemergence treatment interaction was observed for RSA (Table 3). Both 4- and 8-leaf postemergence applications resulted in higher RSA for both varieties but susceptible variety had much higher recovery of RSA compare to the resistant variety (Fig. 2). A significant at-plant by postemergence treatment interaction was observed for root rot severity and incidence, root yield and RSA (Table 3). Both 4- and 8-leaf postemergence applications on untreated seed, Systiva, and Systiva + Quadris I-F resulted in higher RSA with more RSA recovery on untreated and Systiva seed compared to Systiva + Quadris I-F treatment (Fig. 3). Both 4- and 8-leaf postemergence applications resulted in lower root rot with 8-leaf stage better compared to the 4-leaf stage (Fig. 4).

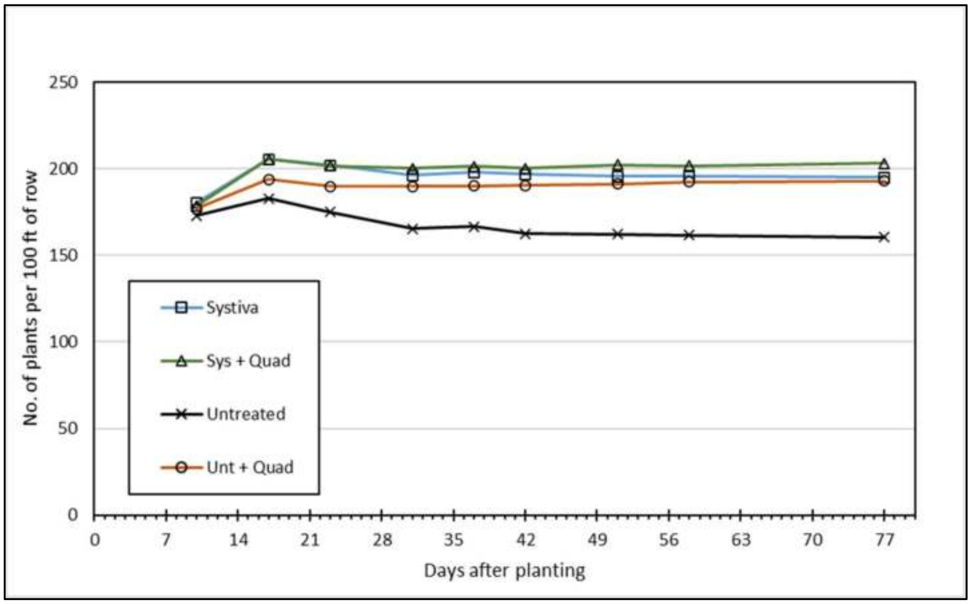

Fig. 1. NWROC site: Emergence and stand establishment for fungicide treatments at-planting or untreated control. Statistical significance of data at each timepoint was discussed in the text. Data shown represents mean of 24 plots averaged across varieties and postemergence treatments.

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 (0-10)[TU]	RCRR % incidence[TV]	Yield ton A^{-1}[T]	Sucrose[T] %	Sucrose[T] lb ton^{-1}	Sucrose[T] lb A^{-1}
Variety[W]							
Resistant	160	0.75	20	22.5 b	18.5 a	347	7809 b
Moderately Susceptible	167	1.04	22	27.0 a	17.9 b	335	9048 a
ANOVA p-value	0.1998	0.2003	0.5228	0.0011	0.0452	0.0553	0.0016
At-planting treatments[X]							
Untreated control	144 c	1.35 b	27 b	24.2 bc	18.1	338	8155
Systiva	163 b	1.31 b	29 b	23.9 c	18.1	340	8108
Quadris In-furrow	171 a	0.58 a	18 a	25.4 ab	18.2	340	8596
Systiva + Quadris I-F	175 a	0.33 a	10 a	25.7 a	18.4	346	8857
ANOVA p-value	<0.0001	<0.0001	0.0002	0.0371	0.1731	0.1547	0.0063
LSD (*P* = 0.05)	7.7	0.3	7.8	1.4	NS	NS	448
Postemergence fungicide[Y]							
None	155 b	1.8 c	38 c	23.5 b	18.0 b	337 b	7921 b
4-leaf Quadris	169 a	0.7 b	18 b	25.2 a	18.3 a	343 a	8626 a
8-leaf Quadris	165 a	0.2 a	8 a	25.6 a	18.3 a	343 a	8739 a
ANOVA p-value	<0.0001	<0.0001	<0.0001	0.0002	0.0367	0.0460	<0.0001
LSD (*P* = 0.05)	5.2	0.24	4.0	0.98	0.20	4.7	332
Vty x at-plant	0.3200	0.1404	0.2079	0.9551	0.7743	0.7949	0.9188
Vty x Post	**0.0184**	0.2702	0.9188	0.0748	0.3426	0.3392	**0.0251**
At-plant x Post	**0.0015**	**<0.0001**	**<0.0001**	**0.0171**	0.1986	0.2448	**0.0019**
Vty x At-plant x Post	0.4754	0.3439	0.4536	0.6947	0.5382	0.6292	0.5773

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, 10 = 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)

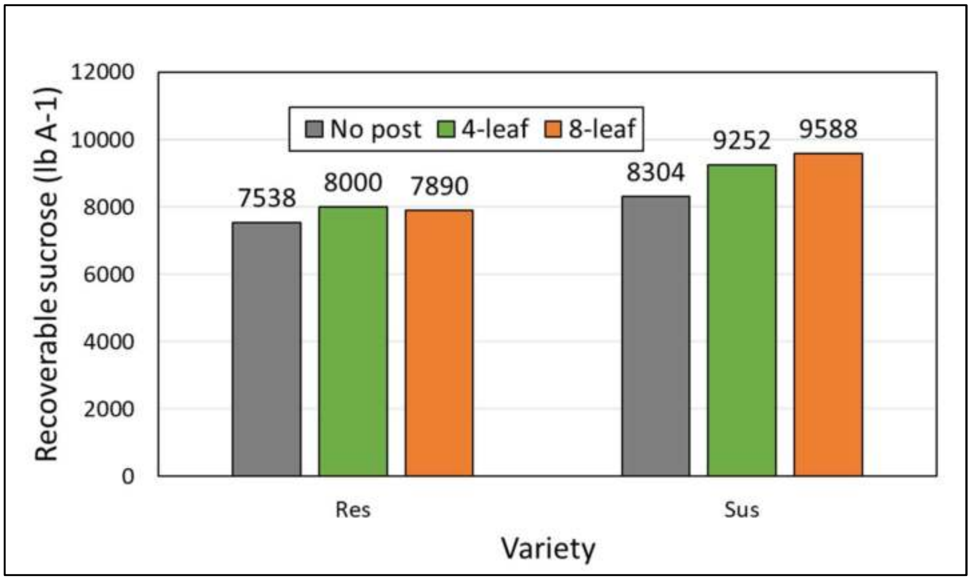

Fig. 2. NWROC site: Effect of variety and postemergence (PE) treatment interaction on recoverable sucrose. Data shown represents mean of 16 plots averaged across at-planting treatments.

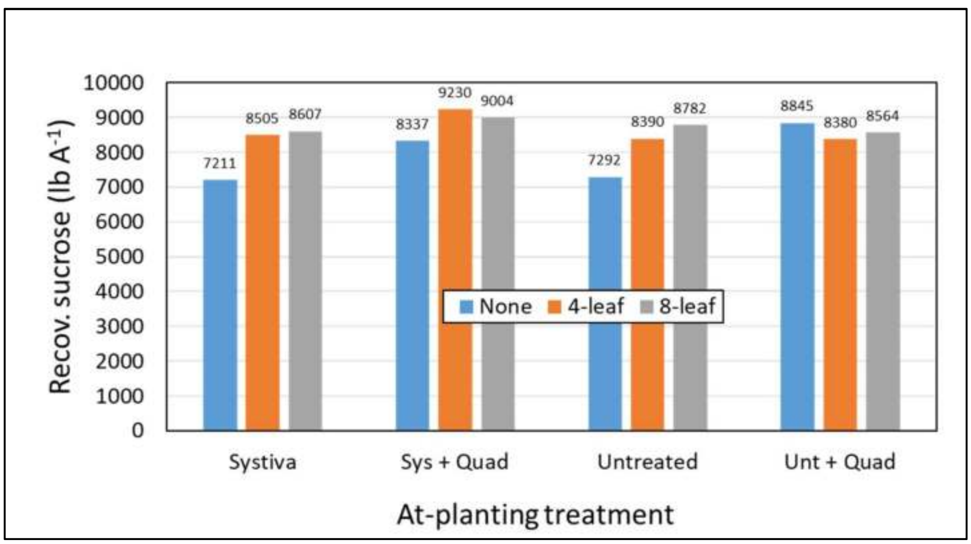

Fig. 3. NWROC site: Effect of at-panting and postemergence (PE) treatment interaction on recoverable sucrose. Data shown represents mean of 8 plots averaged across varieties.

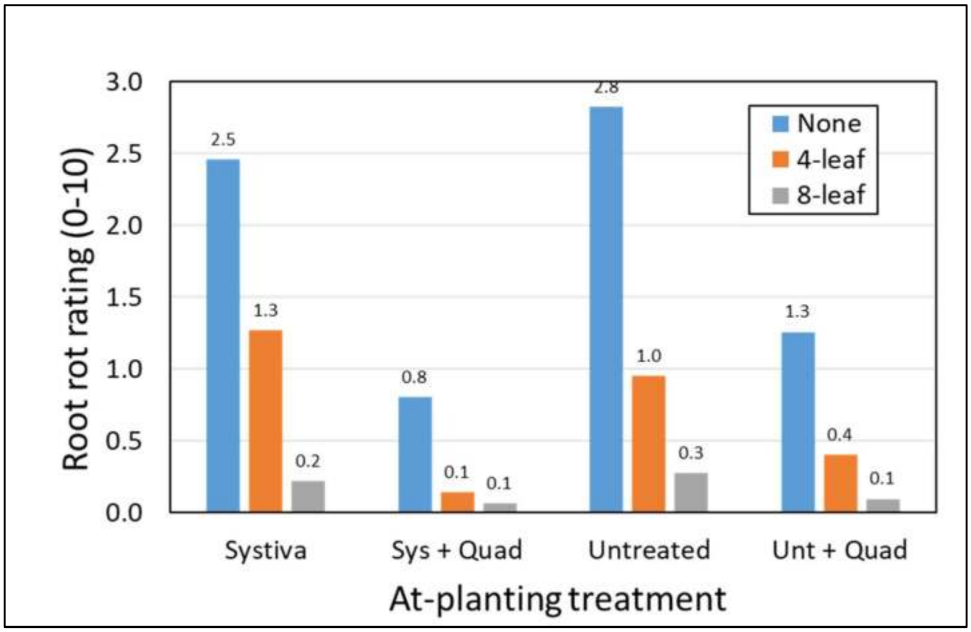

Fig. 4. NWROC site: Effect of at-panting and postemergence (PE) treatment interaction on Rhizoctonia root rot rating. Data shown represents mean of 8 plots averaged across varieties.

MDFC site: The Rhizoctonia disease pressure at this site was none to very low from planting until harvest and no statistical differences were observed for stand counts or harvest parameters except stands at 3 WAP were higher for the susceptible variety, root rot rating and % tare were lower at harvest for the susceptible variety, and purity was higher for the susceptible variety (Table 4). Variety x at-plant x postemergence treatment 3-way interaction was observed for root rot rating (Table 4).

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 (Apron + Maxim on all seed)	RCRR (0-10) [TU]	RCRR % incidence[TV]	Purity	% Tare	Yield ton A^{-1} [T]	Sucrose[T] %	Sucrose lb ton^{-1}	Sucrose lb A^{-1}
Variety[W]								
Resistant	0.3 b	11	89.7	1.7	29.4	17.5	298	8755
Moderately Susceptible	0.2 a	8	90.3	1.1	31.3	17.5	299	9359
ANOVA p-value	**0.0393**	0.0531	**0.0132**	**0.0036**	0.1803	0.7040	0.8305	0.1445
At-planting treatments[X]								
Untreated control	0.2	10	90.2	1.2	30.8	17.5	299	9219
Systiva	0.3	11	89.9	1.5	29.7	17.5	298	8856
Systiva + Quadris I-F	0.2	9	90.0	1.4	30.3	17.5	298	9056
ANOVA p-value	0.7056	0.7673	0.7725	0.9060	0.1959	0.8933	0.8384	0.4351
LSD (*P* = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Postemergence fungicide[Y]								
None	0.2	10	90.0	1.4	30.3	17.5	298	9044
4-leaf Quadris	0.2	10	90.0	1.4	30.4	17.5	298	9069
8-leaf Quadris	0.2	10	90.0	1.3	30.5	17.5	299	9115
ANOVA p-value	0.1259	0.2052	0.9213	0.3773	0.4089	0.8024	0.8391	0.5009
LSD (*P* = 0.05)	NS	NS		NS	NS	NS	NS	NS
Vty x At-plant	0.1576	0.3811	0.3979	0.8450	0.2074	0.8491	0.9540	0.3983
Vty x Post	0.2104	0.1825	0.8085	0.7519	0.3821	0.7036	0.9162	0.3126
At-plant x Post	0.1088	0.0331	0.5281	0.2075	0.0732	0.0673	0.1157	0.0340
Vty x At-plant x Post	**0.0238**	0.3939	0.9668	0.0975	0.4165	0.9882	0.9893	0.5402

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; 0-10 scale (adjusted rating), 0 = root clean, no disease, 10 = 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: Good rainfall during June resulted in moderate disease pressure early in the season (Table 2). Resistant variety had higher stands at 3, 5, and 7 WAP compared to moderately susceptible variety (Fig. 5) but the difference is not statistically significant (Fig. 5). Systiva and Systiva + Quadris I-F had higher stands at 3, 5, and 7 WAP compared to untreated control treatment (Fig. 6). Untreated control had 165 plants/100 ft. row at 7 WAP indicating moderate early season disease pressure at this site and hence Systiva and Systiva + Quadris I-F had 198 and 205 plants/100 ft. row, respectively (Fig. 6). In contrary to 2018 observations (4), Quadris I-F did not reduce stands at this site in 2020 which is very similar to 2019 observation. Some rainfall during July and normal rainfall during August (Table 2) resulted in moderate late season disease pressure at this site. Resistant variety had higher % sucrose and RST and lower root rot severity and incidence compared to the susceptible variety (Table 5). Both 4- and 8-leaf postemergence application resulted in lower root rot severity and incidence, higher % sucrose and RST compared to no postemergence control (Table 5). A significant variety by postemergence treatment interaction was observed for root yield and RSA (Table 5). Wile both varieties responded to 4- or 8-leaf application, the benefit was higher for the susceptible variety as the genetic resistance to Rhizoctonia is weak in this variety. Both 4- and 8-leaf applications resulted in increase in RSA by about 1700 lbs/A for the resistant variety and about 2800 lbs/A for the susceptible variety (Fig 7). Similar benefit from postemergence Quadris application at this location was also evident in 2016 to 2019 (4-7). Both 4- and 8-leaf applications resulted in increase in root yield by 5 tons/A for the resistant variety and 10 tons/A for the susceptible variety (Fig 8). This trial clearly demonstrates the importance of choosing a resistant variety and use of postemergence fungicides for managing Rhizoctonia diseases in the southern MN growing area.

a a a

b b b

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 (0-10)[TU]	RCRR % incidence[TV]	Yield ton A^{-1}[T]	Sucrose[T] %	Sucrose[T] lb ton^{-1}	Sucrose[T] lb A^{-1}
Variety[W]						
Resistant	1.09 a	26 a	30.3	12.2 a	243 a	7414
Moderately Susceptible	1.99 b	41 b	34.0	11.5 b	229 b	7769
ANOVA p-value	<0.0001	0.0004	0.0884	0.0216	0.0231	0.4401
At-planting treatments[X]						
Untreated control	1.54	32	31.3	11.9	238	7509
Systiva	1.80	39	31.7	12.0	234	7478
Systiva + Quadris I-F	1.28	30	32.7	11.8	237	7788
ANOVA p-value	0.1891	0.1580	0.0960	0.8060	0.8028	0.4569
LSD (*P* = 0.05)	NS	NS	NS	NS	NS	NS
Postemergence fungicide[Y]						
None	3.1 b	61 c	27.1 b	10.9 b	219 b	5927 b
4-leaf Quadris	1.0 a	25 b	34.3 a	12.2 a	244 a	8348 a
8-leaf Quadris	0.5 a	15 a	34.4 a	12.3 a	247 a	8499 a
ANOVA p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
LSD (*P* = 0.05)	0.5	7.7	1.3	0.5	10	484
Vty x at-plant	0.1870	0.2210	0.4080	0.2770	0.2730	0.2300
Vty x Post	0.3650	0.3090	**0.0003**	0.1540	0.1620	**0.0050**
At-plant x Post	0.9640	0.1990	0.9540	0.8920	0.9040	0.8640
Vty x at-plant x Post	0.9750	0.5460	0.8390	0.3250	0.3580	0.4942

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; 0-10 scale (adjusted rating), 0 = root clean, no disease, 10 = 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)

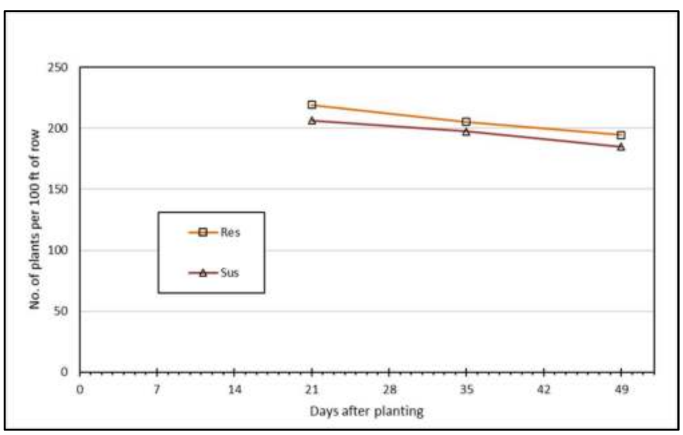

Fig. 5. SMBSC site: Emergence and stand establishment for resistant and moderately susceptible varieties. For each stand count date, values sharing the same letter are not significantly different ($P = 0.05$). Data shown represents mean of 36 plots averaged across at-planting and postemergence treatments.

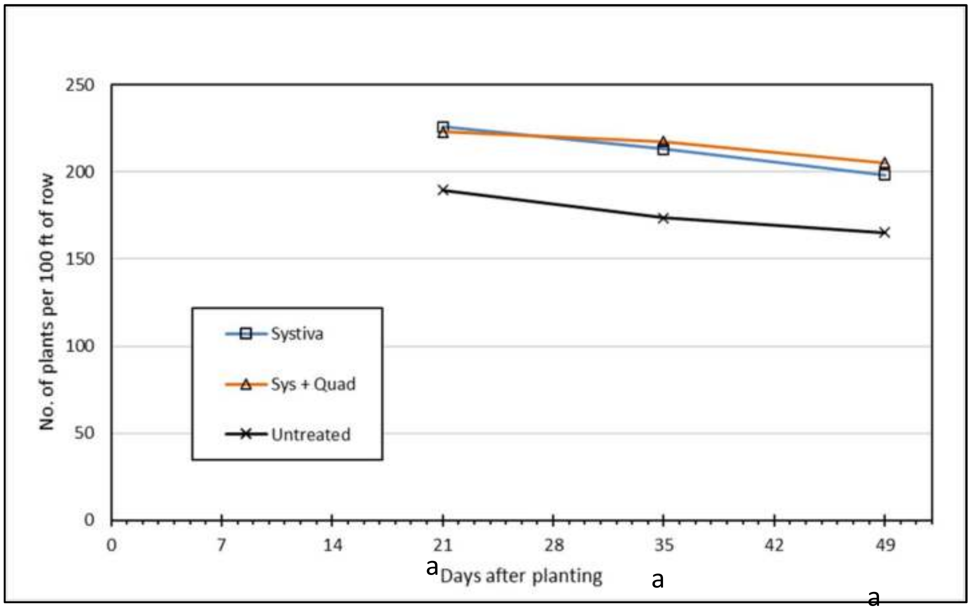

Fig. 6. SMBSC site: Emergence and stand establishment for the at-planting treatments. For each stand count date, values sharing the same letter are not significantly different ($P = 0.05$). Data shown represents mean of 24 plots averaged across varieties and postemergence treatments.

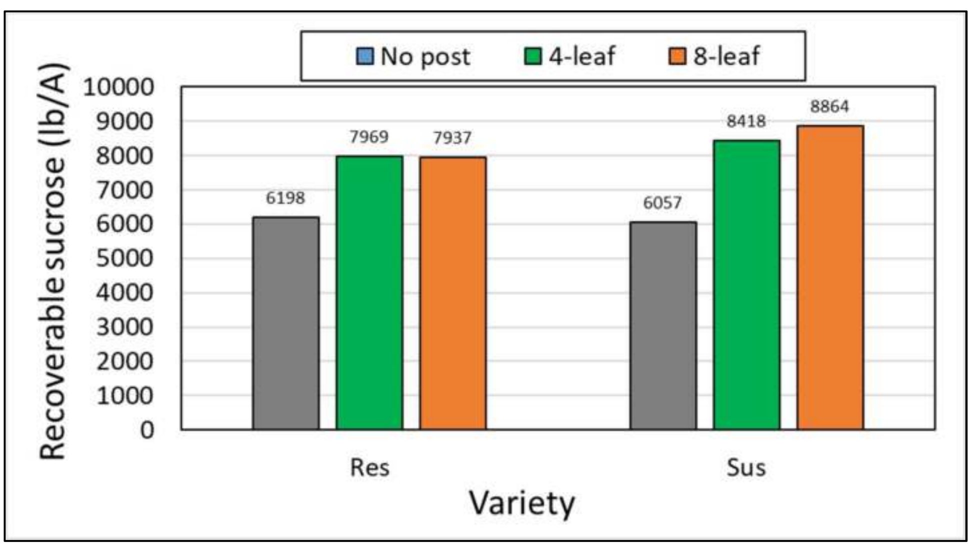

Fig. 7. SMBSC site: Effect of postemergence application on recoverable sucrose. Data shown represents mean of 12 plots averaged across varieties and at-planting treatments.

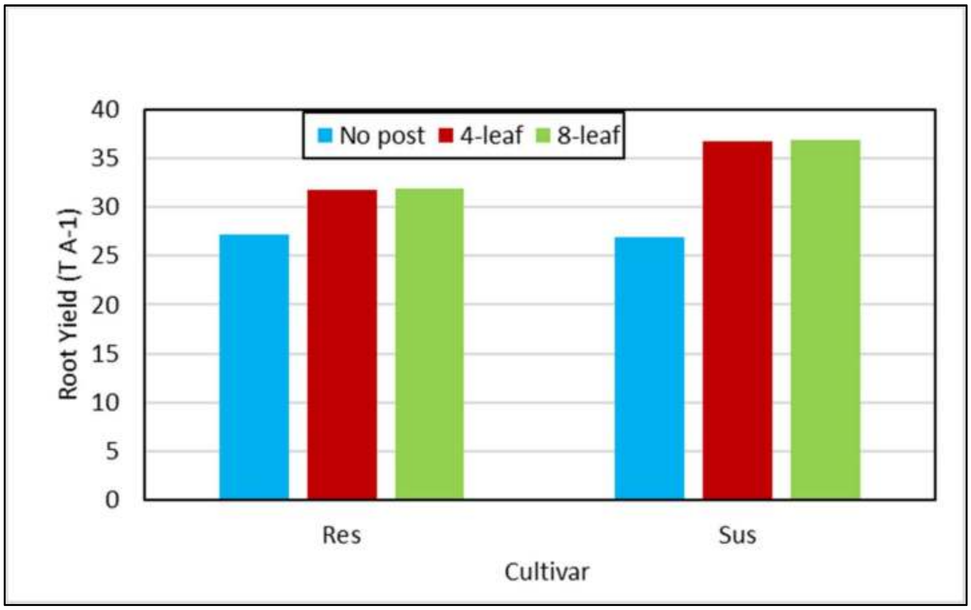

Fig. 8. SMBSC site: Effect of postemergence application on root yield. Data shown represents mean of 12 plots averaged across varieties and at-planting treatments.

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LITERATURE CITED

11. Brantner, J.R. 2019. Plant pathology laboratory: summary of 2017-2018 field samples. 2018 Sugarbeet Res. Ext. Rept. 49:202-203.

12. 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.

13. 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.

14. Chanda, A. K., Brantner, J. R., Lien, A.K., Metzger, M., Burt, E., Bloomquist, M., and Mettler, D. 2020. Integrated Management of Rhizoctonia on Sugarbeet with Resistant Varieties, At-Planting Treatments, and Postemergence Fungicides. 2019 Sugarbeet Res. Ext. Rept. 50:154-164.

15. 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.
16. 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.
17. 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.
18. Niehaus, W.S. 2020. Results of American Crystal's 2019 Official Coded Variety Trials. 2019 Sugarbeet Res. Ext. Rept. 50:195-236.

SENSITIVITY OF *CERCOSPORA BETICOLA* TO FOLIAR FUNGICIDES IN 2020

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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), Headline (pyraclostrobin) and Provysol (mefentrifluconazole). 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 2020, extensive sensitivity monitoring was conducted for Tin, Eminent, Inspire, Proline, Provysol and Headline.

OBJECTIVES

1) Monitor sensitivity of *Cercospora beticola* isolates to Tin (fentin hydroxide)

2) Monitor sensitivity of *Cercospora beticola* to four triazole (DMI) fungicides: Eminent (tetraconazole) and Inspire (difenoconazole) and Proline (prothioconazole) and Provysol (mefentrifluconazole)

3) Monitor *Cercospora beticola* isolates for the presence of the G143A mutation that confers resistance to Headline (pyraclostrobin) fungicide

4) 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 2020, with financial support of the Sugarbeet Research and Extension Board of MN and ND, we tested 1201 *C. beticola* field isolates collected from throughout the sugarbeet production regions of ND and MN for sensitivity testing to Tin, 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 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 2020, and disease pressure continued to be higher 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=1201) representing all production areas and factory districts were tested for sensitivity to six fungicides: fentin hydroxide (Tin), tetraconazole (Eminent), difenoconazole (the most active part of Inspire), prothioconazole (Proline), mefentrifluconazole (Provysol) and pyraclostrobin (Headline).

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**).

DMI (triazoles). Resistance as measured by RF values increased in 2020 for Inspire, Eminent and Provysol (**Figure 3**). RF values for Proline were low, but the low RF values are likely due to using technical grade prothioconazole for testing instead of the active metabolic product desthioconazole. Isolates with RF values >100 ppm were detected for all four DMI fungicides (**Figure 4**), indicating continued increase of resistance levels. Resistance was present and similar in all factory districts, but there was some variability (**Figure 5).**

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, and continued in 2020 (**Figure 6**). In 2020, resistance to Headline continued to be at high levels similar to 2018 and 2019; resistance did not decline (**Figure 6**). Resistance was found at high levels in all factory districts, but resistance levels declined again in the Minn-Dak factory district (**Figure 7**). The reason for this reduction is not clear, and we need ot monitor this trend, 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 other locations where QoI resistance due to the G143A mutation is widespread, it appears that isolates with the G143A mutation are stable and remain 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. Tin resistance declined in 2018 and 2019, but in 2020, the number of fields with tin resistance increased by 69%, and the percentage of spores with resistance/field increased to about 40%. Efforts should continue to preserve this fungicide for ClS management.

2. 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, and we are in the process of validating this test.

3. The presence of isolates with the G143A mutation that results in resistance to Headline continued to be prevalent and widespread in 2020, as in 2018 and 2019, but there was a reduction in Headline resistance in the Minn-Dak factory district for reasons unknown. These findings precluded the effective use of Headline for CLS management in 2020. Headline is not recommended for CLS management, but can be used for frost protection.

4. 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.

New varieties with higher levels of resistance were evaluated in the field with excellent disease resistance profiles. We urge the use of varieties with better CLS resistance.

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. Work is ongoing to adjust the forecasting model to include environmental factors affecting spore germination.

Figure 1. Incidence and severity of tin resistance in *C. beticola* isolates collected from sugarbeet fields in ND and MN from 2003 to 2020

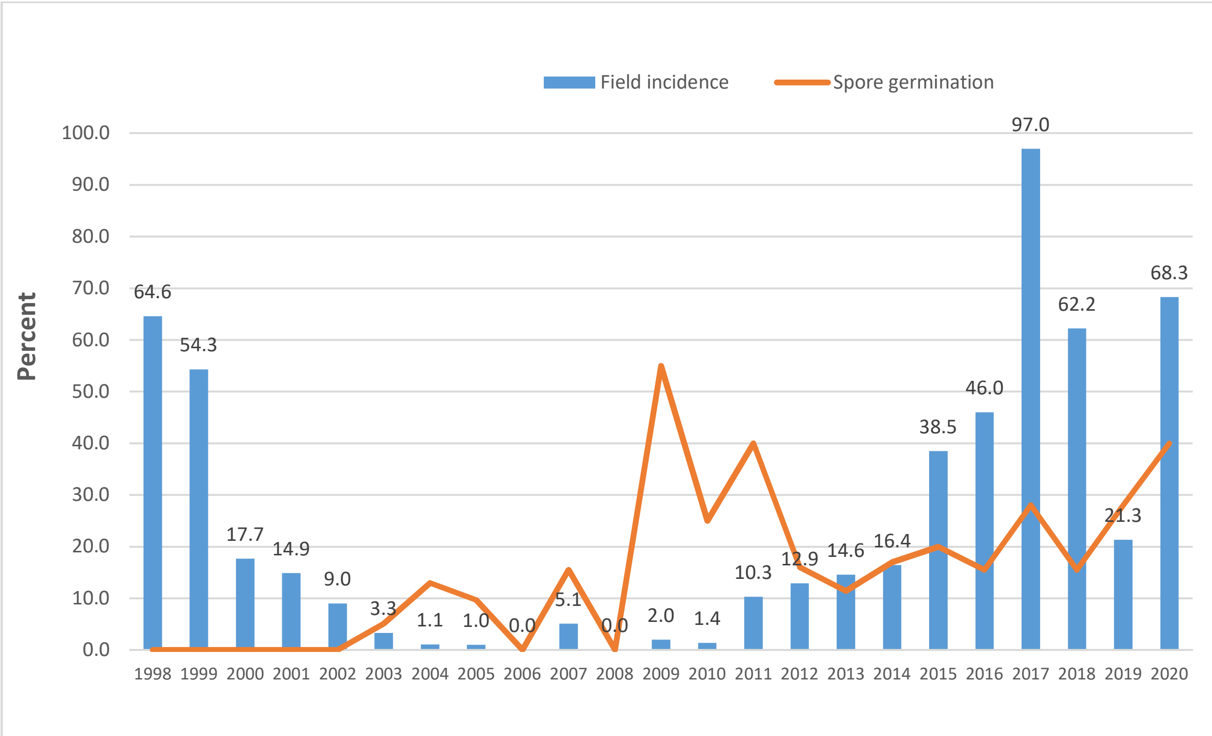


Figure 2. Incidence of fields with *C. beticola* isolates resistant to tin collected in ND and MN from 2015 to 2020 by factory district

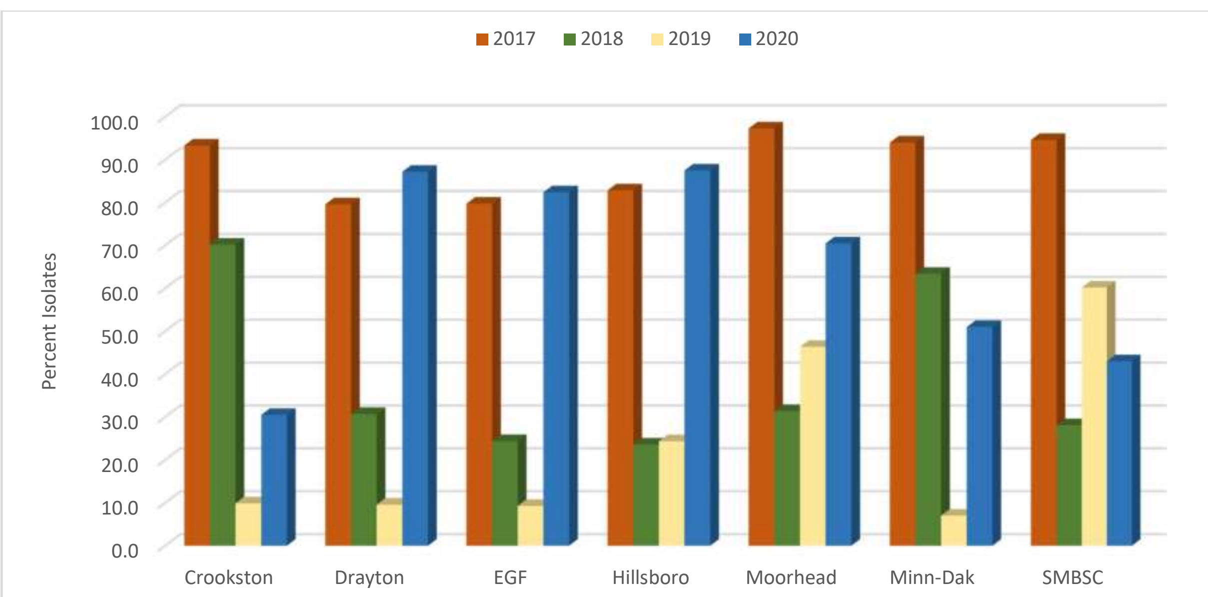


Figure 3. Resistance Factor of C. beticola isolates collected in ND and MN from 2017 to 2020 to Eminent, Inspire, Proline and Provysol

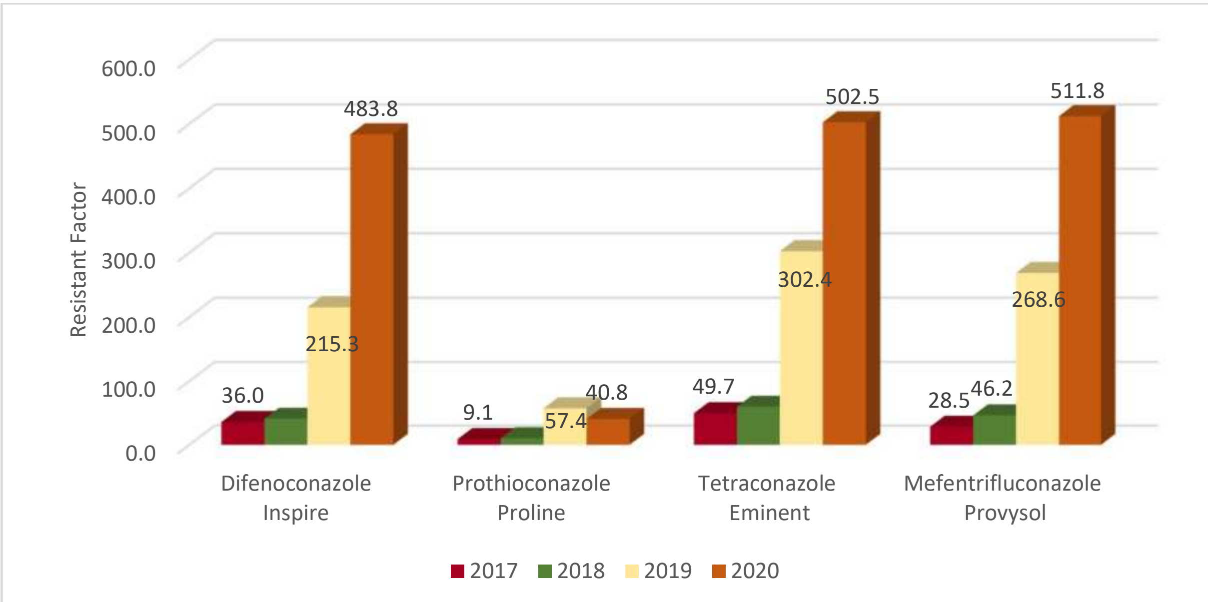


Figure 4. Distribution of sensitivity to Eminent, Inspire, Proline and Provysol of *C. beticola* isolates collected in 2020 as expressed by EC_{50} values

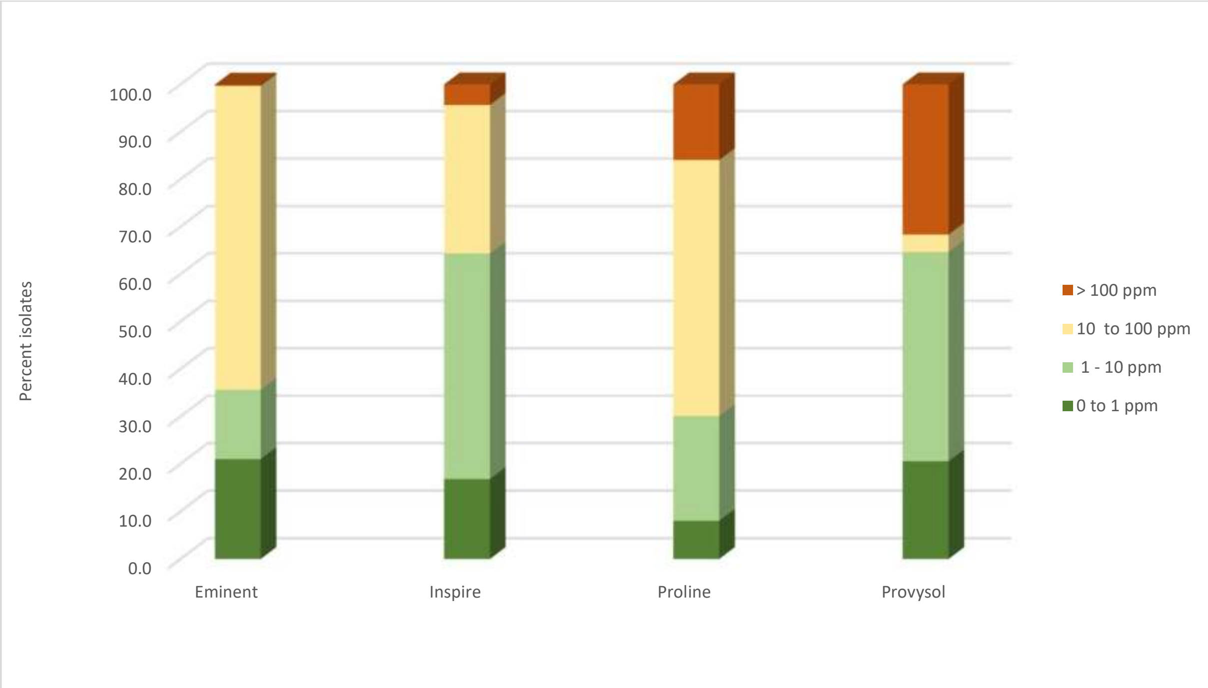


Figure 5. Sensitivity of *C. beticola* isolates collected in 2020 to Eminent, Inspire, Proline and Provysol by factory district as expressed by RF values

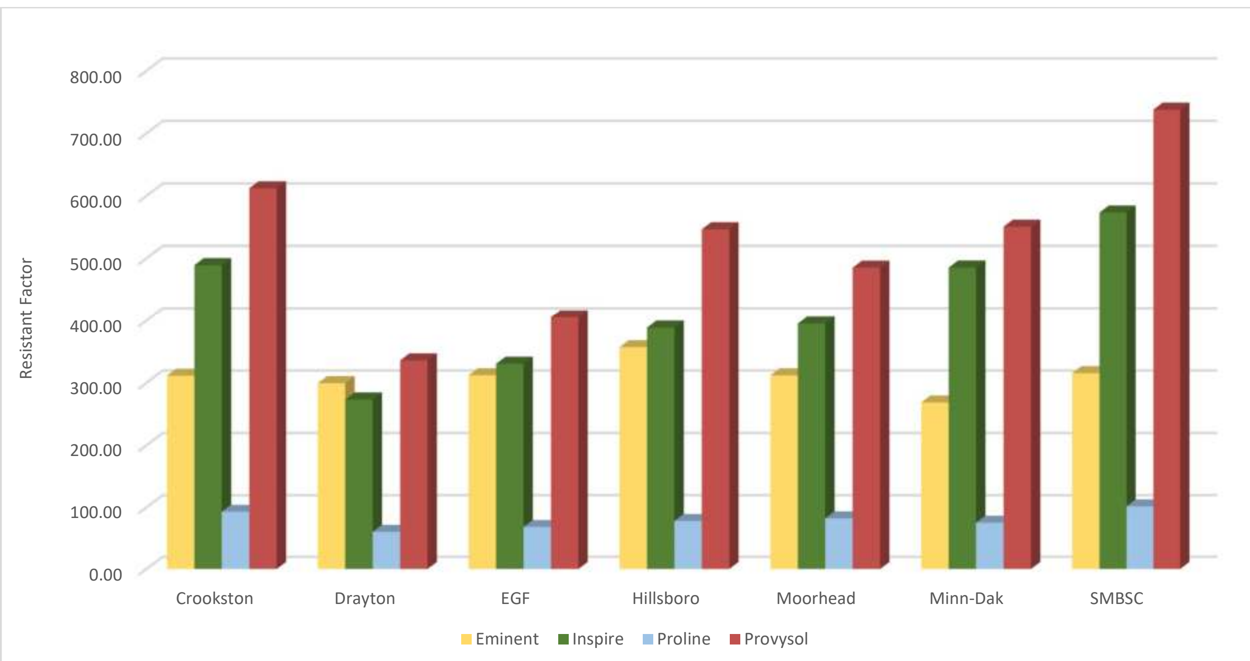


Figure 6. Sensitivity of *C. beticola* isolates collected in ND and MN to Headline from 2012 to 2020 as expressed by the percentage of spores with G143A mutation

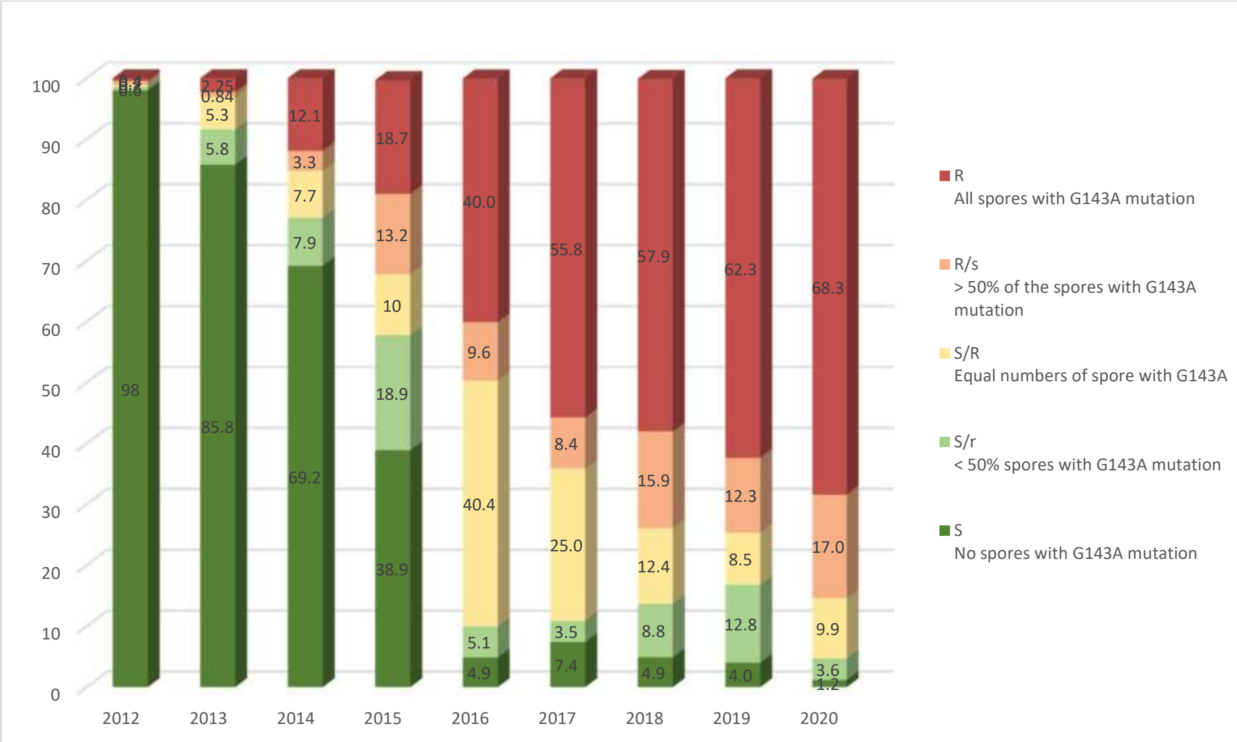
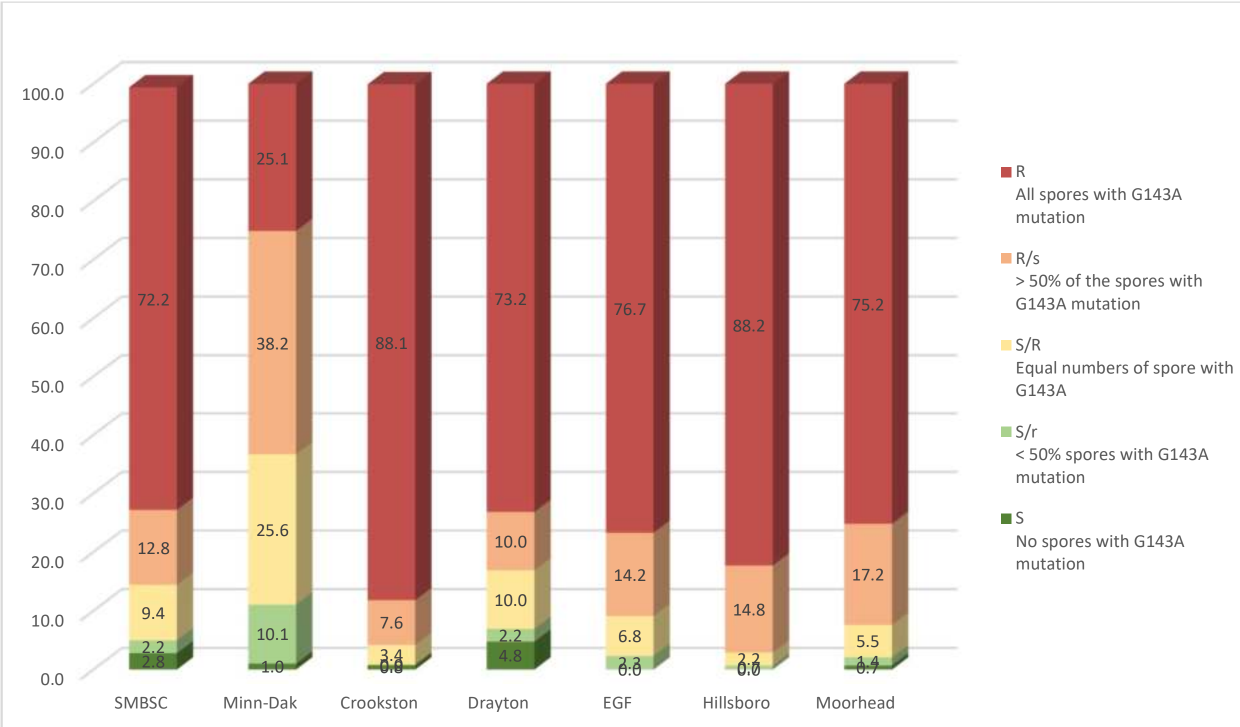


Figure 7. Sensitivity of *C. beticola* isolates collected in ND and MN in 2020 to Headline by factory district as measured by the percentage of spores with G143A mutation


100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
SMBSC
Minn-Dak
Crookston
Drayton
EGF
Hillsboro
Moorhead
72.2
12.8
9.4
2.2
2.8
25.1
38.2
25.6
10.1
1.0
88.1
7.6
3.4
73.2
10.0
10.0
2.2
4.8
76.7
14.2
6.8
0.0
88.2
14.8
2.2
0.0
75.2
17.2
5.5
1.4
0.7
R
All spores with G143A mutation
R/s
> 50% of the spores with G143A mutation
S/R
Equal numbers of spore with G143A
S/r
< 50% spores with G143A mutation
S
No spores with G143A mutation

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 one of the most economically damaging foliar disease of sugarbeet worldwide and is listed as the most important issue for producers 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 2016, the pathogen has developed resistance to QoI fungicides and reduced sensitivity to several other modes of action.

The objective of this research was to evaluate the efficacy of fungicide mixtures used in rotation to control Cercospora leaf spot on sugarbeet.

MATERIALS AND METHODS

A field trial was conducted at Foxhome, MN in 2020. 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 4 May with a variety susceptible to Cercospora Leaf Spot. Seeds were treated with Tachigaren (45 g/kg seed), CruiserMaxx and Vibrance. Seed spacing within the row was 4.7 inches. Weeds were controlled with herbicide applications (Ethotron @ 6 pt) on 11 May, (Roundup Powermax @ 32 fl oz; Outlook @ 12 fl oz; Class Act 1%v/v; Interlock @ 4 fl oz per acre) on 29 May and (Roundup Powermax @ 32 fl oz; Outlook @ 12 fl oz; Class Act 1% v/v; Interlock @ 4 fl oz per acre; Stinger @ 2.5 fl oz) 16 June and (Roundup Powermax @ 32 fl oz; Outlook @ 12 fl oz; Class Act 1% v/v; Interlock 4 fl oz) on 29 June as well as hand weeding throughout the summer. Quadris (14.3 fl oz per acre) was applied on 5 June and 23 June to control *Rhizoctonia solani*. Plots were inoculated on 6 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. Treatments included five fungicide applications on 20 July (application A), 31 July (application B), 12 August (application C), 24 August (application D) and 4 September (application E). Applications that were initiated just prior to row closure were treated starting on 7 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 31 August is reported.

Plots were defoliated mechanically and harvested using a mechanical harvester on 30 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

The area around the Foxhome site received measurable amounts of rainfall for 48 of the 95 days of the crop (over 14.5 inches). As a result, crop growth was slow and row closure occurred around mid-July. Inoculation was done on July 6 and the first fungicide application for some treatments (indicated by and asterisk (*) started on July 7. Lesion development was slow and occurred about 14 days after inoculation. Most fungicide applications started at first symptoms on July 20. Subsequent fungicide applications were reduced to 10 to 12 days interval instead of 14 days because of regular rainfalls that were washing off the fungicides. Disease development then increased rapidly with economic damage occurring in early August and most plants in the non-treated check losing their oldest leaves with regrowth starting by the end of August. All fungicide treatments were effective at reducing disease severity below the economic threshold when evaluations were done in mid-August. However, by the end of August, most fungicide treatments were becoming less effective at reducing disease severity. In September, there was less days with rainfall than the preceding months and disease severity rapidly increased across all fungicide treatments resulting in leaf loss of mature leaves and regrowth by September 15.

The inoculum used was obtained from nearby (Andrea and Foxhome, MN) CLS infected fields. The *C. beticola* population was resistant to QoI fungicides and had the G143A mutation. The use of fungicide mixtures in a rotation program applied at 10 to 12-day intervals effectively controlled CLS until mid-August to late August, especially those treatments that were initiated just prior to row-closure. The non-treated check had significantly higher CLS ratings compared to the fungicide treatments by early August (Table 1). All fungicide treatments resulted in significantly higher tonnage, sugar concentration, recoverable sucrose per ton and recoverable sucrose per acre compared to the non-treated check. Severe CLS in the non-treated check resulted in a 28% reduction in tonnage, 46% reduction in sucrose concentration, and 57% reduction in recoverable sucrose compared to the most effective fungicide treatment. Whereas similar fungicide treatments using the same variety and inoculum source resulted in effective disease control as measured by the leaf spot ratings through harvest in 2019, the pathogen was not effectively controlled in 2020. Wet conditions in 2020 adversely impacted tonnage but drier conditions in September resulted in higher sugar concentration for the fungicide treatments compared to 2019. It should be noted that the same variety used in 2019 when protected effectively with fungicides resulted in 8,534 pounds of recoverable sucrose which was 40% higher than the best fungicide treatment in 2019. It should also be noted that at the research site, improved CLS varieties had yields of over 28 tons per acre and more than 9,000 pounds of recoverable sucrose when disease severity was reduced as a result of genetics and fungicides in the same environmental conditions.

Over the past two decades, we have used our most susceptible CLS varieties in fungicide efficacy trials. Our assumption was that if we can control CLS with fungicides with these susceptible varieties where we inoculate to ensure the pathogen is present, that growers, when using our fungicide recommendation with more tolerant varieties and in non-inoculated conditions, will be successful at reducing disease severity. This has proven true in most years. What we observed in our 2016 and 2020 fungicide efficacy trials, was that when frequent rainfall washed off fungicides soon after applications with our more susceptible varieties compounded by the fact that some fungicides were less effective because of fungicide resistance, disease severity increased rapidly and adversely impacted yield and quality. Since *C. beticola* population with resistance to several fungicides has become widespread over our over 300 miles stretch of sugarbeet production area, and rainfall has become more frequent, it may be prudent for growers to use improved CLS tolerant varieties that can better withstand the disease when fungicides become ineffective because of resistance and or rainfall wash-off.

Our research over the past five years indicated that when conditions are favorable for applications that fungicide mixtures applied starting promptly at first symptoms of CLS and continued during the season will result in low disease severity. However, in years when there are frequent rainfall that washes off the fungicides or delay applications, it becomes impossible to control the disease in susceptible varieties. As under such conditions, applications that start at or just prior to row closure typically result in lower disease severity. Consequently, our current recommendation is to use improved CLS tolerant varieties, start fungicide applications at or just prior to row closure at 10 to 14 day intervals for most effective control of CLS.

General comments for Cercospora leaf spot control in growers' fields in North Dakota and Minnesota where inoculum levels will probably be high in 2021 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 just prior to 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 (and probably impossible with more susceptible varieties) 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 days 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 2020 *C. beticola* population and sensitivity testing, CLS spray applications should start at disease onset or just prior to 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	**Sterol Inhibitors**	**Ethylenebisdithiocarbamate (EBDC)**
Gem	Eminent/Minerva	Penncozeb
(Priaxor)	Inspire XT	Manzate
	Proline	Mancozeb
	Provysol	Maneb
	Enable	(Mankocide)
	Topguard	

Benzimidazole	**TriphenylTin Hydroxide (TPTH)**	**Copper**
Topsin	SuperTin	Kocide 2000 and 3000
	AgriTin	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 near Foxhome, MN in 2020.

Treatment and rate/A	CLS*	Root yield	Sucrose concentration	Recoverable sucrose		Returns**
	1-10	Ton/A	%	lb/Ton	lb/A	$/A

Super Tin 8 fl oz + Badge SC 2 pt***/ Inspire XT 7 fl oz + Badge SC 2 pt/ Super Tin 8 fl oz + Badge SC 2 pt/ Proline 5.7 fl oz + NIS 0.125 % v/v + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Badge SC 4 pt	5.5	17.78	15.39	290.5	5,167	456
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 % v/v + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt §	5.5	16.18	14.88	280.9	4,541	354
Priaxor 6.7 fl oz + Badge SC 2 pt***/ Provysol 4 fl oz + Badge SC 2 pt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125 % v/v + Badge SC 2 pt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Badge SC 4 pt ¥	6.3	15.50	15.04	281.6	4,371	313
Provysol 4 fl oz + Manzate Max 1.6 qt***/ Super Tin 8 fl oz + Topsin 20 fl oz/ Proline 5.7 fl oz + NIS 0.125 % v/v + Manzate Max 1.6 qt/ Manzate Max 1.6qt/ Super Tin 8 fl oz + Priaxor 6.7 fl oz	6.0	15.35	14.70	277.3	4,248	302
Minerva Duo 16 fl oz + Badge SC 2 pt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ 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 % v/v + Badge SC 2 pt	6.5	13.43	14.74	277.9	3,719	249
Super Tin 8 fl oz + Manzate Max 1.6 qt + Topsin 20 fl oz/ 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 % v/v + Badge SC 2 pt/ Super Tin 8 fl oz + Badge SC 2 pt	6.5	14.70	14.21	265.4	3,904	243
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 % v/v + Manzate Max 1.6 qt/ Manzate Max 1.6 qt/ Super Tin 8 fl oz + Priaxor 6.7 fl oz β	6.5	13.98	14.53	271.6	3,800	237
Manzate Max 1.6 qt + Badge SC 2 pt/ Super Tin 8 fl oz + Badge SC 2 pt/ Manzate Max 1.6 qt + Badge SC 2 pt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Badge SC 2 pt	6.8	12.43	14.46	271.7	3,385	234
Super Tin 8 fl oz + Badge SC 2 pt/ Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125 % v/v + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Badge SC 2 pt	6.5	12.98	14.43	272.3	3,539	226
Provysol 4 fl oz + Manzate Max 1.6 qt***/ Proline 5.7 fl oz + NIS 0.125 % v/v + Manzate Max 1.6 qt/ Manzate Max 1.6 qt + Badge SC 2 pt/ Super Tin 8 fl oz + badge SC 2 pt/ Super Tin 8 fl oz + Priaxor 6.7 fl oz	6.8	14.03	14.59	271.7	3,804	223
Super Tin 8 fl oz + Badge SC 2 pt/ Manzate Max 1.6 qt + Badge SC 2 pt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Manzate Max 1.6 qt + Badge SC 2 pt/ Super Tin 8 fl oz + Badge SC 2 pt	6.5	12.60	14.26	267.4	3,372	221
Provysol 4 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Topsin 20 fl oz/ Manzate Max 1.6 qt + Badge SC 2 pt/ Proline 5.7 fl oz + NIS 0.125 % v/v + Manzate Max 1.6 qt/ Manzate Max 1.6 qt + Badge SC 2 pt/ Super Tin 8 fl oz + Priaxor 6.7 fl oz	7.3	14.33	13.94	260.5	3,725	196
Super Tin 8 fl oz + Topsin 20 fl oz/ Manzate Max 1.6 qt + Badge SC 2 pt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125 % v/v + Badge SC 2 pt/ Super Tin 8 fl oz + Badge SC 2 pt	7.5	12.08	14.20	264.9	3,189	186

Proline 5.7 fl oz + NIS 0.125 % v/v + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Topsin 20 fl oz/ Manzate Max 1.6 qt + Badge SC 2 pt/ Provysol 4 fl oz + Manzate Max 1.6 qt/ Manzate Max 1.6 qt + Badge SC 2 pt/ Super Tin 8 fl oz + Priaxor 6.7 fl oz	6.8	13.98	13.98	259.5	3,622	184
Inspire XT 7 fl oz + Manzate Max 1.6 qt***/ Proline 5.7 fl oz + NIS 0.125 % v/v + Manzate Max 1.6 qt/ Manzate Max 1.6 qt + Badge SC 2 pt/ Super Tin 8 fl oz + Badge SC 2 pt/ Super Tin 8 fl oz + Priaxor 6.7 fl oz	7.0	11.85	14.40	270.5	3,226	167
Untreated Check	9.8	9.68	12.78	235.9	2,271	166
LSD (P=0.10)	**0.8**	**2.0**	**0.41**	**8.6**	**538**	**73.5**

*Cercospora leaf spot measured on 1-10 scale (1 = 1- 5 spots/leaf or 0.1% severity and 10 = 50% severity) on 31 August.
**Returns based on American Crystal payment system and subtracting fungicide costs and application.
***Treatment started just prior to row closure on July 7.
§, ¥, and β treatments are typically recommended by Southern Minnesota Beet Sugar Cooperative, Minn-Dak Farmers Cooperative, and American Crystal Sugar Company, respectively.

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.

PRELIMINARY REPORT ON THE EFFECT OF ADJUVANTS WITH FUNGICIDES FOR CONTROLLING CERCOSPORA LEAF SPOT

Mohamed F. R. Khan[1] and Peter C. Hakk[2]

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[2]Research Technician, Plant Pathology Department, North Dakota State University

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 2016, the pathogen has developed resistance to QoI fungicides and reduced sensitivity to several other modes of action. Fungicide mixtures are typically applied during a period when there may be regular rainfall soon after fungicide applications. 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 fungicide mixtures used in a rotation program improved control of Cercospora leaf spot.

MATERIALS AND METHODS

A field trial was conducted at Foxhome, MN in 2020. 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 4 May with a variety susceptible to Cercospora Leaf Spot. Seeds were treated with Tachigaren (45 g/kg seed), CruiserMaxx and Vibrance. Seed spacing within the row was 4.7 inches. Weeds were controlled with herbicide applications (Ethotron @ 6 pt) on 11 May, (Roundup Powermax @ 32 fl oz; Outlook @ 12 fl oz; Class Act 1%v/v; Interlock @ 4 fl oz per acre) on 29 May and (Roundup Powermax @ 32 fl oz; Outlook @ 12 fl oz; Class Act 1% v/v; Interlock @ 4 fl oz per acre; Stinger @ 2.5 fl oz) 16 June and (Roundup Powermax @ 32 fl oz; Outlook @ 12 fl oz; Class Act 1% v/v; Interlock 4 fl oz) on 29 June as well as hand weeding throughout the summer. Quadris (14.3 fl oz per acre) was applied on 5 June and 23 June to control *Rhizoctonia solani*. Plots were inoculated on 6 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 22 July. Treatments included five fungicide applications on 22 July (application A), 3 August (application B), 13 August (application C), 26 August (application D) and 4 September (application E). 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 31 August is reported.

Plots were defoliated mechanically and harvested using a mechanical harvester on 30 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

The research site near Foxhome received measurable amounts of rainfall for 48 of the 95 days of the crop (over 14.5 inches). There were several instances of water-logging that adversely impacted plant growth with row closure occurring around mid-July. Inoculation was done on July 6 and characteristic CLS lesions were observed about two weeks later with the first fungicide application on July 20. Subsequent fungicide applications were reduced to 10 to 12 days interval instead of 14 days because frequent regular rainfall events were washing off the fungicides. Disease development then increased rapidly with economic damage occurring in the non-treated check in mid-August when fungicides with and without adjuvants were significantly reducing disease severity compared to the check. By mid-September, all treatments were ineffective at controlling CLS; none of the treatments with adjuvants appeared to improve the efficacy of fungicides at controlling the disease.

Wet conditions for most of the growing season combined with severe CLS resulted in low tonnage across all treatments with no significant increase in tonnage where fungicides were used compared to the non-treated check. However, since fungicides did significantly reduced disease severity compared to the check until mid-August, these treatments resulted in significantly higher sugar concentration than the check. The addition of Cerium Elite and Complex to Penncozeb did help in reducing disease severity but only at one rating period; unfortunately, there was no concurrent increase in tonnage or recoverable sucrose in those treatments. Overall, there was no gain in any of the parameters (tonnage, sucrose concentration and recovered) evaluated when adjuvants were added to fungicides in 2020.

Table 1. Effect of fungicides and adjuvants on Cercospora leaf spot control and sugarbeet yield and quality near Foxhome, MN in 2020.

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 (ABCDE)	8.5	9.90	13.93	260	2,573
Badge SC 2 pt (ABCDE)	8.5	10.08	13.25	248	2,511
Inspire XT 7 fl oz (ABCDE)	8.5	12.33	13.94	260	3,204
Super Tin 8 fl oz + Badge SC 2 pt (A) Manzate Max 1.6 qt + Badge SC 2 pt (B) Super Tin 8 fl oz + Manzate Max 1.6 qt (C) Manzate Max 1.6 qt + Badge SC 2 pt (D) Super Tin 8 fl oz + Badge SC 2 pt (E)	7.8	9.78	13.88	259	2,516
Penncozeb 2 lb + Cerium Elite 1 qt/100gal (ABCDE)	7.5	8.88	13.64	252	2,229
Badge SC 2 pt + Cerium Elite 1 qt/100gal (ABCDE)	8.5	10.35	13.67	254	2,625
Inspire XT 7 fl oz + Cerium Elite 1 qt/100gal (ABCDE)	8.3	10.68	13.87	258	2,774
Super Tin 8 fl oz + Badge SC 2 pt + Cerium Elite 1 qt/100gal (A) Manzate Max 1.6 qt + Badge SC 2 pt + Cerium Elite 1 qt/100gal (B) Super Tin 8 fl oz + Manzate Max 1.6 qt + Cerium Elite 1 qt/100gal gal (C) Mankocide 4.3 lb + Cerium Elite 1 qt/100gal (D) Super Tin 8 fl oz + Badge SC 2 pt + Cerium Elite 1 qt/100gal (E)	7.0	8.60	14.22	267	2,296
Penncozeb 2 lb + Complex 2 pt/100 gal (ABCDE)	7.5	9.25	13.90	261	2,412
Badge SC 2 pt + Complex 2 pt/100 gal (ABCDE)	8.8	10.55	13.43	246	2,603
Inspire XT 7 fl oz + Complex 2 pt/100 gal (ABCDE)	8.3	8.10	13.60	251	2,043
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) Super Tin 8 fl oz + Badge SC 2 pt + Comples 2 pt/100gal (E)	7.3	11.05	14.42	273	3,022
Penncozeb 2 lb + Transfix 6 fl oz/100 gal (ABCDE)	8.3	10.13	13.75	256	2,577
Badge SC 2 pt + Transfix 6 fl oz /100 gal (ABCDE)	8.8	9.63	13.34	249	2,397
Inspire XT 7 fl oz + Transfix 6 fl oz /100 gal (ABCDE)	8.3	10.08	13.66	253	2,551
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) Super Tin 8 fl oz + Badge SC 2 pt + Transfix 6 fl oz/100gal (E)	7.5	9.08	14.27	266	2,417
Untreated Check	9.3	9.48	12.58	231	2,187
LSD (P=0.10)	**0.7**	**2.4**	**0.5**	**11**	**647**

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.

SUGARBEET VARIETIES/QUALITY TESTING

NOTES

RESULTS OF AMERICAN CRYSTAL SUGAR COMPANY'S 2020 CODED OFFICIAL VARIETY TRIALS

William S. Niehaus, Official Trial Manager
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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 sugarbeet 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 2020 American Crystal OVTs and describes the procedures and cultural practices involved in the trials.

Table	Information in the Table
1	ACSC approved varieties for 2021
2	Multi-year performance of approved varieties (all locations combined)
3	Performance of ACSC Aphanomyces specialty varieties
4	Disease ratings for ACSC tested varieties (multiple diseases)
5	Root Aphid Ratings
6	Official trial sites, cooperators, plant and harvest dates, soil types and disease notes
7	Seed treatments applied to seed used in the OVTs
8-15	2020 Roundup Ready variety trials and combined trials
16-19	Approval calculations for ACSC market
20	Aphanomyces disease nursery ratings
21	Cercospora disease nursery ratings
22	Rhizoctonia disease nursery ratings
23	Fusarium disease nursery ratings
24	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. All Official Trials utilize seed identified by code numbers which prevents ACSC personnel from knowing variety names when conducting trials.

The 2020 official coded variety performance trials and disease nurseries were planted at 18 sites by American Crystal Sugar Company (ACSC) including 13 yield trial sites and five disease nurseries. Seven additional disease nurseries were planted by third party cooperators. Thanks are extended to the dedicated Technical Services staff involved in the official trial plot care, harvest, and data analysis.
Results from the Official Variety Trials sites were good to excellent. Stands in the trials were generally very good this year. Seven sites were used for variety approval calculations. Two sites were abandoned due to erratic emergence (St.Thomas and Hillsboro) and one due to water damage (Stephen). Three sites were used for performance of Aphanomyces Specialty varieties under Aphanomyces conditions (Climax , Grandin and Perley).

Rhizoctonia presence was minimal in 2020. AZteroid (in-furrow), seed treatments and one application of Quadris (POST) were utilized for Rhizoctonia management. Based upon susceptible plot observations, root aphids were present in low levels at one site. Revenue calculations in 2020 are based on a hypothetical $45.12 payment (5-year rolling average) at 17.5% sugar and 1.5% SLM not considering hauling or production costs.

Fusarium ratings are from two Moorhead sites. The Rhizoctonia ratings are from two RRV nurseries. The Aphanomyces ratings are from Shakopee, MN and two RRV nurseries. The Cercospora data is from Foxhome, MN; Randolph, MN; and Michigan USDA.

2020 harvest conditions were excellent. Soil moisture levels remained average to dry throughout the months of August and September, creating good harvest conditions in all five Factory Districts for all involved. With a slightly earlier OVT harvest start date and the benefit of our new harvester, the harvest completion date was earlier than previous years.

The 2020 data has been combined with the previous years' data, and results are enclosed. Bolter data is presented in plants per acre based upon 60,000 seeds per acre. Results for the yield trials from individual sites are available here and on the internet.

Conventional trials were not planted in the 2020 OVT trials. Conventional varieties that were approved for 2020 sales are permitted to continue with sales in 2021.

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 from 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 (water conditioning agent + surfactant) and full rates of fungicides were applied using a pickup sprayer driven down the alleys. Hand weeding was utilized where necessary. All yield trials were treated with Quadris in a band during the 6-10 leaf stage (14 oz/acre) for Rhizoctonia management. Treatments used for Cercospora management in 2020 included Inspire XT/Manzate, Agri Tin/Incognito, Proline/Manzate, and Priaxor/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 PowerMAX were made in the 4-6 (32 oz/acre) and 8 – 12 (22 oz/acre) 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 (Big Red) with increased cleaning capacity. All harvested beets of each plot were used for yield determination while one sample (approx. 25 lbs each) for sugar, and impurity analysis was obtained from each plot. Quality analysis was performed at the ACSC Technical Services Quality Lab in Moorhead, MN.

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. Magno Seed staff for Aphanomyces nursery, 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 2021 Sugarbeet Crop ++

Roundup Ready ®	Full Market	Aph Spec	Rhc Spec	High Rzm
BTS 8337	Yes	Yes		Hi Rzm
BTS 8500	Yes	Yes		Hi Rzm
BTS 8524	Yes	Yes		Hi Rzm
BTS 8606	Yes			Hi Rzm
BTS 8629	Yes	Yes		Hi Rzm
BTS 8767	Yes	Yes		Hi Rzm
BTS 8815	Yes			Hi Rzm
BTS 8882	Yes			Hi Rzm
BTS 8927	New	New		Hi Rzm
BTS 8938	New	New	New	Hi Rzm
BTS 8961	New	New		Hi Rzm
BTS 8976	New	New		Hi Rzm
Crystal 572	Yes			Hi Rzm
Crystal 574	Yes	Yes		Hi Rzm
Crystal 684	Yes	Yes		Hi Rzm
Crystal 793	Yes	Yes		Hi Rzm
Crystal 796	Yes	Yes		Hi Rzm
Crystal 803	Yes	Yes		Hi Rzm
Crystal 804	Yes	Yes	New	Hi Rzm
Crystal 808	Yes	Yes		Hi Rzm
Crystal 912	New	New	New	Hi Rzm
Crystal 913	New	New		Hi Rzm
Crystal 916	New	New		Hi Rzm
Hilleshög HM4448RR +	Yes			Rzm
Hilleshög HM9528RR	Yes	Yes		Hi Rzm
Hilleshög HIL9708	Yes	New	Yes	Rzm
Hilleshög HIL9920	Yes	New		Hi Rzm
Hilleshög HIL2317	New	New		Hi Rzm
Maribo MA504	Yes			Hi Rzm
Maribo MA717	Yes	Yes		Hi Rzm
Maribo MA902	New			Hi Rzm
SX Marathon	Yes			Hi Rzm
SX 1887	Yes	New		Hi Rzm
SX 1888	Yes	Yes		Hi Rzm
SX 1898	Yes	New		Hi Rzm
SV 265	Yes			Hi Rzm
SV 268	Yes	Yes		Hi Rzm
SV 285	Yes	Yes		Hi Rzm
SV 333	Yes	Yes		Hi Rzm
SV 375	Yes			Hi Rzm

2019 Conventional	Full Market	High Rzm
Crystal R761	Yes	Hi Rzm
Crystal 620	Yes	Hi Rzm
Crystal 840	Yes	Hi Rzm
Crystal 950	Yes	Hi Rzm
Hilleshög HM3035Rz	Yes	Rzm
SX 8869 Cnv	Yes	Hi Rzm
SV 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 Rhizomania
New = newly approved

\+ Previously approved varieties not meeting current approval standards. According to Approval Policy, may be sold in 2021

++ Roundup Ready sugarbeets are subject to the ACSC RRSB Bolter Destruction Policy

Created 10/30/2020

Table 2. Performance Data of RR Varieties During 2019 and 2020 Growing Seasons (All Locations Combined) Approved for Sale to ACSC Growers in 2021 +++

	Yrs	Rev/Ton ++			Rev/Acre ++			Rec/Ton		Rec/Acre		Sugar		Yield		Molasses		Emerg		Bolter / Ac		CR +		Aph Root+		Rhizoc.+		Fusarium+		Rzm+
Variety	Com	20	2 Yr	2Y%	20	2 Yr	2Y%	20	2 Yr	20	2 Yr	20	2 Yr	20	2 Yr	20	2 Yr	20	2 Yr	20	2 Yr	20	2 Yr	20	2 Yr	20	2 Yr	20	2 Yr	
Previous Approved # locations		7	14		7	14		7	14	7	14	7	14	7	14	7	14	7	14	7	14	3	6	3	5	2	5	2	4	
BTS 8337	6	51.24	48.74	104	1300	1371	103	341	334	8662	9433	18.14	17.74	25.3	28.3	1.07	1.04	64	67	4	2	4.46	4.43	3.5	3.5	4.4	4.0	3.6	3.6	Hi
BTS 8500	4	43.48	42.67	91	1307	1363	102	314	313	9476	10032	16.81	16.73	30.2	32.2	1.10	1.10	67	66	0	0	4.38	4.19	4.2	4.2	4.6	4.5	2.4	2.3	Hi
BTS 8524	4	44.39	42.16	90	1279	1344	101	317	311	9150	9946	16.97	16.63	28.8	32.1	1.10	1.09	74	72	0	0	4.38	4.45	4.2	4.4	4.1	4.1	3.0	3.1	Hi
BTS 8606	3	45.91	44.58	95	1284	1344	101	323	319	9022	9649	17.17	17.00	28.0	30.3	1.03	1.03	71	67	0	0	4.79	4.74	4.6	4.8	4.8	4.7	2.9	2.8	Hi
BTS 8629	3	44.38	42.86	91	1406	1426	107	317	313	10066	10440	16.89	16.71	31.8	33.4	1.02	1.05	68	67	0	0	4.55	4.60	3.9	4.6	4.3	4.1	3.8	3.7	Hi
BTS 8767	2	45.48	44.57	95	1317	1382	104	321	319	9299	9923	17.08	16.99	29.0	31.1	1.02	1.03	71	70	0	0	4.38	4.32	4.5	4.4	4.7	4.4	2.5	2.5	Hi
BTS 8815	1	47.60	46.78	100	1307	1383	104	329	327	9013	9676	17.45	17.36	27.4	29.6	1.02	1.00	66	66	0	0	4.86	4.73	4.2	4.7	3.9	4.0	2.6	2.6	Hi
BTS 8882	1	43.65	43.44	92	1381	1413	106	315	315	9981	10265	16.80	16.84	31.8	32.6	1.05	1.06	72	65	0	0	4.71	4.44	4.3	4.8	4.3	4.3	2.1	2.5	Hi
Crystal 572	4	51.00	49.32	105	1405	1441	108	341	336	9387	9837	18.02	17.79	27.6	29.3	0.99	0.98	73	71	0	0	4.46	4.57	4.3	4.6	4.2	4.2	2.4	2.4	Hi
Crystal 574	4	44.14	43.32	92	1396	1416	106	317	315	10010	10317	16.91	16.82	31.6	32.8	1.08	1.07	68	70	0	0	4.64	4.46	4.1	4.1	4.2	4.3	2.3	2.1	Hi
Crystal 684	2	44.19	42.94	91	1432	1431	107	317	314	10283	10479	16.90	16.74	32.6	33.5	1.06	1.07	74	69	0	0	4.44	4.28	4.0	4.1	4.2	4.1	2.3	2.2	Hi
Crystal 793	2	49.48	47.70	102	1514	1535	115	335	330	10253	10650	17.70	17.46	30.6	32.3	0.93	0.93	71	68	0	0	4.31	4.18	3.9	3.8	4.8	4.5	2.6	2.7	Hi
Crystal 796	1	45.63	44.28	94	1372	1451	109	322	318	9674	10442	17.14	16.95	30.1	32.8	1.05	1.03	74	76	0	0	4.95	4.85	3.9	3.9	4.5	4.2	2.2	2.3	Hi
Crystal 803	NC	49.01	48.05	102	1444	1469	110	334	332	9811	10142	17.62	17.54	29.3	30.6	0.95	0.96	78	77	0	0	3.93	3.90	4.0	4.2	5.0	4.8	2.5	2.6	Hi
Crystal 804	NC	42.95	43.55	93	1383	1427	107	313	316	10068	10376	16.72	16.86	32.2	32.9	1.10	1.06	66	64	0	0	4.77	4.61	3.6	4.0	3.9	3.8	2.3	2.3	Hi
Crystal 808	NC	46.00	44.52	95	1417	1437	108	323	319	9955	10333	17.19	17.01	30.8	32.4	1.04	1.04	76	75	0	0	5.07	4.92	4.0	3.8	3.9	4.0	2.3	2.4	Hi
Hilleshög HIL9708	3	47.99	45.68	97	1369	1401	105	330	323	9420	9940	17.48	17.14	28.5	30.8	0.98	0.98	72	72	0	0	4.97	4.96	4.0	4.3	3.8	3.8	3.6	3.8	Rzm
Hilleshög HIL9920	2	48.97	47.40	101	1398	1414	106	333	329	9533	9853	17.64	17.44	28.6	30.0	0.97	0.97	70	70	0	0	4.82	4.88	3.6	4.3	5.1	4.9	6.3	5.8	Hi
Hilleshög HM4448RR	7	44.42	43.78	93	1358	1407	106	318	317	9725	10192	16.89	16.82	30.7	32.3	1.01	1.00	75	72	0	2	5.61	5.54	4.1	4.5	4.8	4.4	4.6	4.7	Rzm
Hilleshög HM9528RR	5	46.14	44.94	96	1362	1409	106	324	321	9576	10082	17.21	17.03	29.6	31.5	1.03	1.00	69	67	0	0	4.84	4.88	3.7	4.1	4.6	4.3	4.7	4.4	Hi
Maribo MA504	4	44.42	42.61	91	1368	1394	105	318	312	9787	10241	16.87	16.61	30.9	32.8	1.00	1.00	72	71	0	0	5.35	5.34	5.1	5.6	4.8	4.8	4.3	4.4	Hi
Maribo MA717	2	47.70	46.02	98	1454	1465	110	329	324	10054	10368	17.47	17.23	30.6	32.1	1.03	1.01	75	72	0	0	5.11	5.11	3.8	4.1	4.6	4.4	4.6	4.7	Hi
SV 265	3	48.67	46.49	99	1396	1409	106	332	326	9523	9902	17.58	17.26	28.7	30.4	0.96	0.96	67	65	0	0	4.55	4.41	4.0	4.7	4.2	4.2	5.7	5.7	Hi
SV 268	3	47.51	45.92	98	1317	1363	102	328	324	9093	9630	17.42	17.19	27.6	29.8	1.01	0.99	67	65	0	0	4.78	4.80	4.5	4.8	5.2	4.7	4.0	4.5	Hi
SV 285	NC	49.60	47.59	101	1373	1398	105	336	330	9262	9694	17.74	17.46	27.5	29.4	0.97	0.97	65	62	0	0	4.50	4.67	4.3	4.4	4.0	4.2	5.4	5.1	Hi
SV 333	5	47.34	46.27	98	1391	1400	105	328	325	9635	9861	17.36	17.23	29.4	30.4	0.97	0.97	66	68	0	0	4.69	4.59	4.1	4.4	4.6	4.3	5.6	5.2	Hi
SV 375	1	47.28	46.34	99	1352	1391	104	328	326	9393	9794	17.37	17.25	28.8	30.1	0.99	0.97	63	63	4	2	4.78	4.44	4.0	4.5	4.5	4.3	5.2	5.1	Hi
SX 1887	1	47.02	46.64	99	1334	1378	103	327	327	9270	9658	17.34	17.32	28.3	29.5	1.02	1.00	67	64	0	0	5.09	4.99	3.9	4.3	4.8	4.5	4.3	4.5	Hi
SX 1888	1	47.38	46.34	99	1345	1410	106	328	326	9325	9934	17.40	17.27	28.5	30.6	1.00	0.98	63	62	4	2	4.67	4.78	4.0	4.3	4.2	4.2	5.5	5.5	Hi
SX Marathon	4	47.30	45.59	97	1396	1388	104	328	323	9669	9849	17.37	17.14	29.5	30.6	0.99	0.99	66	61	0	0	4.85	4.82	4.1	4.6	4.3	4.3	5.4	5.5	Hi
Newly Approved																														
BTS 8927	NC	53.07	51.25	109	1482	1533	115	348	343	9720	10284	18.28	18.00	28.0	30.1	0.90	0.87	77	76	0	3	4.42	4.39	3.9	4.0	4.4	4.2	2.6	2.7	Hi
BTS 8938	NC	47.75	47.38	101	1409	1448	109	329	329	9700	10067	17.44	17.39	29.4	30.6	0.98	0.93	67	68	0	0	4.66	4.51	3.9	3.8	3.9	3.7	3.7	3.4	Hi
BTS 8961	NC	45.49	44.32	94	1415	1445	108	321	319	9990	10393	17.12	16.97	31.1	32.6	1.05	1.04	73	73	0	0	4.69	4.48	4.0	4.0	4.1	3.9	2.2	2.4	Hi
BTS 8976	NC	49.57	48.74	104	1351	1438	108	336	334	9116	9845	17.72	17.63	27.1	29.4	0.95	0.94	69	68	0	0	4.15	3.99	3.5	3.6	4.5	4.3	2.9	3.3	Hi
Crystal 912	NC	45.87	44.56	95	1520	1558	117	323	319	10726	11202	17.12	16.96	33.3	35.1	0.99	0.99	75	74	0	0	4.75	4.69	3.7	3.8	3.5	3.6	3.6	3.5	Hi
Crystal 913	NC	48.81	48.37	103	1490	1555	117	333	333	10150	10701	17.61	17.56	30.5	32.2	0.97	0.93	74	73	0	0	4.13	4.12	3.7	3.7	4.6	4.4	2.6	2.6	Hi
Crystal 916	NC	45.26	44.57	95	1410	1493	112	321	319	9967	10704	17.09	17.01	31.0	33.5	1.06	1.04	79	78	0	0	4.49	4.38	3.9	4.0	4.6	4.4	2.4	2.5	Hi
Hilleshög HIL2317	NC	49.24	48.54	103	1385	1443	108	334	333	9428	9940	17.67	17.60	28.2	29.9	0.97	0.94	72	70	0	0	5.05	4.97	3.9	3.9	4.9	4.6	6.0	5.6	Hi
Maribo MA902	NC	48.77	46.45	99	1393	1409	106	333	326	9508	9909	17.60	17.27	28.6	30.5	0.98	0.98	72	76	0	0	4.96	4.94	4.0	4.7	3.9	4.0	4.0	3.9	Hi
SX 1898	NC	50.03	47.96	102	1510	1471	110	337	331	10198	10180	17.80	17.52	30.3	30.8	0.95	0.96	72	66	0	0	4.73	4.70	3.8	4.3	4.2	4.2	5.4	5.3	Hi
Benchmark var. mean		48.98	46.99		1272	1333		333	328	8671	9341	17.72	17.44	26.0	28.6	1.05	1.05	69	68											

2 Yr is mean of 2 years of data, 2 Y% is 2 year mean as percent of benchmark varieties. Emergence is % of planted seeds producing a 4 leaf beet. Created 11/02/2020

++2020 Revenue estimate based on a $45.12 beet payment (5-yr ave) at 17.5% sugar with a 1.5% loss to molasses; 2019 Revenue estimate based on a $44.38 beet payment. Revenue does not consider hauling or production costs.

+ Aphanomyces ratings from RRV & Shakopee (res.<4.4, susc>5.0). Cercospora from Randolph MN, Foxhome MN & Michigan (res.<4.4, susc>5.0). Fusarium from RRV (res.<3.0, susc>5.0). Rhizoctonia from Mhd (res.<3.8, susc>5). Hi may perform better under severe Rizomania.

Bolters /Ac are based upon a plant stand of 60,000.

+++ Sites include Casselton, Glyndon, Scandia, Bathgate, Kennedy, Climax, Argyle in 2019

+++ Sites include Casselton, Glyndon, Ada, Grand Forks, Scandia, E Grand Forks, Bathgate in 2020

Table 3. Performance Data of RR Aphanomyces Specialty Varieties - Under Aphanomyces Conditions (Relative to Susceptible Checks) approved for 2021 Growing Season +++

	Years	Rev/Ton			Rev/Acre			Rec/Ton		Rec/Acre		Sugar		Yield		CR Rating +		Aph Root +		Fusarium +		Rhizoctonia +	
Description	Comm	2020	2019#	%Sus	2020	2019#	%Sus	2020	2019#	2020	2019#	2020	2019#	2020	2019#	20	2Yr	20	2 Yr	20	2Yr	20	2Yr
# of locations		3	0	3	3	0	3	3	0	3	0	3	0	3	0	3	6	3	4	2	4	2	5
Previously Approved																							
BTS 8337	6	40.89	--	133	852	--	144	####	--	6280	--	####	--	20.4	--	4.46	4.43	3.5	3.5	3.6	3.6	4.4	4.0
BTS 8500	4	32.19	--	105	721	--	122	####	--	5986	--	####	--	21.4	--	4.38	4.19	4.2	4.2	2.4	2.3	4.6	4.5
BTS 8524	4	32.86	--	107	722	--	122	####	--	5914	--	####	--	20.9	--	4.38	4.45	4.2	4.4	3.0	3.1	4.1	4.1
BTS 8629	3	32.72	--	106	789	--	134	####	--	6493	--	####	--	23.1	--	4.55	4.60	3.9	4.6	3.8	3.7	4.3	4.1
BTS 8767	2	32.70	--	106	659	--	112	####	--	5410	--	####	--	19.1	--	4.38	4.32	4.5	4.4	2.5	2.5	4.7	4.4
Crystal 574	4	33.16	--	108	777	--	132	####	--	6328	--	####	--	22.3	--	4.64	4.46	4.1	4.1	2.3	2.1	4.2	4.3
Crystal 684	2	32.62	--	106	799	--	136	####	--	6622	--	####	--	23.6	--	4.44	4.28	4.0	4.1	2.3	2.2	4.2	4.1
Crystal 793	2	37.97	--	123	886	--	150	####	--	6732	--	####	--	22.4	--	4.31	4.18	3.9	3.8	2.6	2.7	4.8	4.5
Crystal 796	1	36.17	--	117	795	--	135	####	--	6223	--	####	--	21.2	--	4.95	4.85	3.9	3.9	2.2	2.3	4.5	4.2
Crystal 803	NC	39.43	--	128	908	--	154	####	--	6793	--	####	--	22.3	--	3.93	3.90	4.0	4.2	2.5	2.6	5.0	4.8
Crystal 804	NC	33.22	--	108	864	--	147	####	--	7144	--	####	--	25.4	--	4.77	4.61	3.6	4.0	2.3	2.3	3.9	3.8
Crystal 808	NC	35.29	--	115	833	--	141	####	--	6702	--	####	--	23.4	--	5.07	4.92	4.0	3.8	2.3	2.4	3.9	4.0
Maribo MA717	2	34.86	--	113	731	--	124	####	--	5834	--	####	--	20.2	--	5.11	5.11	3.8	4.1	4.6	4.7	4.6	4.4
SV 268	3	38.06	--	124	829	--	141	####	--	6339	--	####	--	21.3	--	4.78	4.80	4.5	4.8	4.0	4.5	5.2	4.7
SV 285	NC	38.37	--	125	822	--	139	####	--	6301	--	####	--	21.1	--	4.50	4.67	4.3	4.4	5.4	5.1	4.0	4.2
SV 333	5	37.62	--	122	813	--	138	####	--	6231	--	####	--	20.9	--	4.69	4.59	4.1	4.4	5.6	5.2	4.6	4.3
SX 1888	1	37.03	--	120	787	--	133	####	--	6038	--	####	--	20.3	--	4.67	4.78	4.0	4.3	5.5	5.5	4.2	4.2
Newly Approved																							
BTS 8927	NC	43.12	--	140	985	--	167	####	--	7070	--	####	--	22.4	--	4.42	4.39	3.9	4.0	2.6	2.7	4.4	4.2
BTS 8938	NC	37.24	--	121	848	--	144	####	--	6467	--	####	--	21.6	--	4.66	4.51	3.9	3.8	3.7	3.4	3.9	3.7
BTS 8961	NC	36.54	--	119	835	--	142	####	--	6478	--	####	--	22.0	--	4.69	4.48	4.0	4.0	2.2	2.4	4.1	3.9
BTS 8976	NC	38.45	--	125	822	--	139	####	--	6167	--	####	--	20.4	--	4.15	3.99	3.5	3.6	2.9	3.3	4.5	4.3
Crystal 912	NC	35.21	--	114	886	--	150	####	--	7041	--	####	--	24.4	--	4.75	4.69	3.7	3.8	3.6	3.5	3.5	3.6
Crystal 913	NC	39.55	--	128	951	--	161	####	--	7129	--	####	--	23.5	--	4.13	4.12	3.7	3.7	2.6	2.6	4.6	4.4
Crystal 916	NC	35.60	--	116	887	--	150	####	--	7014	--	####	--	24.2	--	4.49	4.38	3.9	4.0	2.4	2.5	4.6	4.4
Hilleshög HIL2317	NC	36.66	--	119	741	--	126	####	--	5836	--	####	--	20.0	--	5.05	4.97	3.9	3.9	6.0	5.6	4.9	4.6
Hilleshög HM9528RR	5	36.06	--	117	720	--	122	####	--	5703	--	####	--	19.6	--	4.84	4.88	3.7	4.1	4.7	4.4	4.6	4.3
Hilleshög HIL9708	3	34.56	--	112	644	--	109	####	--	5192	--	####	--	18.1	--	4.97	4.96	4.0	4.3	3.6	3.8	3.8	3.8
Hilleshög HIL9920	2	35.57	--	115	706	--	120	####	--	5606	--	####	--	19.3	--	4.82	4.88	3.6	4.3	6.3	5.8	5.1	4.9
SX 1887	1	37.29	--	121	790	--	134	####	--	6033	--	####	--	20.2	--	5.09	4.99	3.9	4.3	4.3	4.5	4.8	4.5
SX 1898	NC	37.53	--	122	855	--	145	####	--	6643	--	####	--	22.6	--	4.73	4.70	3.8	4.3	5.4	5.3	4.2	4.2
Aph Susc Checks		30.80	--		590	--		####	--	4984	--	####	--	18.0	--								
Mean of Aph Specialty Varieties		36.28	--		809	--		####	--	6325	--	####	--	21.6	--								

%Sus = % of susceptible varieties. Created 11/2/2020

+ Aphanomyces ratings from Shakopee, Glyndon and Grandin (res.<4.4, susc>5.0). Cercospora from Randolph MN, Foxhome MN & Michigan (res.<4.5, susc>5.0). Fusarium from RRV (res.<3.0, susc>5.0). Rhizoctonia from Mhd (res.<3.8, susc>5).

++ 2020 Revenue estimates based on a $45.12 beet payment at 17.5% sugar and 1.5% loss to molasses. 2019 Revenue estimates based on a $44.38 beet payment. Revenue does not consider hauling or production costs.

+++ 2020 Data from Climax, Perley, and Grandin.

Lack of Aphanomyces pressure at any of the OVT sites prevented collection of Aphanomyces Yield Data for 2019.

Table 4. ACSC Official Trial Disease Nurseries 2018-2020 (Varieties tested in 2020)
Cercospora, Aphanomyces, Rhizoctonia & Fusarium

		< 4.5 Cercospora > 5.0					< 4.4 Aphanomyces > 5.0					< 3.82 Rhizoctonia > 5.0					< 3.0 Fusarium > 5.0					High Rzm
		20	19	18	2 Yr	3 Yr	20	19	18	2 Yr	3 Yr	20	19	18	2 Yr	3 Yr	20	19	18	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	
518	BTS 8007	4.27	--	--	--	--	4.06	--	--	--	--	4.45	--	--	--	--	2.48	--	--	--	--	Rzm
513	BTS 8009	4.27	--	--	--	--	3.83	--	--	--	--	4.36	--	--	--	--	3.37	--	--	--	--	Rzm
549	BTS 8013	3.88	--	--	--	--	4.29	--	--	--	--	4.44	--	--	--	--	2.30	--	--	--	--	Rzm
521	BTS 8018	2.41	--	--	--	--	3.87	--	--	--	--	4.16	--	--	--	--	2.47	--	--	--	--	Rzm
546	BTS 8034	2.70	--	--	--	--	4.36	--	--	--	--	4.56	--	--	--	--	2.26	--	--	--	--	Rzm
550	BTS 8042	4.50	--	--	--	--	3.75	--	--	--	--	4.00	--	--	--	--	2.46	--	--	--	--	Rzm
570	BTS 8055	4.16	--	--	--	--	3.61	--	--	--	--	4.21	--	--	--	--	2.27	--	--	--	--	Rzm
571	BTS 8073	4.68	--	--	--	--	3.45	--	--	--	--	4.11	--	--	--	--	2.58	--	--	--	--	Rzm
520	BTS 8090	4.35	--	--	--	--	4.07	--	--	--	--	3.99	--	--	--	--	2.53	--	--	--	--	Rzm
505	BTS 8092	4.26	--	--	--	--	3.85	--	--	--	--	3.81	--	--	--	--	3.70	--	--	--	--	Rzm
510	BTS 8337	4.46	4.40	4.64	4.43	4.50	3.48	3.45	3.74	3.46	3.56	4.43	3.62	4.07	4.02	4.04	3.63	3.57	4.18	3.60	3.79	Hi Rzm
573	BTS 8500	4.38	4.00	4.40	4.19	4.26	4.16	4.30	4.43	4.23	4.30	4.64	4.28	4.36	4.46	4.43	2.38	2.27	2.46	2.32	2.37	Hi Rzm
552	BTS 8524	4.38	4.52	4.50	4.45	4.47	4.21	4.51	4.08	4.36	4.27	4.14	4.00	4.23	4.07	4.12	3.01	3.14	3.93	3.08	3.36	Hi Rzm
564	BTS 8606	4.79	4.69	4.80	4.74	4.76	4.56	5.11	4.43	4.84	4.70	4.75	4.60	4.24	4.67	4.53	2.87	2.68	3.66	2.78	3.07	Hi Rzm
524	BTS 8629	4.55	4.66	4.52	4.60	4.57	3.92	5.32	3.89	4.62	4.38	4.30	3.89	4.02	4.10	4.07	3.78	3.71	4.40	3.75	3.96	Hi Rzm
536	BTS 8767	4.38	4.26	4.32	4.32	4.32	4.46	4.32	4.28	4.39	4.35	4.68	4.14	4.10	4.41	4.30	2.45	2.45	3.41	2.45	2.77	Hi Rzm
575	BTS 8815	4.86	4.61	4.65	4.73	4.71	4.17	5.24	3.97	4.71	4.46	3.92	4.03	3.88	3.98	3.94	2.58	2.69	3.64	2.63	2.97	Hi Rzm
543	BTS 8882	4.71	4.18	4.53	4.44	4.47	4.33	5.17	4.98	4.75	4.83	4.26	4.27	4.37	4.26	4.30	2.11	2.91	3.39	2.51	2.80	Hi Rzm
532	BTS 8927	4.42	4.35	--	4.39	--	3.87	4.06	--	3.96	--	4.37	3.93	--	4.15	--	2.59	2.77	--	2.68	--	Hi Rzm
563	BTS 8938	4.66	4.35	--	4.51	--	3.86	3.75	--	3.80	--	3.90	3.47	--	3.69	--	3.66	3.06	--	3.36	--	Hi Rzm
531	BTS 8961	4.69	4.27	--	4.48	--	4.04	3.89	--	3.97	--	4.11	3.79	--	3.95	--	2.19	2.55	--	2.37	--	Hi Rzm
555	BTS 8976	4.15	3.83	--	3.99	--	3.55	3.55	--	3.55	--	4.52	4.02	--	4.27	--	2.92	3.68	--	3.30	--	Hi Rzm
554	Crystal 021	2.20	--	--	--	--	3.46	--	--	--	--	3.88	--	--	--	--	2.85	--	--	--	--	Hi Rzm
556	Crystal 022	4.71	--	--	--	--	3.81	--	--	--	--	3.49	--	--	--	--	2.60	--	--	--	--	Hi Rzm
567	Crystal 024	4.70	--	--	--	--	3.65	--	--	--	--	3.69	--	--	--	--	2.43	--	--	--	--	Hi Rzm
515	Crystal 025	4.56	--	--	--	--	3.40	--	--	--	--	3.72	--	--	--	--	2.51	--	--	--	--	Hi Rzm
506	Crystal 026	4.76	--	--	--	--	3.75	--	--	--	--	3.57	--	--	--	--	2.31	--	--	--	--	Hi Rzm
527	Crystal 027	4.38	--	--	--	--	3.72	--	--	--	--	4.15	--	--	--	--	2.44	--	--	--	--	Hi Rzm
542	Crystal 029	4.67	--	--	--	--	3.60	--	--	--	--	4.31	--	--	--	--	2.42	--	--	--	--	Hi Rzm
547	Crystal 572	4.46	4.68	4.45	4.57	4.53	4.28	4.98	4.47	4.63	4.57	4.21	4.14	4.54	4.17	4.30	2.36	2.39	3.70	2.37	2.81	Hi Rzm
514	Crystal 574	4.64	4.28	4.42	4.46	4.44	4.11	3.99	4.32	4.05	4.14	4.18	4.45	4.36	4.32	4.33	2.26	2.03	2.87	2.15	2.39	Hi Rzm
509	Crystal 684	4.44	4.12	4.41	4.28	4.33	3.97	4.33	3.83	4.15	4.04	4.15	4.01	4.39	4.08	4.18	2.32	2.10	2.96	2.21	2.46	Hi Rzm
565	Crystal 793	4.31	4.04	4.26	4.18	4.20	3.87	3.72	3.32	3.79	3.64	4.84	4.18	4.11	4.51	4.38	2.61	2.71	3.59	2.66	2.97	Hi Rzm
516	Crystal 796	4.95	4.74	4.74	4.85	4.81	3.85	3.97	3.61	3.91	3.81	4.45	3.85	3.97	4.15	4.09	2.20	2.45	3.36	2.33	2.67	Hi Rzm
533	Crystal 803	3.93	3.88	4.01	3.90	3.94	3.96	4.45	3.86	4.20	4.09	5.00	4.54	4.67	4.77	4.73	2.52	2.70	4.11	2.61	3.11	Hi Rzm
503	Crystal 804	4.77	4.46	4.42	4.61	4.55	3.61	4.30	3.58	3.95	3.83	3.90	3.72	4.02	3.81	3.88	2.29	2.28	3.05	2.28	2.54	Hi Rzm
560	Crystal 808	5.07	4.78	4.86	4.92	4.90	4.02	3.57	3.60	3.79	3.73	3.88	4.09	3.83	3.98	3.93	2.35	2.39	3.12	2.37	2.62	Hi Rzm
569	Crystal 912	4.75	4.62	--	4.69	--	3.67	3.91	--	3.79	--	3.54	3.58	--	3.56	--	3.61	3.37	--	3.49	--	Hi Rzm
511	Crystal 913	4.13	4.11	--	4.12	--	3.75	3.58	--	3.66	--	4.58	4.31	--	4.44	--	2.59	2.56	--	2.57	--	Hi Rzm
558	Crystal 916	4.49	4.26	--	4.38	--	3.85	4.17	--	4.01	--	4.56	4.26	--	4.41	--	2.44	2.49	--	2.46	--	Hi Rzm
519	Hilleshög HIL2233	5.23	5.26	4.87	5.24	5.12	3.77	4.43	4.02	4.10	4.07	4.43	3.78	4.04	4.11	4.08	4.44	4.35	5.28	4.40	4.69	Hi Rzm
557	Hilleshög HIL2317	5.05	4.90	--	4.97	--	3.86	3.96	--	3.91	--	4.95	4.19	--	4.57	--	5.97	5.30	--	5.63	--	Hi Rzm
528	Hilleshög HIL2320	5.11	4.92	--	5.02	--	3.55	4.58	--	4.06	--	4.64	4.04	--	4.34	--	4.56	4.37	--	4.47	--	Hi Rzm
544	Hilleshög HIL2366	4.94	--	--	--	--	3.81	--	--	--	--	4.24	--	--	--	--	4.55	--	--	--	--	Hi Rzm
517	Hilleshög HIL2367	5.08	--	--	--	--	3.51	--	--	--	--	4.26	--	--	--	--	4.44	--	--	--	--	Hi Rzm
502	Hilleshög HIL2368	4.69	--	--	--	--	3.70	--	--	--	--	3.52	--	--	--	--	3.86	--	--	--	--	Hi Rzm
534	Hilleshög HIL2369	5.55	--	--	--	--	3.61	--	--	--	--	4.63	--	--	--	--	4.78	--	--	--	--	Hi Rzm
553	Hilleshög HIL2370	4.79	--	--	--	--	4.16	--	--	--	--	4.50	--	--	--	--	2.25	--	--	--	--	Hi Rzm
574	Hilleshög HIL9708	4.97	4.96	4.71	4.96	4.88	3.96	4.61	4.25	4.28	4.27	3.83	3.87	3.71	3.85	3.80	3.64	3.89	4.61	3.76	4.05	Rzm
559	Hilleshög HIL9920	4.82	4.95	4.79	4.88	4.85	3.65	5.05	4.09	4.35	4.26	5.12	4.68	4.65	4.90	4.82	6.28	5.42	5.51	5.85	5.74	Hi Rzm
508	Hilleshög HM4448RR	5.61	5.48	5.26	5.54	5.45	4.09	4.86	4.53	4.47	4.49	4.76	4.04	4.38	4.40	4.39	4.58	4.80	5.23	4.69	4.87	Rzm
526	Hilleshög HM9528RR	4.84	4.93	4.79	4.88	4.85	3.72	4.56	4.22	4.14	4.17	4.57	4.10	4.04	4.33	4.24	4.68	4.16	4.95	4.42	4.60	Hi Rzm
535	Maribo MA504	5.35	5.34	4.98	5.34	5.22	5.06	6.17	5.30	5.61	5.51	4.83	4.69	4.25	4.76	4.59	4.25	4.61	4.80	4.43	4.55	Hi Rzm
561	Maribo MA717	5.11	5.11	4.78	5.11	5.00	3.77	4.42	4.15	4.10	4.12	4.61	4.15	4.35	4.38	4.37	4.62	4.81	4.86	4.72	4.77	Hi Rzm
538	Maribo MA902	4.96	4.91	--	4.94	--	4.01	5.31	--	4.66	--	3.93	3.97	--	3.95	--	4.01	3.71	--	3.86	--	Hi Rzm
537	Maribo MA903	5.15	5.25	--	5.20	--	3.42	4.56	--	3.99	--	3.97	3.89	--	3.93	--	4.87	4.60	--	4.73	--	Hi Rzm
529	Maribo MA922	4.77	--	--	--	--	3.69	--	--	--	--	4.83	--	--	--	--	4.28	--	--	--	--	Hi Rzm
541	Maribo MA923	4.81	--	--	--	--	4.59	--	--	--	--	5.03	--	--	--	--	5.60	--	--	--	--	Hi Rzm
562	SV 201	4.83	--	--	--	--	3.92	--	--	--	--	4.69	--	--	--	--	4.91	--	--	--	--	Hi Rzm
523	SV 202	4.12	--	--	--	--	4.61	--	--	--	--	5.90	--	--	--	--	2.79	--	--	--	--	Hi Rzm
572	SV 203	5.03	--	--	--	--	4.34	--	--	--	--	4.29	--	--	--	--	5.26	--	--	--	--	Hi Rzm
568	SV 204	4.88	--	--	--	--	4.20	--	--	--	--	4.60	--	--	--	--	4.24	--	--	--	--	Hi Rzm
548	SV 265	4.55	4.28	4.48	4.41	4.44	3.98	5.47	4.16	4.73	4.54	4.21	4.25	4.32	4.23	4.26	5.70	5.64	5.44	5.67	5.59	Hi Rzm
551	SV 268	4.78	4.82	4.70	4.80	4.77	4.49	5.08	4.21	4.78	4.59	5.24	4.21	4.21	4.73	4.55	4.04	4.92	5.12	4.48	4.69	Hi Rzm
539	SV 285	4.50	4.84	4.52	4.67	4.62	4.28	4.47	3.98	4.38	4.25	4.03	4.38	4.35	4.21	4.26	5.40	4.76	5.42	5.08	5.19	Hi Rzm
504	SV 333	4.69	4.49	4.78	4.59	4.66	4.09	4.70	4.06	4.40	4.29	4.61	4.08	4.23	4.34	4.31	5.64	4.74	5.14	5.19	5.17	Hi Rzm
576	SV 375	4.78	4.11	4.96	4.44	4.62	4.04	5.03	3.83	4.54	4.30	4.54	4.05	4.13	4.30	4.24	5.25	4.97	5.51	5.11	5.24	Hi Rzm
501	SV 393	4.87	4.94	--	4.90	--	4.02	5.03	--	4.53	--	4.96	4.33	--	4.65	--	4.18	5.24	--	4.71	--	Hi Rzm
540	SX 1801	4.63	--	--	--	--	4.44	--	--	--	--	5.21	--	--	--	--	3.70	--	--	--	--	Hi Rzm
545	SX 1802	5.54	--	--	--	--	4.60	--	--	--	--	4.46	--	--	--	--	2.71	--	--	--	--	Hi Rzm
507	SX 1803	4.87	--	--	--	--	4.52	--	--	--	--	4.32	--	--	--	--	4.81	--	--	--	--	Hi Rzm
530	SX 1804	4.76	--	--	--	--	4.02	--	--	--	--	4.38	--	--	--	--	5.56	--	--	--	--	Hi Rzm
566	SX 1887	5.09	4.89	4.89	4.99	4.95	3.92	4.67	4.49	4.30	4.36	4.80	4.18	4.16	4.49	4.38	4.30	4.68	5.35	4.49	4.77	Hi Rzm
512	SX 1888	4.67	4.89	4.92	4.78	4.83	3.99	4.65	4.03	4.32	4.22	4.17	4.19	4.57	4.18	4.31	5.54	5.51	5.47	5.52	5.51	Hi Rzm
522	SX 1898	4.73	4.68	--	4.70	--	3.76	4.74	--	4.25	--	4.16	4.21	--	4.19	--	5.41	5.14	--	5.28	--	Hi Rzm
525	SX Marathon	4.85	4.79	5.27	4.82	4.97	4.12	5.15	4.72	4.64	4.66	4.26	4.36	4.19	4.31	4.27	5.37	5.70	5.51	5.53	5.53	Hi Rzm

Created 11/2/2020

Green highlighted ratings indicate specialty or good resistance.
Red highlighted ratings indicate level of concern for some fields.
-- indicates data not available

Table 5. Root Aphid Ratings
2020 Growing Season

Intentionally Left Blank

Table 6. Planting & Harvest Dates, Previous Crop and Disease Levels for 2020 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 ND	Mhd/Hlb	Todd Weber Farms	5/4	9/30	Wheat	Medium/Light	L-M	L	N	N	N	N	A few Rhc spots. Heavier Aph in NE and SW corners.
Glyndon MN	Mhd/Hlb	Menholt Farms	5/3	9/9	Wheat	Medium/Light	L	L-M	N	N	N	N	Moderate Rhc in NE corner.
Perley MN	Mhd/Hlb	Hoff Farms	6/7	9/2	Soybeans	Medium	L-M	N	N	N	N	N	Some standing water in spots.
Ada MN	Mhd/Hlb	Corey Jacobson	5/15	9/10	Wheat	Medium	L	N	L	N	N	N	Uniform site.
Hillsboro ND	Mhd/Hlb	SK Farms	5/31	Abandon	Wheat	Medium	L-M	L	N	N	N	N	Non-uniform stunting in Official Trials.
Grandin ND	Mhd/Hlb	Paulsrud Farms	5/23	9/4	Wheat	Medium	L-V	L	N	N	N	N	Aph heavier on south side and nursery. Nursery rated.
Grand Forks ND	EGF/Crk	Drees Farming Association	5/22	9/22	Wheat	Medium/Light	N	L	N	N	N	N	Light Rzm on a few beets. Scattered damage from standing water.
Scandia MN	EGF/Crk	Deboer Farms	5/18	9/8	Wheat	Medium	N	N	L-M	N	N	N	Scattered Rzm symptoms. Some stunted areas.
Climax MN	EGF/Crk	Knutson Farms	5/23	9/28	Wheat	Medium/Light	L-M	N	N	N	N	N	Moderate Aph scattered throughout.
East Grand Forks MN	EGF/Crk	Mark Holy	5/15	9/15	Wheat	Medium	L	N	N	N	N	N	Weaker stands in W end of commercial trial.
St. Thomas ND	Dtn	Kennelly Farms	5/12	9/16 Exp	Wheat	Medium/Light	N	N	N	N	N	N	Commercial trial abandoned due to erratic stands.
Stephen MN	Dtn	Jensen Farms	5/3	Abandon	Wheat	Medium/Heavy	NA	NA	NA	NA	NA	NA	Heavy water damage.
Bathgate ND	Dtn	Shady Bend Farms	5/21	9/18	Wheat	Medium	N	N	N	N	N	L	A few root aphids.

Location	District / Trial Type	Cooperator	Planting Date	Rating Date	Preceding Crop	Soil Type	Diseases Present @ Aph	Rhc	Rzm	Fus	Maggot	Rt Aphid	Comments
Moorhead Fus-N MN	Fus Nurs	Nelson Farms	5/17	Multiple	Wheat	Medium/Heavy	NA	NA	NA	V	NA	NA	
Moorhead Fus-S MN	Fus Nurs	Oberg Farms	5/17	Multiple	Soybeans	Medium	NA	L	NA	V	NA	NA	
Mhd Rhc-E MN	Rhc Nurs	Jon Hickel	5/24	8/25	Soybeans	Heavy	NA	V	NA	L	NA	NA	
Mhd Rhc-W MN	Rhc Nurs	Jon Hickel	5/24	8/5	Soybeans	Heavy	NA	V	NA	L-M	NA	NA	
NWROC MN	Rhc Nurs	Albert Sims	5/16	Abandon	Soybeans	Medium	NA	NA	NA	NA	NA	NA	Standing water damaged the site
BSDF MI	Rhc Nurs	Mitch McGrath	5/26	8/11	NA	NA	NA	V	NA	NA	NA	NA	Abandoned
Shakopee MN	Aphanomyces	Patrick O'Boyle	5/8	8/27	NA	NA	V	NA	NA	NA	NA	NA	
Glyndon MN	Aphanomyces	Dennis Simmons	5/30	8/25	Corn	Medium	V	NA	NA	NA	NA	NA	
Perley MN	Aphanomyces	Hoff Farms	6/7	Abandon	Soybeans	Medium	L-M	N	N	N	N	N	Water and deer damage
Grandin ND	Aphanomyces	Paulsrud Farms	5/23	8/24	Wheat	Medium	M-V	L	N	N	N	N	Symptoms more severe on S side.
Longmont CO	Root Aphids	Kara Guffey	5/8	10/9	NA	NA	NA	NA	NA	NA	NA	V	
Foxhome MN	Cercospora	NDSU/Kevin Etzler	5/8	Multiple	Wheat	Medium	NA	NA	NA	NA	NA	NA	
BSDF MI	Cercospora	Mitch McGrath	5/23	Multiple	NA	NA	NA	NA	NA	NA	NA	NA	Nursery was reinoculated due to rain following first inoculation.
Randolph MN	Cercospora	Patrick O'Boyle	5/3	Multiple	NA	NA	NA	NA	NA	NA	NA	NA	

Created 10-30-2020

* Fertilizer applied in accordance with cooperative recommendations.

@ Disease notes for Aphanomyces, Rhizoctonia, Rhizomania, Fusarium, Root Maggot and Root Aphids were based upon visual evaluations (N=none, L=light, M=moderate, V=severe, NA=not observed)

Table 7. Seed Treatments Used on Varieties in Official Variety Trials in 2020

Description	Years in Trial	Years Comm.	Fungicide (Rhizoctonia)	Insecticide Spring Tails & Maggots	Tachigaren Rate (Aphanomyces)	Priming (Emergence)	Fungicide (Damping Off)
ACSC Commercial							
BTS 8337	8	6	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8500	6	4	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8524	6	4	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8606	5	3	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8629	5	3	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8767	4	2	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8815	3	1	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8882	3	1	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
Crystal 572	6	4	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 574	6	4	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 684	5	2	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 793	4	2	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 796	4	1	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Hilleshög HIL9708	6	3	Vibrance	Cruiser Maxx	20	XBEET	Apron XL Maxim
Hilleshög HIL9920	4	2	Vibrance	Cruiser Maxx	20	XBEET	Apron XL Maxim
Hilleshög HM4448RR	8	7	Vibrance	Cruiser Maxx	20	XBEET	Apron XL Maxim
Hilleshög HM9528RR	7	5	Vibrance	Cruiser Maxx	20	XBEET	Apron XL Maxim
Maribo MA504	6	4	Vibrance	Cruiser Maxx	20	XBEET	Apron XL Maxim
Maribo MA717	4	2	Vibrance	Cruiser Maxx	20	XBEET	Apron XL Maxim
SV 265	5	3	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV 268	5	3	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV 333	8	5	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV 375	4	1	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SX 1887	3	1	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SX 1888	3	1	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SX Marathon	6	4	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
Crystal 355RR(Check)	8	5	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 578RR (Check)	6	3	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
BTS 8572 (Check)	6	4	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
AP SUS RR#5	4	7	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
AP CHK MOD RES RR#4	9	7	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Root Aphid Susc Chk#3	7	5	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
ACSC Experimental							
BTS 8007	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8009	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8013	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8018	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8034	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8042	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8055	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8073	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8090	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8092	1	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8927	2	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8938	2	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8961	2	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
BTS 8976	2	NC	Kabina	Poncho Beta	35	Ultripro	Allegiance Thiram
Crystal 021	1	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 022	1	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 024	1	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 025	1	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 026	1	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 027	1	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 029	1	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 803	3	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 804	3	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 808	3	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 912	2	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 913	2	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Crystal 916	2	NC	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
Hilleshög HIL2233	3	NC	Vibrance	Cruiser Maxx	45	HIL-Activate	Apron XL Maxim
Hilleshög HIL2317	2	NC	Vibrance	Cruiser Maxx	45	HIL-Activate	Apron XL Maxim
Hilleshög HIL2320	2	NC	Vibrance	Cruiser Maxx	45	HIL-Activate	Apron XL Maxim
Hilleshög HIL2366	1	NC	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Hilleshög HIL2367	1	NC	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Hilleshög HIL2368	1	NC	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Hilleshög HIL2369	1	NC	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Hilleshög HIL2370	1	NC	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Maribo MA902	2	NC	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Maribo MA903	2	NC	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Maribo MA922	1	NC	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
Maribo MA923	1	NC	Vibrance	Cruiser Maxx	45	XBEET	Apron XL Maxim
SV 201	1	NC	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV 202	1	NC	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV 203	1	NC	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV 204	1	NC	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV 285	3	NC	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SV 393	2	NC	Metlock/Rizolex/Vibrance	NipsIt	45	XBEET	Sebring Thiram
SX 1801	1	NC	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SX 1802	1	NC	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SX 1803	1	NC	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SX 1804	1	NC	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
SX 1898	2	NC	Metlock/Rizolex/Kabina	NipsIt	20	XBEET	Sebring Thiram
Crystal 355RR(Check)	8	5	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram
BTS 8572 (Check)	6	4	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
BTS 8337 (Check)	8	6	Systiva	Poncho Beta	35	Ultipro	Allegiance Thiram
Crystal 578RR (Check)	6	3	Kabina	Poncho Beta	45	XBEET	Allegiance Thiram

Created 10/29/2020

Table 8. 2020 Performance of 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	112	341.4	102	8662	100	1.07	51.24	105	1300	102	18.14	25.34	164	1666	325	4	64.5
BTS 8500	123	314.2	94	9476	109	1.10	43.48	89	1307	103	16.81	30.24	190	1679	334	0	67.2
BTS 8524	101	317.4	95	9150	106	1.10	44.39	91	1279	101	16.97	28.83	185	1715	328	0	74.4
BTS 8606	109	322.7	97	9022	104	1.03	45.91	94	1284	101	17.17	27.98	187	1620	302	0	70.7
BTS 8629	105	317.4	95	10066	116	1.02	44.38	91	1406	111	16.89	31.76	184	1519	323	0	68.0
BTS 8767	116	321.2	96	9299	107	1.02	45.48	93	1317	104	17.08	28.95	179	1639	287	0	71.4
BTS 8815	108	328.6	99	9013	104	1.02	47.60	97	1307	103	17.45	27.40	186	1656	282	0	65.8
BTS 8882	107	314.8	94	9981	115	1.05	43.65	89	1381	109	16.80	31.78	186	1684	302	0	72.4
Crystal 572	103	340.6	102	9387	108	0.99	51.00	104	1405	110	18.02	27.62	139	1518	310	0	73.3
Crystal 574	126	316.5	95	10010	115	1.08	44.14	90	1396	110	16.91	31.60	192	1689	321	0	67.7
Crystal 684	119	316.7	95	10283	119	1.06	44.19	90	1432	113	16.90	32.59	187	1667	310	0	73.8
Crystal 793	102	335.2	101	10253	118	0.93	49.48	101	1514	119	17.70	30.58	155	1486	273	0	71.3
Crystal 796	124	321.7	96	9674	112	1.05	45.63	93	1372	108	17.14	30.08	178	1650	314	0	73.5
Hilleshög HIL9708	117	330.0	99	9420	109	0.98	47.99	98	1369	108	17.48	28.54	189	1518	284	0	72.0
Hilleshög HIL9920	122	333.4	100	9533	110	0.97	48.97	100	1398	110	17.64	28.60	177	1605	262	0	69.7
Hilleshög HM4448RR	120	317.5	95	9725	112	1.01	44.42	91	1358	107	16.89	30.73	173	1542	312	0	74.6
Hilleshög HM9528RR	125	323.5	97	9576	110	1.03	46.14	94	1362	107	17.21	29.63	197	1578	310	0	68.6
Maribo MA504	118	317.5	95	9787	113	1.00	44.42	91	1368	108	16.87	30.85	192	1559	288	0	72.2
Maribo MA717	113	329.0	99	10054	116	1.03	47.70	97	1454	114	17.47	30.63	191	1563	310	0	74.7
SV 265	121	332.4	100	9523	110	0.96	48.67	99	1396	110	17.58	28.65	153	1556	272	0	67.4
SV 268	111	328.3	98	9093	105	1.01	47.51	97	1317	104	17.42	27.64	173	1576	298	0	66.9
SV 333	114	327.7	98	9635	111	0.97	47.34	97	1391	109	17.36	29.44	161	1555	280	0	65.8
SV 375	104	327.5	98	9393	108	0.99	47.28	97	1352	106	17.37	28.78	161	1575	290	4	62.8
SX 1887	110	326.6	98	9270	107	1.02	47.02	96	1334	105	17.34	28.31	194	1586	296	0	66.9
SX 1888	106	327.9	98	9325	108	1.00	47.38	97	1345	106	17.40	28.50	164	1601	294	4	63.0
SX Marathon	115	327.6	98	9669	112	0.99	47.30	97	1396	110	17.37	29.53	162	1582	289	0	66.0
Crystal 355RR(Check)	127	333.8	100	8166	94	1.07	49.08	100	1200	94	17.76	24.48	159	1644	335	0	72.4
Crystal 578RR (Check)	128	323.5	97	9087	105	1.02	46.12	94	1296	102	17.19	28.08	182	1616	292	0	72.7
BTS 8572 (Check)	129	335.2	101	8768	101	1.02	49.47	101	1292	102	17.78	26.20	152	1539	323	8	64.0
AP SUS RR#5	130	315.1	94	8829	102	1.07	43.74	89	1226	96	16.82	28.00	234	1682	294	4	61.1
AP CHK MOD RES RR#4	131	324.2	97	8999	104	0.99	46.32	95	1286	101	17.20	27.76	185	1618	269	0	72.3
Root Aphid Susc Chk#3	132	339.1	102	8184	94	1.01	50.60	103	1221	96	17.97	24.10	191	1565	301	0	62.3
Experimental Trial (Comm status)																	
BTS 8007	236	322.3	97	10104	117	1.05	45.76	93	1433	113	17.17	31.40	194	1672	308	0	66.8
BTS 8009	218	336.0	101	9184	106	0.98	49.72	102	1354	106	17.78	27.39	162	1566	295	0	61.6
BTS 8013	228	343.5	103	9198	106	0.92	51.88	106	1391	109	18.09	26.72	142	1470	277	12	71.8
BTS 8018	247	332.8	100	10212	118	0.94	48.79	100	1501	118	17.58	30.59	161	1514	279	12	75.1
BTS 8034	211	327.3	98	10616	122	1.03	47.20	96	1534	121	17.40	32.36	189	1707	286	0	78.1
BTS 8042	227	333.1	100	9582	111	0.99	48.89	100	1399	110	17.64	28.93	168	1653	272	0	71.4
BTS 8055	250	332.1	100	9467	109	1.02	48.58	99	1386	109	17.62	28.47	167	1662	296	0	73.0
BTS 8073	246	337.0	101	10371	120	0.96	49.97	102	1537	121	17.79	30.79	145	1492	303	0	72.1
BTS 8090	224	334.7	100	9366	108	1.03	49.36	101	1380	108	17.75	28.02	140	1545	341	0	67.2
BTS 8092	233	329.9	99	10144	117	0.93	47.93	98	1474	116	17.42	30.75	160	1469	282	0	68.9
BTS 8927	238	347.7	104	9720	112	0.90	53.07	108	1482	117	18.28	27.95	140	1452	268	0	77.1
BTS 8938	237	329.2	99	9700	112	0.98	47.75	97	1409	111	17.44	29.43	172	1486	310	0	66.9
BTS 8961	203	321.4	96	9990	115	1.05	45.49	93	1415	111	17.12	31.06	190	1673	311	0	72.9
BTS 8976	212	335.5	101	9116	105	0.95	49.57	101	1351	106	17.72	27.10	160	1566	270	0	68.8
Crystal 021	201	326.6	98	10344	119	0.99	46.98	96	1489	117	17.31	31.69	190	1634	273	0	67.0
Crystal 022	217	348.5	104	10047	116	0.90	53.31	109	1536	121	18.32	28.86	133	1474	265	0	72.0
Crystal 024	209	322.5	97	10183	117	1.01	45.83	94	1443	113	17.14	31.66	185	1624	293	0	67.2
Crystal 025	243	332.8	100	9876	114	1.01	48.79	100	1444	114	17.64	29.73	173	1625	297	0	65.5
Crystal 026	234	329.1	99	10280	119	1.00	47.71	97	1491	117	17.45	31.26	175	1686	270	0	73.4
Crystal 027	239	348.7	105	9308	107	0.93	53.35	109	1425	112	18.36	26.69	148	1477	280	0	71.6
Crystal 029	220	333.7	100	10051	116	0.99	49.05	100	1477	116	17.67	30.13	156	1542	309	0	73.7
Crystal 803	242	333.6	100	9811	113	0.95	49.01	100	1444	114	17.62	29.35	151	1522	283	0	77.6
Crystal 804	215	312.5	94	10068	116	1.10	42.95	88	1383	109	16.72	32.22	209	1691	337	0	65.8
Crystal 808	207	323.1	97	9955	115	1.04	46.00	94	1417	111	17.19	30.83	213	1628	303	0	76.2
Crystal 912	230	322.7	97	10726	124	0.99	45.87	94	1520	120	17.12	33.31	188	1468	318	0	74.7
Crystal 913	245	332.9	100	10150	117	0.97	48.81	100	1490	117	17.61	30.48	171	1488	301	0	73.7
Crystal 916	206	320.6	96	9967	115	1.06	45.26	92	1410	111	17.09	31.04	176	1684	319	0	79.1
Hilleshög HIL2233	213	333.9	100	9749	112	0.98	49.12	100	1429	112	17.66	29.27	167	1520	303	0	78.8
Hilleshög HIL2317	226	334.3	100	9428	109	0.97	49.24	101	1385	109	17.67	28.24	185	1594	265	0	71.9
Hilleshög HIL2320	221	333.4	100	10017	116	1.02	48.97	100	1467	115	17.68	30.12	179	1569	314	0	71.8
Hilleshög HIL2366	240	328.2	98	9593	111	0.95	47.46	97	1383	109	17.40	29.32	185	1533	303	0	78.7
Hilleshög HIL2367	244	334.8	100	9791	113	1.01	49.36	101	1440	113	17.74	29.30	175	1573	307	0	69.7
Hilleshög HIL2368	214	345.2	104	8598	99	0.97	52.37	107	1301	102	18.23	24.95	171	1560	285	0	72.0
Hilleshög HIL2369	241	324.4	97	9600	111	1.03	46.38	95	1366	107	17.24	29.75	164	1573	324	0	58.0
Hilleshög HIL2370	216	317.9	95	9937	115	1.01	44.48	91	1392	109	16.90	31.24	179	1581	302	0	74.9
Maribo MA902	223	332.7	100	9508	110	0.98	48.77	100	1393	110	17.60	28.61	176	1535	291	0	72.5
Maribo MA903	219	338.1	101	9601	111	0.96	50.30	103	1425	112	17.85	28.48	153	1516	294	0	77.6
Maribo MA922	225	314.2	94	10068	116	1.14	43.44	89	1388	109	16.85	32.14	240	1700	349	0	72.9
Maribo MA923	249	316.3	95	9074	105	1.10	44.01	90	1259	99	16.91	28.77	214	1613	352	0	61.2
SV 201	229	333.0	100	9309	107	1.02	48.84	100	1361	107	17.66	28.05	166	1624	303	0	61.8
SV 202	232	324.1	97	8613	99	1.02	46.29	95	1230	97	17.22	26.56	212	1606	293	0	60.0
SV 203	204	333.5	100	9983	115	1.00	48.99	100	1466	115	17.67	29.93	159	1616	298	0	63.5
SV 204	208	332.1	100	9203	106	0.98	48.59	99	1347	106	17.58	27.72	175	1605	278	0	63.6
SV 285	235	335.6	101	9262	107	0.97	49.60	101	1373	108	17.74	27.51	149	1595	280	0	64.7
SV 393	248	326.5	98	9208	106	1.05	46.96	96	1325	104	17.36	28.17	197	1640	314	0	59.2
SX 1801	210	330.8	99	9081	105	0.99	48.22	98	1327	104	17.52	27.35	185	1584	286	0	61.7
SX 1802	222	319.3	96	10457	121	1.06	44.90	92	1467	115	17.02	32.80	182	1561	346	0	73.3
SX 1803	231	321.8	97	9370	108	1.02	45.62	93	1325	104	17.11	29.17	164	1613	313	0	63.1
SX 1804	202	329.9	99	9624	111	1.01	47.93	98	1393	110	17.50	29.30	161	1621	303	0	70.6
SX 1898	205	337.2	101	10198	118	0.95	50.03	102	1510	119	17.80	30.34	149	1562	275	0	72.4
Crystal 355RR(Check)	251	333.5	100	8204	95	1.11	48.99	100	1203	95	17.78	24.64	174	1678	357	0	72.4
BTS 8572 (Check)	252	336.3	101	8804	102	1.04	49.77	102	1303	102	17.84	26.17	161	1562	339	0	63.8
BTS 8337 (Check)	253	342.6	103	8382	97	1.02	51.62	105	1262	99	18.15	24.45	154	1667	300	0	64.9
Crystal 578RR (Check)	254	321.5	96	9292	107	1.02	45.53	93	1319	104	17.10	28.84	181	1674	291	0	75.3
Comm Benchmark Mean		333.5		8671		1.05	48.98		1272		17.72	26.03	167	1645	322		69.1
Comm Trial Mean		325.9		9385		1.02	46.81		1346		17.31	28.85	178	1601	300		69.0
Coeff. of Var. (%)		3.3		5.4		8.0	6.6		7.7		2.9	4.4	22.3	5.1	15.0		12.6
Mean LSD (0.05)		6.7		335		0.05	1.92		64		0.32	1.00	22	45	24		5.1
Mean LSD (0.01)		8.9		442		0.06	2.53		85		0.42	1.31	29	59	32		6.8
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2020 Data from 7 sites   Bolters based upon 60,000 seed per acre.   Created 10/28/2020

%Bnch = percentage of four benchmark varieties.

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial.

++ Revenue estimates are based on a $45.12 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 9. 2020 Performance of 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	112	344.7	102	11549	94	1.25	52.19	103	1750	96	18.49	33.57	198	1569	477	28	75.9
BTS 8500	123	312.4	92	13243	108	1.18	42.96	85	1823	100	16.81	42.39	218	1563	424	0	88.3
BTS 8524	101	324.0	96	13276	108	1.26	46.27	91	1891	104	17.46	41.16	205	1613	469	0	89.2
BTS 8606	109	334.3	99	12404	101	1.13	49.20	97	1829	100	17.85	37.05	216	1526	397	0	91.0
BTS 8629	105	320.7	95	13577	111	1.17	45.34	90	1918	105	17.21	42.27	215	1497	433	0	87.0
BTS 8767	116	329.3	97	12538	102	1.12	47.79	94	1819	100	17.58	38.15	195	1543	381	0	88.6
BTS 8815	108	343.5	101	12721	104	1.03	51.83	102	1920	105	18.21	37.10	185	1555	319	0	84.4
BTS 8882	107	315.7	93	13436	110	1.20	43.91	87	1871	102	16.99	42.50	224	1619	420	0	81.2
Crystal 572	103	342.9	101	12934	106	1.17	51.67	102	1949	107	18.32	37.53	180	1509	441	0	90.2
Crystal 574	126	321.9	95	13867	113	1.18	45.68	90	1971	108	17.27	42.96	205	1613	408	0	84.9
Crystal 684	119	322.1	95	13885	113	1.17	45.74	90	1970	108	17.28	43.00	204	1569	419	0	88.1
Crystal 793	102	342.9	101	14081	115	1.06	51.66	102	2121	116	18.20	41.02	186	1407	379	0	82.9
Crystal 796	124	328.7	97	13331	109	1.20	47.61	94	1935	106	17.63	40.41	210	1525	442	0	90.4
Hilleshög HIL9708	117	332.7	98	12648	103	1.15	48.75	96	1848	101	17.78	38.23	232	1406	429	0	87.8
Hilleshög HIL9920	122	341.5	101	12820	105	1.03	51.28	101	1927	105	18.10	37.61	201	1482	331	0	82.7
Hilleshög HM4448RR	120	315.5	93	12384	101	1.14	43.86	87	1719	94	16.93	39.36	223	1377	438	0	93.2
Hilleshög HM9528RR	125	330.2	97	12818	105	1.20	48.05	95	1865	102	17.70	38.99	238	1508	435	0	75.9
Maribo MA504	118	322.4	95	13026	106	1.18	45.81	90	1854	101	17.30	40.37	235	1468	437	0	91.5
Maribo MA717	113	336.2	99	13058	107	1.20	49.76	98	1934	106	18.01	38.93	219	1492	449	0	88.6
SV 265	121	340.9	100	13000	106	1.09	51.09	101	1945	106	18.13	37.91	185	1509	377	0	86.9
SV 268	111	335.1	99	11992	98	1.11	49.43	98	1767	97	17.86	35.76	197	1473	396	0	86.1
SV 333	114	338.3	100	12974	106	1.08	50.36	99	1928	106	17.99	38.38	177	1460	386	0	83.8
SV 375	104	333.5	98	12429	101	1.08	48.99	97	1827	100	17.76	37.41	198	1453	375	28	85.1
SX 1887	110	342.1	101	12375	101	1.06	51.43	102	1864	102	18.17	36.33	184	1472	365	0	85.3
SX 1888	106	333.2	98	12323	101	1.08	48.91	97	1809	99	17.74	37.02	183	1443	386	28	81.5
SX Marathon	115	331.5	98	12734	104	1.16	48.43	96	1862	102	17.74	38.18	202	1544	421	0	76.2
Crystal 355RR(Check)	127	339.2	100	12211	100	1.26	50.61	100	1817	99	18.22	35.96	181	1643	477	0	92.2
Crystal 578RR (Check)	128	337.2	99	12685	104	1.12	50.04	99	1886	103	17.98	37.44	192	1498	403	0	91.4
BTS 8572 (Check)	129	335.9	99	12544	102	1.22	49.66	98	1854	101	18.02	37.41	196	1493	479	0	82.2
AP SUS RR#5	130	316.3	93	11867	97	1.22	44.07	87	1652	90	17.03	37.46	299	1578	421	28	80.3
AP CHK MOD RES RR#4	131	325.7	96	12734	104	1.15	46.76	92	1830	100	17.42	38.98	248	1524	386	0	88.6
Root Aphid Susc Chk#3	132	337.7	100	11413	93	1.14	50.18	99	1697	93	18.02	33.95	268	1423	402	0	72.2
Experimental Trial (Comm status)																	
BTS 8007	236	330.7	97	14111	115	1.21	48.21	95	2057	113	17.76	42.63	157	1720	432	0	75.0
BTS 8009	218	326.7	96	12847	105	1.18	47.07	93	1849	101	17.53	39.33	174	1743	404	0	63.1
BTS 8013	228	348.6	103	12634	103	1.04	53.28	105	1928	106	18.47	36.26	137	1491	362	0	82.2
BTS 8018	247	342.0	101	13871	113	1.01	51.40	102	2083	114	18.11	40.56	144	1501	339	0	85.5
BTS 8034	211	346.4	102	14824	121	1.09	52.65	104	2253	123	18.41	42.75	156	1740	331	0	84.2
BTS 8042	227	337.2	99	13077	107	1.13	50.04	99	1939	106	17.99	38.79	161	1725	365	0	79.2
BTS 8055	250	336.1	99	12874	105	1.12	49.74	98	1903	104	17.93	38.31	145	1641	388	0	78.1
BTS 8073	246	330.8	98	13176	108	1.17	48.25	95	1921	105	17.73	39.81	149	1551	451	0	78.4
BTS 8090	224	338.5	100	12799	105	1.20	50.41	100	1905	104	18.13	37.80	119	1613	471	0	81.5
BTS 8092	233	333.8	98	13414	110	1.07	49.09	97	1970	108	17.76	40.19	156	1493	379	0	84.0
BTS 8927	238	343.3	101	12873	105	1.10	51.80	102	1941	106	18.27	37.46	153	1570	386	0	81.2
BTS 8938	237	332.1	98	13082	107	1.13	48.61	96	1914	105	17.75	39.35	163	1475	432	0	78.3
BTS 8961	203	329.4	97	13695	112	1.22	47.86	95	1988	109	17.70	41.56	183	1722	420	0	82.9
BTS 8976	212	343.8	101	13482	110	1.09	51.92	103	2035	111	18.28	39.20	166	1684	347	0	78.2
Crystal 021	201	330.3	97	14574	119	1.16	48.11	95	2120	116	17.69	44.12	166	1728	382	0	80.0
Crystal 022	217	347.4	102	13594	111	1.05	52.94	105	2071	113	18.42	39.10	141	1495	368	0	77.9
Crystal 024	209	313.4	92	13259	108	1.19	43.27	85	1834	100	16.86	42.24	195	1630	427	0	68.7
Crystal 025	243	332.1	98	12704	104	1.26	48.61	96	1860	102	17.87	38.19	183	1701	481	0	67.0
Crystal 026	234	332.2	98	13647	111	1.11	48.63	96	1998	109	17.74	41.03	170	1721	349	0	79.0
Crystal 027	239	358.5	106	12786	104	0.99	56.09	111	1998	109	18.92	35.68	130	1477	339	0	84.4
Crystal 029	220	331.7	98	13587	111	1.18	48.48	96	1986	109	17.77	40.94	152	1553	447	0	77.7
Crystal 803	242	338.0	100	13338	109	1.06	50.26	99	1983	109	17.96	39.45	136	1566	367	0	86.4
Crystal 804	215	310.9	92	13158	107	1.33	42.58	84	1799	98	16.87	42.36	177	1732	508	0	71.5
Crystal 808	207	333.9	98	13719	112	1.18	49.11	97	2018	110	17.87	41.05	179	1571	434	0	83.1
Crystal 912	230	322.7	95	13871	113	1.19	45.94	91	1972	108	17.33	43.01	177	1477	471	0	85.1
Crystal 913	245	335.7	99	13801	113	1.10	49.61	98	2038	112	17.88	41.14	164	1493	406	0	84.1
Crystal 916	206	327.6	97	13844	113	1.19	47.31	93	2000	109	17.57	42.21	146	1730	411	0	87.6
Hilleshög HIL2233	213	333.8	98	12091	99	1.20	49.09	97	1778	97	17.89	36.18	173	1570	454	0	83.9
Hilleshög HIL2317	226	337.0	99	12438	102	1.08	50.00	99	1847	101	17.93	36.82	154	1633	360	0	74.7
Hilleshög HIL2320	221	330.4	97	12523	102	1.25	48.13	95	1824	100	17.78	37.87	186	1640	480	0	81.1
Hilleshög HIL2366	240	322.5	95	12104	99	1.24	45.88	91	1722	94	17.37	37.48	207	1641	468	0	88.3
Hilleshög HIL2367	244	332.3	98	12235	100	1.25	48.66	96	1789	98	17.86	36.84	160	1650	472	0	77.8
Hilleshög HIL2368	214	334.9	99	11575	95	1.33	49.39	98	1705	93	18.07	34.57	187	1698	512	0	84.1
Hilleshög HIL2369	241	321.9	95	12363	101	1.37	45.71	90	1753	96	17.47	38.42	187	1645	563	0	72.6
Hilleshög HIL2370	216	326.2	96	13417	110	1.13	46.93	93	1927	105	17.44	41.16	182	1614	385	0	79.7
Maribo MA902	223	328.8	97	12454	102	1.18	47.69	94	1805	99	17.64	37.87	185	1508	459	0	84.6
Maribo MA903	219	337.5	99	12313	101	1.17	50.13	99	1827	100	18.05	36.49	150	1573	441	0	85.7
Maribo MA922	225	309.7	91	12850	105	1.47	42.23	83	1754	96	16.95	41.44	248	1812	580	0	83.2
Maribo MA923	249	315.3	93	11593	95	1.41	43.85	87	1611	88	17.19	36.76	210	1781	566	0	71.9
SV 201	229	326.4	96	12404	101	1.27	46.96	93	1787	98	17.59	37.92	148	1782	465	0	63.4
SV 202	232	328.5	97	11361	93	1.19	47.56	94	1645	90	17.62	34.55	187	1684	410	0	69.1
SV 203	204	331.6	98	12600	103	1.24	48.47	96	1841	101	17.82	37.95	191	1726	442	0	71.7
SV 204	208	338.1	100	12342	101	1.11	50.29	99	1835	100	18.02	36.49	135	1710	369	0	72.0
SV 285	235	350.1	103	13098	107	1.07	53.69	106	2006	110	18.58	37.45	133	1510	387	0	75.6
SV 393	248	340.1	100	12563	103	1.19	50.86	100	1876	103	18.20	36.97	148	1721	413	0	67.8
SX 1801	210	342.2	101	12693	104	1.08	51.45	102	1907	104	18.18	37.09	156	1584	369	0	65.7
SX 1802	222	324.2	96	14026	115	1.23	46.35	92	2006	110	17.44	43.22	152	1664	458	0	92.6
SX 1803	231	320.7	95	12276	100	1.17	45.38	90	1736	95	17.21	38.26	137	1679	426	0	71.3
SX 1804	202	334.9	99	12174	99	1.17	49.38	98	1792	98	17.92	36.39	160	1736	400	0	75.4
SX 1898	205	348.1	103	13056	107	1.07	53.13	105	1993	109	18.48	37.45	135	1529	383	0	77.7
Crystal 355RR(Check)	251	333.8	98	11967	98	1.28	49.08	97	1756	96	17.97	35.90	181	1812	454	0	81.7
BTS 8572 (Check)	252	340.1	100	12639	103	1.22	50.84	100	1890	103	18.22	37.14	137	1642	470	0	70.8
BTS 8337 (Check)	253	342.6	101	11494	94	1.24	51.57	102	1731	95	18.37	33.51	148	1738	448	0	67.5
Crystal 578RR (Check)	254	340.6	100	12888	105	1.11	51.00	101	1929	106	18.14	37.84	137	1633	380	0	89.8
Comm Benchmark Mean		339.3		12247		1.21	50.63		1827		18.18	36.10	150	1706	438		77.4
Comm Trial Mean		331.5		12777		1.15	48.42		1864		17.72	38.59	209	1511	412		85.4
Coeff. of Var. (%)		3.2		4.4		7.9	6.2		6.9		2.7	2.9	18.4	5.5	12.4		5.7
Mean LSD (0.05)		13.0		680		0.11	3.72		159		0.59	1.34	47	99	63		5.9
Mean LSD (0.01)		17.2		898		0.15	4.91		210		0.78	1.76	62	130	84		7.8
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2020 Data from Casselton ND Bolters based upon 60,000 seed per acre. Created 10/19/2020

%Bnch = percentage of four benchmark varieties.

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. Trial # = 208301

++ Revenue estimates are based on a $45.12 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 10. 2020 Performance of 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	112	328.8	103	8517	103	0.93	47.65	106	1238	107	17.37	25.80	157	1447	278	0	57.0
BTS 8500	123	311.7	97	9309	113	0.90	42.76	95	1278	110	16.48	29.82	158	1383	269	0	71.9
BTS 8524	101	308.8	97	9145	111	0.94	41.95	93	1244	108	16.38	29.64	168	1446	283	0	74.2
BTS 8606	109	314.9	98	8828	107	0.84	43.69	97	1220	105	16.58	28.15	157	1278	257	0	72.7
BTS 8629	105	312.0	98	9768	119	0.80	42.84	95	1349	117	16.40	31.10	139	1206	250	0	70.3
BTS 8767	116	310.6	97	8701	106	0.86	42.43	94	1187	103	16.38	28.04	174	1370	237	0	68.0
BTS 8815	108	309.9	97	8399	102	0.91	42.25	94	1143	99	16.40	27.27	189	1423	254	0	70.6
BTS 8882	107	302.0	94	9629	117	0.87	40.01	89	1271	110	15.97	31.97	194	1392	232	0	76.8
Crystal 572	103	326.9	102	8893	108	0.84	47.11	104	1278	110	17.18	27.31	136	1235	268	0	84.4
Crystal 574	126	308.6	96	9841	119	0.89	41.88	93	1340	116	16.32	31.79	163	1397	257	0	69.0
Crystal 684	119	309.3	97	9989	121	0.88	42.09	93	1354	117	16.35	32.51	166	1406	250	0	65.9
Crystal 793	102	324.3	101	9739	118	0.80	46.36	103	1395	121	17.02	30.02	156	1243	232	0	80.0
Crystal 796	124	317.0	99	9261	112	0.87	44.26	98	1301	112	16.72	29.18	145	1371	256	0	77.9
Hilleshög HIL9708	117	324.1	101	9282	113	0.78	46.31	103	1323	114	16.98	28.78	143	1243	222	0	79.2
Hilleshög HIL9920	122	324.9	102	9745	118	0.82	46.52	103	1400	121	17.07	29.76	135	1294	243	0	81.3
Hilleshög HM4448RR	120	310.6	97	9793	119	0.87	42.46	94	1339	116	16.40	31.70	150	1315	268	0	81.0
Hilleshög HM9528RR	125	318.8	100	9586	116	0.88	44.78	99	1358	117	16.82	29.86	165	1290	271	0	72.4
Maribo MA504	118	312.5	98	9919	120	0.80	43.00	95	1369	118	16.43	31.58	164	1254	228	0	77.6
Maribo MA717	113	328.0	103	9878	120	0.87	47.43	105	1427	123	17.27	30.22	178	1292	263	0	71.9
SV 265	121	320.6	100	9517	116	0.76	45.29	100	1346	116	16.78	29.71	150	1226	207	0	68.8
SV 268	111	319.0	100	9034	110	0.80	44.85	99	1263	109	16.75	28.43	158	1242	234	0	72.1
SV 333	114	313.5	98	9252	112	0.79	43.28	96	1276	110	16.47	29.65	150	1275	220	0	65.4
SV 375	104	320.1	100	9147	111	0.85	45.16	100	1276	110	16.85	28.94	143	1310	258	0	66.4
SX 1887	110	313.2	98	8906	108	0.82	43.19	96	1229	106	16.48	28.25	157	1263	245	0	66.7
SX 1888	106	314.1	98	9182	111	0.81	43.46	96	1270	110	16.52	29.04	138	1300	235	0	72.9
SX Marathon	115	315.5	99	9272	113	0.81	43.84	97	1295	112	16.58	29.30	144	1273	238	0	65.9
Crystal 355RR(Check)	127	320.1	100	7623	93	0.91	45.17	100	1072	93	16.92	23.67	150	1355	290	0	76.0
Crystal 578RR (Check)	128	305.5	95	8568	104	0.88	40.99	91	1141	99	16.15	28.18	202	1384	240	0	76.0
BTS 8572 (Check)	129	325.3	102	8240	100	0.82	46.65	103	1177	102	17.08	25.36	123	1271	258	0	62.8
AP SUS RR#5	130	304.2	95	8325	101	0.89	40.62	90	1121	97	16.10	27.15	229	1395	234	0	76.3
AP CHK MOD RES RR#4	131	312.5	98	8450	103	0.84	42.98	95	1164	101	16.47	26.89	151	1366	233	0	86.2
Root Aphid Susc Chk#3	132	334.5	105	8045	98	0.83	49.27	109	1192	103	17.55	23.90	162	1298	235	0	74.7
Experimental Trial (Comm status)																	
BTS 8007	236	303.0	95	10223	124	0.91	40.28	89	1356	117	16.06	33.67	224	1365	255	0	66.0
BTS 8009	218	320.9	100	8100	98	0.78	45.41	101	1151	99	16.83	25.05	151	1200	225	0	71.4
BTS 8013	228	332.9	104	8019	97	0.79	48.82	108	1176	102	17.43	24.07	138	1198	233	0	76.6
BTS 8018	247	320.5	100	9435	115	0.79	45.28	100	1324	114	16.81	29.39	144	1207	230	85	79.9
BTS 8034	211	305.1	95	9602	117	0.90	40.87	91	1281	111	16.15	31.44	201	1420	244	0	79.7
BTS 8042	227	313.9	98	9186	112	0.83	43.42	96	1262	109	16.53	29.27	163	1376	213	0	71.7
BTS 8055	250	315.8	99	8276	100	0.86	43.94	97	1149	99	16.65	26.12	163	1330	249	0	75.0
BTS 8073	246	315.5	99	9888	120	0.82	43.87	97	1378	119	16.60	31.19	146	1244	245	0	68.5
BTS 8090	224	323.3	101	9165	111	0.82	46.07	102	1305	113	16.99	28.23	131	1194	267	0	76.5
BTS 8092	233	315.3	99	9976	121	0.80	43.80	97	1382	119	16.57	31.57	168	1146	251	0	67.2
BTS 8927	238	337.1	105	9405	114	0.76	50.02	111	1392	120	17.62	27.86	162	1162	213	0	83.3
BTS 8938	237	306.1	96	8693	106	0.85	41.15	91	1168	101	16.15	28.39	172	1116	291	0	68.9
BTS 8961	203	299.8	94	9096	110	0.92	39.38	87	1192	103	15.90	30.35	182	1328	285	0	80.8
BTS 8976	212	317.8	99	8002	97	0.77	44.53	99	1112	96	16.66	25.32	173	1161	218	0	73.8
Crystal 021	201	305.7	96	9690	118	0.85	41.05	91	1297	112	16.13	31.64	225	1260	233	0	73.3
Crystal 022	217	333.2	104	8929	108	0.81	48.88	108	1307	113	17.46	26.78	126	1241	240	0	73.0
Crystal 024	209	312.0	98	9936	121	0.86	42.86	95	1360	118	16.45	31.80	192	1340	230	0	69.7
Crystal 025	243	322.1	101	10111	123	0.88	45.73	101	1436	124	16.99	31.28	149	1421	241	0	66.4
Crystal 026	234	310.0	97	9571	116	0.86	42.31	94	1302	112	16.36	30.78	192	1380	219	0	67.9
Crystal 027	239	327.9	102	8588	104	0.78	47.38	105	1239	107	17.17	26.20	129	1194	235	0	80.7
Crystal 029	220	319.9	100	9305	113	0.86	45.12	100	1313	113	16.86	28.98	145	1275	268	0	74.4
Crystal 803	242	320.6	100	9442	115	0.81	45.31	100	1343	116	16.85	28.97	130	1239	238	0	73.9
Crystal 804	215	306.5	96	10021	122	0.90	41.27	91	1351	117	16.22	32.57	230	1348	242	0	64.6
Crystal 808	207	310.3	97	9713	118	0.90	42.39	94	1326	115	16.41	31.11	217	1324	257	0	80.7
Crystal 912	230	314.5	98	10423	127	0.82	43.59	97	1439	124	16.55	33.10	188	1199	247	0	65.6
Crystal 913	245	308.9	97	9648	117	0.82	41.96	93	1311	113	16.26	31.19	191	1171	250	0	78.4
Crystal 916	206	310.6	97	8702	106	0.85	42.47	94	1182	102	16.38	28.00	161	1316	244	0	84.0
Hilleshög HIL2233	213	324.2	101	9871	120	0.84	46.33	103	1414	122	17.05	30.33	135	1269	258	0	87.2
Hilleshög HIL2317	226	314.1	98	8990	109	0.84	43.46	96	1237	107	16.54	28.62	212	1260	233	0	72.7
Hilleshög HIL2320	221	325.3	102	10215	124	0.87	46.65	103	1463	126	17.14	31.35	157	1216	289	0	66.2
Hilleshög HIL2366	240	321.1	100	9471	115	0.83	45.44	101	1341	116	16.88	29.41	175	1158	261	0	81.7
Hilleshög HIL2367	244	329.0	103	9287	113	0.83	47.70	106	1351	117	17.28	28.12	164	1266	241	0	64.0
Hilleshög HIL2368	214	336.8	105	8599	104	0.81	49.91	111	1269	110	17.65	25.37	160	1258	226	0	67.6
Hilleshög HIL2369	241	309.4	97	10094	123	0.87	42.12	93	1374	119	16.34	32.58	149	1328	264	0	53.7
Hilleshög HIL2370	216	300.9	94	9806	119	0.85	39.69	88	1286	111	15.88	32.65	192	1248	249	0	81.8
Maribo MA902	223	325.4	102	9072	110	0.81	46.67	103	1301	112	17.08	27.80	161	1261	225	0	71.7
Maribo MA903	219	330.2	103	9811	119	0.84	48.05	107	1421	123	17.34	29.73	163	1234	254	0	80.3
Maribo MA922	225	306.3	96	10605	129	0.96	41.21	91	1422	123	16.27	34.40	245	1297	302	0	78.7
Maribo MA923	249	302.6	95	9451	115	0.96	40.16	89	1256	109	16.08	31.03	228	1324	296	0	66.6
SV 201	229	325.0	102	8538	104	0.87	46.56	103	1220	105	17.11	26.25	143	1337	259	0	61.5
SV 202	232	318.0	99	8095	98	0.80	44.59	99	1129	98	16.69	25.49	186	1206	223	0	58.3
SV 203	204	323.8	101	9215	112	0.80	46.22	102	1315	114	16.99	28.38	121	1286	226	0	52.6
SV 204	208	323.9	101	9198	112	0.81	46.24	102	1314	114	17.00	28.26	151	1257	231	0	62.1
SV 285	235	318.8	100	8900	108	0.79	44.81	99	1250	108	16.73	27.90	150	1209	233	0	61.7
SV 393	248	307.5	96	8682	105	0.89	41.56	92	1175	102	16.26	28.09	210	1199	289	0	59.1
SX 1801	210	315.2	99	8539	104	0.81	43.79	97	1186	103	16.57	26.99	192	1162	236	0	65.5
SX 1802	222	306.5	96	9331	113	0.90	41.28	92	1254	108	16.22	30.40	201	1124	314	0	71.4
SX 1803	231	311.7	97	8904	108	0.80	42.78	95	1219	105	16.38	28.61	132	1231	238	0	64.1
SX 1804	202	317.7	99	9304	113	0.82	44.49	99	1296	112	16.71	29.27	148	1249	243	0	66.3
SX 1898	205	318.8	100	9585	116	0.78	44.80	99	1338	116	16.72	30.10	130	1200	239	0	76.6
Crystal 355RR(Check)	251	321.6	101	7281	88	0.92	45.59	101	1031	89	17.00	22.53	163	1348	292	0	68.9
BTS 8572 (Check)	252	316.7	99	8161	99	0.89	44.22	98	1134	98	16.72	25.82	178	1255	283	0	71.0
BTS 8337 (Check)	253	329.0	103	8238	100	0.89	47.70	106	1192	103	17.33	25.01	152	1379	256	0	61.5
Crystal 578RR (Check)	254	312.3	98	9268	113	0.84	42.95	95	1270	110	16.46	29.65	174	1358	222	0	73.1
Comm Benchmark Mean		319.9		8237		0.89	45.12		1157		16.88	25.75	167	1335	263		68.6
Comm Trial Mean		316.3		9118		0.85	44.08		1270		16.66	28.84	159	1320	248		72.9
Coeff. of Var. (%)		3.0		4.6		7.0	6.2		6.9		2.7	3.7	18.7	6.4	11.9		15.3
Mean LSD (0.05)		11.0		533		0.07	3.13		109		0.52	1.38	36	102	34		12.7
Mean LSD (0.01)		14.5		705		0.09	4.14		144		0.68	1.83	48	134	44		16.8
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2020 Data from Glyndon MN   Bolters based upon 60,000 seed per acre.   Created 10/16/2020

%Bnch = percentage of four benchmark varieties.

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial.   Trial # = 208302

++ Revenue estimates are based on a $45.12 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 11. 2020 Performance of Varieties - ACSC Official Trials

Ada 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	112	324.8	101	8061	103	0.90	46.52	103	1148	104	17.14	24.87	135	1608	222	0	70.9
BTS 8500	123	307.6	96	8809	113	0.89	41.59	92	1194	109	16.28	28.63	135	1492	248	0	74.8
BTS 8524	101	304.8	95	8323	107	0.94	40.80	90	1118	102	16.19	27.36	161	1583	252	0	81.8
BTS 8606	109	312.5	97	8155	105	0.86	42.98	95	1116	102	16.47	26.02	140	1494	218	0	74.8
BTS 8629	105	310.5	97	8900	114	0.88	42.43	94	1220	111	16.40	28.60	148	1427	248	0	76.8
BTS 8767	116	308.6	96	8340	107	0.88	41.87	92	1129	103	16.30	27.21	157	1568	206	0	75.9
BTS 8815	108	321.9	100	7994	102	0.85	45.67	101	1138	104	16.95	24.94	136	1490	210	0	69.4
BTS 8882	107	308.2	96	9125	117	0.90	41.77	92	1233	112	16.32	29.72	132	1573	236	0	83.5
Crystal 572	103	327.9	102	8286	106	0.79	47.38	104	1201	109	17.19	25.28	100	1323	228	0	76.6
Crystal 574	126	311.0	97	9067	116	0.91	42.56	94	1248	114	16.47	29.09	144	1560	243	0	73.6
Crystal 684	119	311.7	97	9482	122	0.92	42.77	94	1309	119	16.51	30.49	148	1549	245	0	82.6
Crystal 793	102	323.2	101	9050	116	0.78	46.04	101	1285	117	16.95	28.04	110	1361	202	0	78.4
Crystal 796	124	311.4	97	8670	111	0.88	42.68	94	1187	108	16.45	27.88	143	1524	226	0	78.4
Hilleshög HIL9708	117	322.8	101	8749	112	0.82	45.92	101	1243	113	16.96	26.98	161	1382	214	0	77.5
Hilleshög HIL9920	122	332.1	104	8987	115	0.81	48.60	107	1315	120	17.41	27.04	132	1470	189	0	69.4
Hilleshög HM4448RR	120	311.3	97	9173	118	0.88	42.65	94	1260	115	16.45	29.54	125	1436	257	0	79.8
Hilleshög HM9528RR	125	314.0	98	8530	109	0.89	43.43	96	1170	106	16.60	27.30	149	1497	236	0	74.5
Maribo MA504	118	310.8	97	9357	120	0.81	42.50	94	1281	117	16.34	30.10	144	1426	193	0	82.5
Maribo MA717	113	327.5	102	9312	119	0.85	47.28	104	1341	122	17.21	28.42	131	1495	211	0	79.0
SV 265	121	320.9	100	8930	114	0.76	45.37	100	1262	115	16.80	27.73	114	1342	195	0	76.8
SV 268	111	317.6	99	8450	108	0.79	44.45	98	1177	107	16.66	26.52	118	1438	190	0	72.2
SV 333	114	319.6	100	9198	118	0.74	45.02	99	1297	118	16.72	28.82	112	1361	171	0	73.8
SV 375	104	318.3	99	8677	111	0.84	44.64	98	1217	111	16.76	27.29	120	1447	221	0	60.8
SX 1887	110	322.8	101	8762	112	0.83	45.94	101	1242	113	16.99	27.30	142	1444	207	0	74.0
SX 1888	106	318.1	99	8839	113	0.82	44.58	98	1238	113	16.74	27.88	117	1484	199	0	66.4
SX Marathon	115	315.9	98	9170	118	0.79	43.97	97	1278	116	16.58	28.91	110	1449	187	0	75.9
Crystal 355RR(Check)	127	323.5	101	7533	97	0.92	46.13	102	1075	98	17.10	23.34	130	1472	278	0	76.9
Crystal 578RR (Check)	128	310.2	97	7798	100	0.84	42.35	93	1061	97	16.34	25.09	144	1478	205	0	79.0
BTS 8572 (Check)	129	324.6	101	7816	100	0.83	46.45	102	1113	101	17.06	24.11	110	1405	233	0	69.0
AP SUS RR#5	130	308.6	96	8158	105	0.86	41.88	92	1112	101	16.28	26.25	184	1492	202	0	70.4
AP CHK MOD RES RR#4	131	311.8	97	8020	103	0.76	42.79	94	1099	100	16.35	25.88	141	1371	173	0	78.6
Root Aphid Susc Chk#3	132	337.9	105	7635	98	0.87	50.24	111	1136	103	17.76	22.34	133	1455	245	0	65.2
Experimental Trial (Comm status)																	
BTS 8007	236	308.4	96	8800	113	0.83	41.83	92	1191	108	16.25	28.53	139	1449	198	0	73.4
BTS 8009	218	326.0	102	8031	103	0.79	46.84	103	1149	105	17.08	24.68	109	1376	198	0	66.0
BTS 8013	228	331.8	103	8236	106	0.73	48.53	107	1201	109	17.31	24.80	102	1250	188	0	78.5
BTS 8018	247	318.4	99	8815	113	0.81	44.68	98	1233	112	16.73	27.71	122	1338	224	0	83.6
BTS 8034	211	310.4	97	8703	112	0.88	42.41	93	1186	108	16.40	28.00	146	1550	210	0	86.7
BTS 8042	227	312.4	97	7962	102	0.80	42.95	95	1093	99	16.41	25.47	117	1453	181	0	81.3
BTS 8055	250	320.1	100	8624	111	0.88	45.16	100	1215	111	16.88	26.91	132	1540	217	0	75.0
BTS 8073	246	324.3	101	8739	112	0.78	46.36	102	1244	113	16.99	26.94	115	1335	205	0	85.6
BTS 8090	224	324.7	101	8213	105	0.82	46.49	102	1172	107	17.05	25.30	106	1366	230	0	75.0
BTS 8092	233	321.1	100	8535	109	0.75	45.45	100	1204	110	16.80	26.60	106	1281	198	0	78.5
BTS 8927	238	333.7	104	8588	110	0.73	49.06	108	1257	114	17.41	25.78	106	1275	178	0	80.5
BTS 8938	237	323.8	101	7979	102	0.76	46.22	102	1136	103	16.95	24.63	109	1292	203	0	75.0
BTS 8961	203	304.3	95	8432	108	0.89	40.64	90	1125	102	16.11	27.70	143	1517	229	0	80.5
BTS 8976	212	328.7	102	7918	101	0.71	47.63	105	1145	104	17.14	24.09	107	1328	152	0	78.1
Crystal 021	201	316.6	99	8424	108	0.78	44.15	97	1170	106	16.60	26.67	138	1425	166	0	77.7
Crystal 022	217	327.1	102	8307	106	0.75	47.17	104	1195	109	17.10	25.36	113	1283	192	0	76.2
Crystal 024	209	312.3	97	8544	110	0.81	42.94	95	1166	106	16.42	27.47	138	1439	188	0	78.9
Crystal 025	243	322.4	101	8865	114	0.82	45.80	101	1257	114	16.93	27.49	114	1480	194	0	77.0
Crystal 026	234	313.0	98	8544	110	0.83	43.13	95	1175	107	16.48	27.30	126	1500	193	0	80.5
Crystal 027	239	337.7	105	7763	100	0.76	50.21	111	1149	105	17.65	22.98	107	1306	195	0	75.0
Crystal 029	220	319.8	100	8707	112	0.78	45.08	99	1223	111	16.77	27.25	116	1323	202	0	81.6
Crystal 803	242	323.3	101	8483	109	0.75	46.06	102	1205	110	16.91	26.26	115	1307	184	0	82.0
Crystal 804	215	303.2	95	8831	113	0.96	40.33	89	1168	106	16.12	29.18	181	1548	257	0	71.1
Crystal 808	207	305.8	95	8474	109	0.85	41.07	91	1138	104	16.14	27.68	174	1481	197	0	82.0
Crystal 912	230	309.2	96	8869	114	0.79	42.04	93	1201	109	16.25	28.74	133	1308	213	0	77.7
Crystal 913	245	323.8	101	8791	113	0.79	46.22	102	1252	114	16.97	27.15	126	1340	203	0	86.7
Crystal 916	206	309.2	96	8640	111	0.91	42.05	93	1171	107	16.36	27.97	120	1526	245	0	84.4
Hilleshög HIL2233	213	327.5	102	8435	108	0.83	47.27	104	1212	110	17.20	25.78	118	1368	228	0	77.0
Hilleshög HIL2317	226	332.1	104	8858	114	0.78	48.61	107	1293	118	17.39	26.71	132	1398	182	0	77.3
Hilleshög HIL2320	221	330.5	103	8562	110	0.81	48.16	106	1240	113	17.33	25.97	137	1412	194	0	75.8
Hilleshög HIL2366	240	324.8	101	8571	110	0.80	46.52	103	1225	111	17.04	26.37	128	1362	205	0	87.5
Hilleshög HIL2367	244	317.3	99	8327	107	0.90	44.33	98	1161	106	16.76	26.30	135	1489	248	0	81.6
Hilleshög HIL2368	214	326.3	102	7601	97	0.78	46.92	103	1088	99	17.08	23.34	136	1366	178	0	77.3
Hilleshög HIL2369	241	317.4	99	8402	108	0.81	44.37	98	1172	107	16.67	26.46	114	1380	213	0	69.1
Hilleshög HIL2370	216	305.9	95	8597	110	0.86	41.10	91	1154	105	16.16	28.08	128	1403	241	0	82.4
Maribo MA902	223	323.9	101	8447	108	0.83	46.24	102	1200	109	17.02	26.10	134	1415	214	0	75.8
Maribo MA903	219	329.3	103	7832	100	0.78	47.80	105	1133	103	17.24	23.79	115	1378	191	0	80.1
Maribo MA922	225	291.3	91	8955	115	0.96	36.90	81	1130	103	15.53	30.78	213	1521	256	0	77.0
Maribo MA923	249	309.7	97	8328	107	0.88	42.20	93	1129	103	16.36	26.90	141	1424	245	0	63.7
SV 201	229	321.2	100	8202	105	0.81	45.48	100	1158	105	16.86	25.52	118	1428	195	0	72.7
SV 202	232	316.3	99	7210	92	0.79	44.06	97	1002	91	16.60	22.82	130	1385	192	0	73.1
SV 203	204	319.0	99	9104	117	0.74	44.84	99	1277	116	16.69	28.53	112	1366	163	0	71.9
SV 204	208	326.3	102	8543	109	0.75	46.95	104	1225	111	17.07	26.21	116	1386	167	0	73.1
SV 285	235	321.5	100	8293	106	0.79	45.55	100	1171	107	16.86	25.82	108	1453	184	0	69.1
SV 393	248	320.6	100	8303	106	0.83	45.31	100	1170	106	16.86	25.87	131	1450	204	0	74.6
SX 1801	210	319.9	100	8223	105	0.84	45.10	99	1156	105	16.83	25.72	136	1474	207	0	71.9
SX 1802	222	311.4	97	9236	118	0.80	42.68	94	1262	115	16.37	29.65	115	1351	214	0	76.2
SX 1803	231	312.3	97	8689	111	0.77	42.93	95	1193	108	16.38	27.78	112	1410	170	0	69.1
SX 1804	202	320.2	100	9112	117	0.77	45.18	100	1282	117	16.77	28.51	103	1368	187	0	80.5
SX 1898	205	323.1	101	9504	122	0.77	46.02	101	1350	123	16.92	29.49	112	1398	180	0	80.9
Crystal 355RR(Check)	251	323.3	101	7714	99	0.93	46.07	102	1097	100	17.09	23.88	129	1514	263	0	78.1
BTS 8572 (Check)	252	326.6	102	7781	100	0.84	47.02	104	1119	102	17.16	23.83	111	1372	238	0	71.1
BTS 8337 (Check)	253	324.9	101	7567	97	0.87	46.55	103	1080	98	17.11	23.31	129	1526	215	0	70.7
Crystal 578RR (Check)	254	308.3	96	8146	104	0.86	4[illegible].81	92	1101	100	16.27	26.40	133	1475	216	0	80.9
Comm Benchmark Mean		320.8		7802		0.87	45.36		1099		16.91	24.35	126	1472	233		75.2
Comm Trial Mean		317.3		8605		0.85	44.35		1201		16.71	27.16	135	1465	218		75.0
Coeff. of Var. (%)		2.8		4.0		7.1	5.8		6.2		2.6	3.2	19.4	5.7	14.3		8.3
Mean LSD (0.05)		10.5		425		0.07	2.99		90		0.50	1.11	31	102	38		7.8
Mean LSD (0.01)		13.8		562		0.10	3.94		119		0.66	1.47	41	134	50		10.3
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2020 Data from Ada MN — Bolters based upon 60,000 seed per acre. — Created 10/16/2020

%Bnch = percentage of four benchmark varieties.

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. — Trial # = 208304

++ Revenue estimates are based on a $45.12 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 12. 2020 Performance of Varieties - ACSC Official Trials
Grand Forks 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	112	366.8	103	8613	102	1.00	58.48	105	1379	104	19.35	23.40	155	1818	242	0	64.2
BTS 8500	123	334.9	94	9416	111	1.14	49.38	88	1387	105	17.88	28.17	187	1903	308	0	66.6
BTS 8524	101	338.5	95	8585	101	1.12	50.42	90	1280	97	18.04	25.28	183	1848	310	0	72.6
BTS 8606	109	340.1	95	8969	106	1.02	50.87	91	1343	102	18.03	26.37	185	1778	249	0	65.4
BTS 8629	105	337.2	94	9857	116	1.04	50.05	90	1461	110	17.90	29.23	180	1693	294	0	68.2
BTS 8767	116	358.1	100	9521	113	0.96	56.01	100	1490	113	18.87	26.59	140	1764	225	0	66.3
BTS 8815	108	367.8	103	8977	106	1.00	58.77	105	1437	109	19.38	24.37	153	1746	253	0	66.3
BTS 8882	107	335.9	94	10213	121	1.12	49.68	89	1509	114	17.90	30.40	203	1859	295	0	68.6
Crystal 572	103	368.5	103	9282	110	0.94	58.99	106	1486	112	19.38	25.21	124	1674	242	0	69.0
Crystal 574	126	342.2	96	9866	117	1.08	51.47	92	1485	112	18.20	28.80	175	1836	290	0	70.7
Crystal 684	119	345.4	97	10320	122	1.04	52.37	94	1561	118	18.29	29.95	151	1829	260	0	72.2
Crystal 793	102	359.0	100	10213	121	0.92	56.28	101	1601	121	18.88	28.45	145	1645	227	0	61.9
Crystal 796	124	339.7	95	9525	113	1.10	50.75	91	1427	108	18.09	28.00	186	1836	298	0	71.8
Hilleshög HIL9708	117	357.6	100	9554	113	0.98	55.86	100	1496	113	18.86	26.63	184	1704	238	0	66.2
Hilleshög HIL9920	122	363.7	102	9375	111	0.93	57.60	103	1488	112	19.12	25.74	147	1754	207	0	67.9
Hilleshög HM4448RR	120	344.1	96	9775	116	1.00	52.02	93	1481	112	18.21	28.37	143	1703	270	0	67.3
Hilleshög HM9528RR	125	341.6	96	9270	110	1.05	51.30	92	1398	106	18.15	27.00	195	1729	290	0	65.1
Maribo MA504	118	337.1	94	9541	113	1.02	50.03	90	1419	107	17.88	28.29	202	1763	247	0	62.7
Maribo MA717	113	349.2	98	9837	116	0.98	53.46	96	1507	114	18.43	28.06	175	1643	261	0	70.5
SV 265	121	355.0	99	9254	109	0.94	55.14	99	1437	109	18.69	26.07	134	1683	230	0	66.1
SV 268	111	349.8	98	8955	106	1.02	53.65	96	1380	104	18.51	25.42	162	1716	279	0	68.9
SV 333	114	348.0	97	9155	108	0.98	53.13	95	1402	106	18.39	26.26	154	1699	252	0	69.1
SV 375	104	354.0	99	8862	105	0.96	54.83	98	1377	104	18.65	24.93	135	1693	244	0	64.3
SX 1887	110	337.2	94	8595	102	1.10	50.04	90	1283	97	17.94	25.28	215	1751	304	0	66.4
SX 1888	106	356.0	100	9194	109	0.97	55.40	99	1431	108	18.77	25.84	135	1729	241	0	57.8
SX Marathon	115	351.3	98	9347	110	0.95	54.06	97	1444	109	18.52	26.52	136	1686	238	0	62.4
Crystal 355RR(Check)	127	358.0	100	7622	90	1.04	55.98	100	1189	90	18.94	21.37	135	1805	279	0	68.2
Crystal 578RR (Check)	128	347.2	97	8894	105	1.08	52.89	95	1355	102	18.44	25.60	175	1820	288	0	62.7
BTS 8572 (Check)	129	357.9	100	8718	103	1.01	55.95	100	1368	103	18.91	24.28	152	1681	282	0	67.1
AP SUS RR#5	130	327.5	92	8543	101	1.07	47.26	85	1236	93	17.45	26.01	228	1845	259	0	56.9
AP CHK MOD RES RR#4	131	351.9	98	9383	111	0.96	54.23	97	1450	110	18.55	26.56	159	1798	207	0	68.2
Root Aphid Susc Chk#3	132	364.8	102	8026	95	0.96	57.91	104	1276	96	19.21	21.97	158	1750	226	0	60.9
Experimental Trial (Comm status)																	
BTS 8007	236	350.9	98	9083	107	0.99	53.93	97	1388	105	18.55	26.07	159	1849	253	0	62.9
BTS 8009	218	363.9	102	8618	102	0.95	57.67	103	1373	104	19.14	23.49	147	1807	233	0	62.6
BTS 8013	228	343.3	96	8453	100	0.98	51.74	93	1285	97	18.15	24.42	153	1714	279	85	59.6
BTS 8018	247	347.8	97	10739	127	0.94	53.07	95	1629	123	18.35	31.07	165	1732	237	0	74.4
BTS 8034	211	355.3	99	10386	123	0.99	55.18	99	1615	122	18.76	29.33	196	1896	229	0	76.1
BTS 8042	227	378.2	106	9282	110	0.90	61.80	111	1514	114	19.80	24.60	123	1684	225	0	60.8
BTS 8055	250	356.9	100	9882	117	1.00	55.65	100	1550	117	18.84	27.56	179	1887	239	0	78.8
BTS 8073	246	357.4	100	10896	129	0.94	55.81	100	1709	129	18.81	30.34	141	1636	267	0	70.0
BTS 8090	224	357.6	100	8816	104	0.94	55.88	100	1382	104	18.83	24.64	126	1701	259	0	66.2
BTS 8092	233	342.7	96	10190	120	0.95	51.57	92	1542	117	18.09	29.48	145	1676	268	0	70.9
BTS 8927	238	369.2	103	10167	120	0.85	59.22	106	1641	124	19.30	27.36	136	1630	205	0	72.6
BTS 8938	237	348.7	98	10049	119	0.96	53.32	96	1531	116	18.41	29.00	188	1673	269	0	60.9
BTS 8961	203	351.6	98	10491	124	0.93	54.14	97	1629	123	18.51	29.51	163	1802	218	0	67.7
BTS 8976	212	358.7	100	8818	104	0.95	56.18	101	1372	104	18.89	24.97	153	1761	244	0	60.5
Crystal 021	201	354.7	99	10391	123	0.97	55.04	99	1608	122	18.72	29.31	175	1820	235	0	66.1
Crystal 022	217	372.6	104	10130	120	0.83	60.16	108	1641	124	19.45	27.12	126	1607	192	0	71.8
Crystal 024	209	346.9	97	9944	118	0.96	52.80	95	1521	115	18.32	28.49	153	1839	229	0	60.0
Crystal 025	243	357.0	100	10475	124	1.00	55.69	100	1633	123	18.85	29.45	164	1842	260	0	67.5
Crystal 026	234	355.2	99	10109	119	0.98	55.18	99	1565	118	18.75	28.65	173	1808	249	0	83.9
Crystal 027	239	378.7	106	9573	113	0.85	61.95	111	1554	117	19.78	25.53	124	1615	205	0	69.3
Crystal 029	220	353.9	99	10498	124	0.96	54.80	98	1639	124	18.65	29.33	153	1708	265	0	70.9
Crystal 803	242	343.5	96	9706	115	0.93	51.82	93	1465	111	18.12	28.24	159	1652	253	0	73.9
Crystal 804	215	330.6	92	9570	113	1.09	48.09	86	1400	106	17.62	28.76	211	1843	307	0	71.3
Crystal 808	207	350.7	98	9361	111	0.98	53.86	96	1453	110	18.52	26.45	180	1809	249	0	70.6
Crystal 912	230	332.7	93	10487	124	1.01	48.69	87	1556	118	17.63	31.02	202	1611	306	0	70.1
Crystal 913	245	350.9	98	9882	117	0.93	53.91	97	1519	115	18.48	28.26	142	1739	237	0	57.0
Crystal 916	206	340.9	95	10081	119	1.10	51.04	91	1509	114	18.16	29.68	196	1852	321	0	72.0
Hilleshög HIL2233	213	366.9	103	9859	117	0.94	58.54	105	1585	120	19.29	26.73	147	1711	252	0	71.0
Hilleshög HIL2317	226	361.4	101	8916	105	0.95	56.93	102	1423	108	19.01	24.30	176	1797	230	0	68.9
Hilleshög HIL2320	221	349.5	98	9659	114	0.98	53.52	96	1494	113	18.45	27.27	156	1718	273	0	69.8
Hilleshög HIL2366	240	359.8	101	10051	119	0.98	56.53	101	1581	120	18.98	27.99	174	1750	267	0	72.9
Hilleshög HIL2367	244	351.7	98	9728	115	0.98	54.15	97	1502	114	18.57	27.65	174	1642	287	0	75.3
Hilleshög HIL2368	214	378.8	106	8696	103	0.94	61.97	111	1419	107	19.89	23.13	139	1727	247	0	65.5
Hilleshög HIL2369	241	354.6	99	10163	120	0.97	55.01	99	1573	119	18.72	28.76	133	1726	274	0	56.2
Hilleshög HIL2370	216	340.9	95	9902	117	1.00	51.04	91	1492	113	18.05	28.79	160	1711	295	0	65.3
Maribo MA902	223	357.7	100	9404	111	0.95	55.91	100	1464	111	18.85	26.45	165	1685	257	0	67.6
Maribo MA903	219	360.0	101	9205	109	1.00	56.58	101	1454	110	19.00	25.50	155	1706	291	0	69.1
Maribo MA922	225	340.4	95	9376	111	1.09	50.91	91	1390	105	18.13	27.93	235	1921	287	0	63.0
Maribo MA923	249	334.1	93	7976	94	1.03	49.09	88	1191	90	17.74	23.42	196	1744	299	0	57.4
SV 201	229	353.4	99	8942	106	1.04	54.66	98	1400	106	18.71	25.04	164	1813	295	0	57.7
SV 202	232	338.8	95	7855	93	1.04	50.44	90	1165	88	17.99	23.42	221	1816	271	0	58.8
SV 203	204	362.5	101	9823	116	1.00	57.25	103	1549	117	19.13	27.25	153	1812	273	0	69.9
SV 204	208	345.0	97	8090	96	1.00	52.23	94	1226	93	18.26	23.47	182	1819	258	0	60.0
SV 285	235	361.3	101	8840	104	0.93	56.90	102	1389	105	19.00	24.67	129	1791	229	0	64.2
SV 393	248	350.6	98	8699	103	1.08	53.84	96	1353	102	18.61	24.44	156	1906	307	0	53.2
SX 1801	210	346.4	97	8259	98	1.00	52.66	94	1275	96	18.32	23.51	198	1719	275	0	61.3
SX 1802	222	340.0	95	9840	116	1.00	50.80	91	1484	112	18.01	28.50	143	1723	298	0	75.9
SX 1803	231	343.2	96	8457	100	0.98	51.72	93	1291	98	18.14	24.35	151	1729	279	0	60.8
SX 1804	202	356.8	100	9114	108	0.97	55.62	100	1423	108	18.81	25.43	138	1794	255	0	78.0
SX 1898	205	368.8	103	9372	111	0.89	59.08	106	1489	113	19.34	25.74	122	1678	226	0	70.0
Crystal 355RR(Check)	251	358.2	100	7570	89	1.11	56.05	100	1171	89	19.03	21.45	157	1818	349	0	69.6
BTS 8572 (Check)	252	364.4	102	8764	104	0.93	57.81	104	1404	106	19.14	23.82	129	1758	234	0	58.7
BTS 8337 (Check)	253	361.5	101	8580	101	1.03	56.96	102	1356	103	19.10	23.67	154	1894	266	0	62.7
Crystal 578RR (Check)	254	345.8	97	8933	106	1.06	52.48	94	1360	103	18.36	25.72	180	1868	298	0	63.9
Comm Benchmark Mean		357.5		8462		1.03	55.83		1323		18.91	23.66	155	1835	287		63.7
Comm Trial Mean		349.6		9227		1.01	5[illegible].57		1414		18.49	26.39	165	1756	260		66.3
Coeff. of Var. (%)		3.3		5.4		8.3	6.1		7.4		2.9	4.2	22.9	5.0	19.3		16.9
Mean LSD (0.05)		14.3		634		0.10	4.09		133		0.67	1.43	45	109	60		ns
Mean LSD (0.01)		18.9		838		0.13	5.41		176		0.88	1.89	59	144	80		ns
Sig Lvl		**		**		**	**		**		**	**	**	**	**		ns

2020 Data from Grand Forks ND — Bolters based upon 60,000 seed per acre. — Created 10/16/2020

%Bnch = percentage of four benchmark varieties.

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. — Trial # = 208307

++ Revenue estimates are based on a $45.12 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 13. 2020 Performance of 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	112	323.9	102	8148	103	0.98	46.25	105	1165	105	17.17	25.00	155	1601	279	0	74.9
BTS 8500	123	307.4	97	8915	112	0.98	41.53	94	1188	108	16.33	29.27	190	1659	248	0	78.4
BTS 8524	101	302.2	96	8312	105	0.96	40.06	91	1102	100	16.07	27.54	175	1720	219	0	80.8
BTS 8606	109	301.8	95	8146	102	0.91	39.93	91	1081	98	16.01	26.98	188	1570	219	0	74.0
BTS 8629	105	301.4	95	9719	122	0.93	39.82	90	1285	116	16.00	32.25	183	1503	251	0	75.1
BTS 8767	116	289.9	92	8152	103	0.98	36.55	83	1030	93	15.48	28.10	207	1642	249	0	79.7
BTS 8815	108	306.0	97	8300	104	0.93	41.13	93	1112	101	16.23	27.18	190	1626	222	0	76.3
BTS 8882	107	302.2	96	9605	121	0.99	40.04	91	1272	115	16.11	31.87	197	1718	241	0	81.3
Crystal 572	103	321.8	102	8661	109	0.90	45.65	104	1229	111	16.99	26.87	149	1496	247	0	75.3
Crystal 574	126	304.0	96	9078	114	1.00	40.56	92	1213	110	16.20	29.93	193	1703	248	0	73.8
Crystal 684	119	288.4	91	9716	122	1.02	36.12	82	1221	110	15.45	33.71	227	1712	254	0	79.0
Crystal 793	102	313.1	99	9598	121	0.86	43.16	98	1313	119	16.50	30.67	165	1470	223	0	79.5
Crystal 796	124	300.4	95	8811	111	0.92	39.53	90	1153	104	15.94	29.49	178	1602	223	0	76.3
Hilleshög HIL9708	117	297.2	94	8425	106	0.87	38.64	88	1097	99	15.74	28.32	208	1499	201	0	84.5
Hilleshög HIL9920	122	303.5	96	8324	105	0.84	40.42	92	1110	100	16.01	27.39	182	1547	173	0	75.1
Hilleshög HM4448RR	120	283.5	90	8934	112	0.90	34.70	79	1098	99	15.07	31.46	177	1587	207	0	80.1
Hilleshög HM9528RR	125	285.3	90	8897	112	0.94	35.23	80	1100	100	15.20	31.08	272	1573	213	0	73.9
Maribo MA504	118	283.0	90	8549	108	0.82	34.58	79	1045	95	14.97	30.18	172	1512	175	0	79.9
Maribo MA717	113	293.7	93	9815	123	0.90	37.63	85	1253	113	15.58	33.42	198	1567	212	0	84.9
SV 265	121	321.5	102	9294	117	0.84	45.55	103	1314	119	16.91	28.93	115	1520	211	0	74.6
SV 268	111	318.1	101	8774	110	0.86	44.60	101	1233	112	16.77	27.54	159	1536	202	0	80.5
SV 333	114	313.8	99	9031	114	0.85	43.37	98	1246	113	16.55	28.93	148	1482	207	0	80.6
SV 375	104	310.3	98	9517	120	0.90	42.35	96	1301	118	16.42	30.73	162	1530	227	0	77.4
SX 1887	110	311.3	98	9060	114	0.92	42.66	97	1236	112	16.48	29.11	170	1598	232	0	79.0
SX 1888	106	312.8	99	9260	117	0.92	43.09	98	1276	115	16.56	29.62	171	1552	236	0	72.6
SX Marathon	115	311.3	98	9258	116	0.88	42.66	97	1271	115	16.45	29.65	147	1550	219	0	76.2
Crystal 355RR(Check)	127	314.4	99	7568	95	1.00	43.54	99	1049	95	16.71	23.98	168	1682	267	0	78.6
Crystal 578RR (Check)	128	297.3	94	8146	102	0.91	38.65	88	1060	96	15.77	27.37	187	1592	217	0	79.2
BTS 8572 (Check)	129	329.0	104	7929	100	0.86	47.69	108	1146	104	17.31	24.19	121	1466	232	0	79.4
AP SUS RR#5	130	306.9	97	8563	108	0.93	41.38	94	1149	104	16.27	27.91	179	1669	217	0	65.7
AP CHK MOD RES RR#4	131	308.1	97	8271	104	0.91	41.75	95	1116	101	16.33	26.99	179	1633	210	0	80.8
Root Aphid Susc Chk#3	132	319.9	101	7661	96	0.88	45.11	102	1078	98	16.89	24.13	165	1558	208	0	71.2
Experimental Trial (Comm status)																	
BTS 8007	236	307.3	97	10704	135	0.95	41.43	94	1463	132	16.32	34.37	233	1669	261	0	82.4
BTS 8009	218	324.5	103	9959	125	0.90	46.48	106	1437	130	17.14	30.36	220	1494	279	0	75.1
BTS 8013	228	335.4	106	9815	123	0.83	49.63	113	1469	133	17.57	28.91	177	1400	253	0	77.2
BTS 8018	247	320.3	101	9182	116	0.91	45.24	103	1303	118	16.93	28.43	231	1499	272	0	77.7
BTS 8034	211	311.7	99	11548	145	0.95	42.70	97	1596	144	16.53	36.71	223	1641	277	0	91.8
BTS 8042	227	310.0	98	10545	133	0.95	42.22	96	1452	131	16.45	33.67	238	1638	264	0	85.1
BTS 8055	250	304.7	96	9029	114	0.95	40.70	92	1213	110	16.16	29.44	240	1577	284	0	83.1
BTS 8073	246	321.6	102	10206	128	0.85	45.61	104	1454	132	16.89	31.51	178	1399	269	0	77.0
BTS 8090	224	323.0	102	10084	127	0.90	46.03	105	1449	131	17.04	30.94	180	1495	281	0	83.7
BTS 8092	233	314.2	99	10675	134	0.89	43.46	99	1488	135	16.58	33.62	214	1513	258	0	87.3
BTS 8927	238	332.6	105	9624	121	0.76	48.82	111	1425	129	17.37	28.64	135	1338	234	0	83.2
BTS 8938	237	325.0	103	11203	141	0.96	46.60	106	1619	147	17.20	34.12	199	1503	317	0	80.9
BTS 8961	203	303.3	96	10733	135	0.97	40.27	91	1436	130	16.12	35.06	243	1609	289	0	88.0
BTS 8976	212	323.5	102	9041	114	0.84	46.17	105	1301	118	17.00	27.71	189	1485	240	0	83.1
Crystal 021	201	313.6	99	11419	144	0.87	43.27	98	1592	144	16.55	35.98	234	1607	210	0	86.0
Crystal 022	217	332.4	105	11348	143	0.88	48.77	111	1681	152	17.49	33.73	166	1515	262	0	79.6
Crystal 024	209	310.9	98	11668	147	0.97	42.51	97	1610	146	16.54	37.08	256	1578	298	0	81.2
Crystal 025	243	301.9	95	10675	134	0.92	39.87	91	1416	128	15.99	35.10	254	1525	269	0	81.7
Crystal 026	234	316.9	100	11139	140	0.92	44.23	100	1573	142	16.77	34.72	199	1677	248	0	91.0
Crystal 027	239	337.1	107	9752	123	0.76	50.12	114	1463	132	17.58	28.58	174	1386	205	0	87.3
Crystal 029	220	319.0	101	10154	128	0.96	44.86	102	1445	131	16.92	31.40	233	1560	295	0	90.4
Crystal 803	242	322.0	102	10455	132	0.89	45.73	104	1499	136	16.98	32.10	203	1549	253	0	88.7
Crystal 804	215	307.5	97	11877	149	1.01	41.50	94	1618	146	16.39	38.19	248	1706	297	0	77.3
Crystal 808	207	290.5	92	10478	132	0.96	36.58	83	1342	121	15.52	35.49	309	1574	268	0	85.6
Crystal 912	230	310.9	98	11984	151	0.90	42.50	97	1649	149	16.45	38.24	235	1450	281	0	93.3
Crystal 913	245	327.2	103	10104	127	0.85	47.23	107	1465	133	17.19	30.67	187	1385	266	0	84.1
Crystal 916	206	306.9	97	10659	134	0.96	41.33	94	1445	131	16.33	34.40	221	1671	282	0	90.8
Hilleshög HIL2233	213	285.5	90	9560	120	0.85	35.11	80	1174	106	15.12	33.34	278	1439	221	0	88.7
Hilleshög HIL2317	226	297.3	94	9236	116	0.89	38.51	87	1211	110	15.75	30.78	249	1561	237	0	83.1
Hilleshög HIL2320	221	305.0	96	11273	142	0.87	40.77	93	1521	138	16.12	36.54	247	1515	229	0	93.3
Hilleshög HIL2366	240	289.4	92	9847	124	0.94	36.24	82	1249	113	15.39	33.62	305	1469	275	0	93.2
Hilleshög HIL2367	244	305.3	97	10766	135	0.87	40.88	93	1462	132	16.15	34.73	244	1552	217	0	87.3
Hilleshög HIL2368	214	312.6	99	8844	111	0.82	42.97	98	1234	112	16.44	27.85	247	1436	211	0	92.0
Hilleshög HIL2369	241	286.7	91	10556	133	0.83	35.42	80	1312	119	15.17	36.53	227	1512	209	0	73.7
Hilleshög HIL2370	216	300.0	95	9857	124	0.92	39.33	89	1304	118	15.93	32.53	210	1531	284	0	90.4
Maribo MA902	223	296.3	94	8893	112	0.86	38.23	87	1167	106	15.67	29.52	222	1542	215	0	93.1
Maribo MA903	219	300.2	95	10011	126	0.83	39.39	89	1324	120	15.83	33.01	191	1486	221	0	93.6
Maribo MA922	225	297.9	94	10090	127	0.90	38.70	88	1317	119	15.79	33.63	239	1573	247	0	85.3
Maribo MA923	249	285.7	90	9206	116	0.94	35.15	80	1137	103	15.22	31.99	290	1438	286	0	70.8
SV 201	229	309.1	98	10517	132	0.90	41.97	95	1436	130	16.36	33.79	223	1568	254	0	79.5
SV 202	232	310.9	98	9410	118	0.93	42.52	97	1299	118	16.47	29.91	264	1546	262	0	86.1
SV 203	204	317.5	100	10522	132	0.93	44.42	101	1484	134	16.80	32.79	211	1556	285	0	85.9
SV 204	208	312.0	99	9759	123	0.90	42.82	97	1346	122	16.50	31.08	249	1570	242	0	80.8
SV 285	235	313.7	99	8588	108	0.87	43.33	98	1199	109	16.54	27.10	189	1529	242	0	80.1
SV 393	248	300.8	95	10036	126	0.99	39.58	90	1327	120	16.01	33.12	315	1571	281	0	79.2
SX 1801	210	321.7	102	10658	134	0.84	45.64	104	1531	139	16.92	32.69	194	1494	235	0	76.3
SX 1802	222	298.5	94	11940	150	0.92	38.88	88	1560	141	15.85	39.79	238	1495	288	0	86.2
SX 1803	231	307.5	97	9191	116	0.89	41.50	94	1253	113	16.26	29.58	188	1555	254	0	74.3
SX 1804	202	302.1	96	10496	132	0.95	39.92	91	1399	127	16.05	34.40	239	1551	297	0	87.4
SX 1898	205	312.3	99	10880	137	0.90	42.88	97	1514	137	16.53	34.37	222	1544	256	0	90.4
Crystal 355RR(Check)	251	312.8	99	7829	99	1.00	43.06	98	1081	98	16.66	24.90	214	1663	310	0	89.4
BTS 8572 (Check)	252	317.8	101	7285	92	1.00	44.51	101	1016	92	16.88	22.98	249	1508	336	0	75.9
BTS 8337 (Check)	253	337.0	107	7456	94	0.88	50.10	114	1116	101	17.70	21.96	196	1561	244	0	79.3
Crystal 578RR (Check)	254	297.1	94	9221	116	0.88	38.46	87	1207	109	15.72	30.69	201	1628	218	0	90.4
Comm Benchmark Mean		316.2		7948		0.94	44.03		1105		16.74	25.14	215	1590	277		83.7
Comm Trial Mean		305.7		8764		0.92	41.06		1173		16.20	28.74	177	1584	225		77.5
Coeff. of Var. (%)		3.0		5.3		6.5	6.3		7.6		2.6	4.6	21.8	3.6	15.2		9.0
Mean LSD (0.05)		12.5		646		0.08	3.57		122		0.59	1.86	54	78	47		ns
Mean LSD (0.01)		16.5		855		0.11	4.72		161		0.78	2.46	72	104	63		ns
Sig Lvl		**		**		**	**		**		**	**	**	**	**		ns

2020 Data from Scandia MN Bolters based upon 60,000 seed per acre. Created 10/19/2020

%Bnch = percentage of four benchmark varieties.

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. Trial # = 208308

++ Revenue estimates are based on a $45.12 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 14. 2020 Performance of Varieties - ACSC Official Trials

East Grand Forks 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	112	344.2	103	7574	99	1.17	52.05	107	1149	103	18.37	21.81	171	1775	374	0	63.4
BTS 8500	123	309.6	93	8511	111	1.27	42.17	86	1153	103	16.74	27.64	186	1819	435	0	54.1
BTS 8524	101	319.9	96	7804	102	1.21	45.12	93	1095	98	17.20	24.60	172	1898	368	0	63.4
BTS 8606	109	314.3	94	7937	104	1.27	43.51	89	1085	97	17.00	25.64	235	1838	410	0	60.0
BTS 8629	105	306.4	92	9389	123	1.24	41.25	85	1260	113	16.56	30.70	217	1680	431	0	52.2
BTS 8767	116	310.0	93	8319	109	1.22	42.27	87	1120	100	16.71	27.13	206	1801	393	0	67.8
BTS 8815	108	323.6	97	8241	108	1.19	46.16	95	1179	106	17.38	25.44	206	1868	354	0	49.7
BTS 8882	107	316.7	95	8987	118	1.14	44.19	91	1252	112	16.98	28.40	178	1819	339	0	59.4
Crystal 572	103	343.1	103	8646	113	1.06	51.74	106	1300	116	18.23	25.35	123	1622	346	0	59.7
Crystal 574	126	309.4	93	9101	119	1.23	42.10	86	1242	111	16.69	29.25	223	1798	401	0	60.3
Crystal 684	119	308.9	93	9345	122	1.23	41.96	86	1262	113	16.69	30.55	212	1787	398	0	62.5
Crystal 793	102	333.2	100	9366	122	1.05	48.90	100	1370	123	17.72	28.32	144	1579	339	0	69.1
Crystal 796	124	318.7	96	9048	118	1.18	44.75	92	1266	113	17.13	28.40	180	1797	376	0	63.1
Hilleshög HIL9708	117	328.6	99	8788	115	1.11	47.59	98	1274	114	17.54	26.74	179	1705	344	0	61.3
Hilleshög HIL9920	122	319.9	96	8538	112	1.20	45.11	93	1192	107	17.17	26.78	230	1836	363	0	60.6
Hilleshög HM4448RR	120	307.5	92	8514	111	1.18	41.57	85	1156	104	16.55	27.59	234	1681	388	0	60.9
Hilleshög HM9528RR	125	329.6	99	9060	118	1.15	47.87	98	1308	117	17.62	27.65	180	1724	367	0	60.6
Maribo MA504	118	317.6	95	8881	116	1.17	44.46	91	1237	111	17.05	28.17	187	1725	380	0	63.1
Maribo MA717	113	314.9	95	8760	115	1.27	43.68	90	1211	109	17.03	27.94	200	1746	442	0	69.1
SV 265	121	331.0	99	8388	110	1.05	48.28	99	1221	109	17.61	25.39	144	1744	299	0	53.1
SV 268	111	314.5	95	8226	108	1.24	43.55	89	1144	103	16.95	26.05	228	1811	396	0	55.6
SV 333	114	319.0	96	9082	119	1.16	44.85	92	1279	115	17.10	28.36	186	1784	358	0	57.2
SV 375	104	314.3	94	8602	113	1.19	43.49	89	1180	106	16.92	27.69	213	1742	380	0	44.1
SX 1887	110	326.3	98	8762	115	1.12	46.94	96	1255	112	17.43	26.77	246	1735	329	0	56.6
SX 1888	106	319.3	96	8508	111	1.23	44.92	92	1198	107	17.21	26.68	224	1823	390	0	54.7
SX Marathon	115	332.6	100	9219	121	1.08	48.73	100	1350	121	17.70	27.66	162	1702	326	0	57.8
Crystal 355RR(Check)	127	336.9	101	6885	90	1.15	49.95	102	1017	91	18.00	20.54	166	1739	367	0	58.4
Crystal 578RR (Check)	128	326.7	98	8327	109	1.13	47.06	97	1196	107	17.47	25.62	181	1729	343	0	64.4
BTS 8572 (Check)	129	323.0	97	7798	102	1.18	46.00	94	1102	99	17.34	24.37	186	1686	393	0	44.1
AP SUS RR#5	130	315.2	95	8305	109	1.20	43.77	90	1152	103	16.98	26.34	210	1893	349	0	50.0
AP CHK MOD RES RR#4	131	321.2	97	7399	97	1.13	45.49	93	1042	93	17.20	23.20	189	1814	327	0	57.5
Root Aphid Susc Chk#3	132	329.0	99	7776	102	1.18	47.70	98	1132	101	17.62	23.38	219	1738	379	0	50.9
Experimental Trial (Comm status)																	
BTS 8007	236	316.3	95	8953	117	1.21	44.01	90	1234	111	17.04	28.63	227	1762	365	0	58.2
BTS 8009	218	339.0	102	8962	117	1.13	50.58	104	1321	118	18.06	26.74	166	1656	347	0	50.1
BTS 8013	228	345.7	104	8393	110	1.01	52.52	108	1284	115	18.32	24.00	145	1541	308	0	63.4
BTS 8018	247	337.5	101	9453	124	1.03	50.13	103	1405	126	17.92	27.95	152	1647	296	0	62.0
BTS 8034	211	316.6	95	9212	120	1.21	44.10	90	1265	113	17.05	29.65	226	1766	362	0	69.9
BTS 8042	227	336.0	101	8659	113	1.09	49.73	102	1275	114	17.90	26.12	165	1760	297	0	61.7
BTS 8055	250	344.0	103	8730	114	1.11	52.03	107	1308	117	18.31	25.55	152	1744	318	0	64.1
BTS 8073	246	347.3	104	9770	128	1.01	53.01	109	1494	134	18.40	28.21	124	1564	313	0	66.4
BTS 8090	224	323.1	97	8304	109	1.25	45.96	94	1190	107	17.42	25.79	182	1648	443	0	44.5
BTS 8092	233	334.0	100	9349	122	1.02	49.16	101	1376	123	17.76	28.30	187	1519	307	0	49.5
BTS 8927	238	348.7	105	8943	117	0.98	53.40	110	1360	122	18.41	25.58	140	1519	296	0	73.3
BTS 8938	237	332.4	100	8949	117	1.08	48.66	100	1304	117	17.69	27.23	143	1650	319	0	56.9
BTS 8961	203	323.5	97	8281	108	1.22	46.09	95	1189	106	17.41	25.90	212	1835	348	0	54.7
BTS 8976	212	334.2	100	8017	105	1.10	49.21	101	1180	106	17.81	24.02	164	1698	319	0	56.8
Crystal 021	201	328.0	99	9016	118	1.09	47.42	97	1318	118	17.52	27.56	180	1750	286	0	47.2
Crystal 022	217	361.0	109	8840	116	0.96	56.95	117	1400	125	19.02	24.51	116	1498	287	0	66.8
Crystal 024	209	333.8	100	9346	122	1.04	49.09	101	1364	122	17.73	28.12	164	1666	292	0	64.5
Crystal 025	243	340.6	102	8809	115	0.98	51.05	105	1293	116	18.00	26.06	144	1600	270	0	68.6
Crystal 026	234	321.5	97	9430	123	1.12	45.52	93	1346	121	17.22	29.34	181	1785	303	0	59.3
Crystal 027	239	349.5	105	8588	112	1.07	53.65	110	1312	118	18.54	24.78	136	1607	329	0	58.7
Crystal 029	220	338.7	102	9157	120	1.08	50.48	104	1377	123	18.02	27.01	146	1616	329	0	63.2
Crystal 803	242	347.9	105	8840	116	1.03	53.17	109	1357	122	18.44	25.32	138	1637	300	0	72.5
Crystal 804	215	307.1	92	8963	117	1.16	41.36	85	1209	108	16.53	29.21	212	1738	339	0	56.1
Crystal 808	207	321.1	97	8568	112	1.22	45.41	93	1208	108	17.28	26.90	234	1747	365	0	66.7
Crystal 912	230	328.6	99	9747	127	1.09	47.59	98	1386	124	17.51	30.30	183	1532	349	0	74.0
Crystal 913	245	337.7	101	9576	125	1.04	50.21	103	1428	128	17.94	28.48	154	1529	329	0	69.1
Crystal 916	206	320.7	96	8774	115	1.18	45.30	93	1232	110	17.22	27.40	179	1747	369	0	63.2
Hilleshög HIL2233	213	334.5	101	8416	110	1.07	49.31	101	1216	109	17.79	25.76	175	1572	320	0	76.0
Hilleshög HIL2317	226	337.6	101	8377	110	1.07	50.17	103	1244	111	17.95	24.88	172	1687	300	0	67.9
Hilleshög HIL2320	221	340.8	102	9349	122	1.10	51.10	105	1414	127	18.15	27.39	191	1656	315	0	53.4
Hilleshög HIL2366	240	338.1	102	8201	107	1.00	50.33	103	1210	108	17.91	24.45	145	1580	288	0	60.4
Hilleshög HIL2367	244	348.0	105	9509	124	1.01	53.20	109	1435	129	18.41	27.51	156	1648	280	0	51.2
Hilleshög HIL2368	214	353.8	106	7388	97	1.03	54.87	113	1150	103	18.73	20.58	163	1664	281	0	63.4
Hilleshög HIL2369	241	328.6	99	8797	115	1.13	47.58	98	1280	115	17.57	27.07	182	1629	349	0	56.4
Hilleshög HIL2370	216	313.8	94	8974	117	1.16	43.29	89	1253	112	16.86	28.34	186	1733	348	0	64.0
Maribo MA902	223	337.7	101	8581	112	1.11	50.20	103	1289	116	17.99	24.98	197	1652	329	0	62.8
Maribo MA903	219	343.3	103	8406	110	1.00	51.81	106	1280	115	18.19	24.67	136	1570	296	0	70.6
Maribo MA922	225	321.3	97	8600	112	1.24	45.46	93	1218	109	17.31	26.90	236	1823	364	0	69.9
Maribo MA923	249	325.0	98	8730	114	1.21	46.52	95	1246	112	17.44	26.75	250	1703	372	0	59.3
SV 201	229	339.7	102	8287	108	1.08	50.80	104	1239	111	18.09	24.67	162	1679	315	0	62.7
SV 202	232	331.8	100	7852	103	1.11	48.51	99	1144	102	17.71	23.99	182	1724	315	0	51.5
SV 203	204	343.0	103	9623	126	1.04	51.72	106	1437	129	18.17	28.11	131	1644	310	0	53.4
SV 204	208	324.3	97	8399	110	1.14	46.32	95	1214	109	17.37	25.76	215	1646	344	0	60.0
SV 285	235	330.3	99	7914	104	1.18	48.05	99	1155	103	17.70	23.97	181	1786	354	0	62.3
SV 393	248	323.1	97	8013	105	1.16	45.96	94	1135	102	17.30	24.96	196	1707	350	0	48.0
SX 1801	210	332.1	100	8018	105	1.12	48.59	100	1159	104	17.72	24.61	193	1716	316	0	57.3
SX 1802	222	319.8	96	9361	122	1.24	45.04	92	1321	118	17.23	29.21	208	1742	402	0	54.0
SX 1803	231	315.2	95	8504	111	1.28	43.70	90	1143	102	17.03	27.70	244	1761	413	0	57.1
SX 1804	202	332.8	100	8624	113	1.12	48.80	100	1264	113	17.78	26.26	162	1688	339	0	57.2
SX 1898	205	329.1	99	9234	121	1.14	47.74	98	1343	120	17.64	28.60	177	1734	336	0	60.2
Crystal 355RR(Check)	251	333.9	100	6827	89	1.24	49.13	101	1014	91	17.95	20.37	191	1768	402	0	66.6
BTS 8572 (Check)	252	336.7	101	8282	108	1.22	49.91	102	1218	109	18.05	24.96	165	1651	432	0	51.4
BTS 8337 (Check)	253	346.9	104	7649	100	1.06	52.88	108	1171	105	18.40	21.71	150	1721	282	0	64.4
Crystal 578RR (Check)	254	313.3	94	7827	102	1.12	43.14	88	1061	95	16.78	25.30	198	1793	291	0	71.7
Comm Benchmark Mean		332.7		7646		1.16	48.77		1116		17.80	23.09	176	1733	352		63.5
Comm Trial Mean		321.4		8503		1.18	45.54		1199		17.25	26.57	194	1764	371		58.3
Coeff. of Var. (%)		4.3		7.6		10.1	8.7		10.2		3.6	7.3	28.9	4.7	17.6		17.3
Mean LSD (0.05)		18.3		880		0.16	5.21		164		0.80	2.67	73	107	90		12.6
Mean LSD (0.01)		24.1		1163		0.21	6.89		216		1.05	3.53	96	141	119		16.7
Sig Lvl		**		**		ns	**		**		**	**	ns	**	ns		**

2020 Data from East Grand Forks MN Bolters based upon 60,000 seed per acre. Created 10/16/2020

%Bnch = percentage of four benchmark varieties.

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial. Trial # = 208310

++ Revenue estimates are based on a $45.12 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 15. 2020 Performance of 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	112	356.4	102	8054	97	1.21	55.51	104	1249	98	19.03	22.72	160	1812	398	0	45.9
BTS 8500	123	319.1	92	8184	98	1.32	44.89	84	1148	90	17.28	25.73	252	1937	417	0	32.5
BTS 8524	101	326.8	94	8534	103	1.26	47.08	88	1227	97	17.60	26.13	233	1910	387	0	57.6
BTS 8606	109	338.2	97	8511	102	1.21	50.33	94	1268	100	18.12	25.24	197	1855	370	0	54.8
BTS 8629	105	331.5	95	9382	113	1.12	48.42	91	1371	108	17.69	28.32	213	1635	352	0	46.7
BTS 8767	116	341.7	98	9332	112	1.09	51.32	96	1403	111	18.17	27.18	167	1760	318	0	56.3
BTS 8815	108	330.6	95	8376	101	1.24	48.15	90	1216	96	17.76	25.36	250	1902	365	0	43.4
BTS 8882	107	325.6	93	9012	108	1.17	46.74	88	1296	102	17.45	27.67	189	1811	355	0	55.8
Crystal 572	103	354.2	102	8964	108	1.19	54.89	103	1392	110	18.91	25.37	161	1752	397	0	57.1
Crystal 574	126	316.9	91	9188	110	1.30	44.25	83	1278	101	17.14	29.05	253	1917	403	0	41.6
Crystal 684	119	332.7	95	9356	112	1.19	48.76	92	1374	108	17.83	28.18	206	1831	359	0	64.9
Crystal 793	102	355.1	102	9770	117	1.05	55.16	104	1517	120	18.80	27.45	161	1671	310	0	48.1
Crystal 796	124	335.8	96	9027	109	1.22	49.64	93	1338	105	18.01	26.86	204	1886	369	0	55.1
Hilleshög HIL9708	117	346.9	100	8518	102	1.11	52.82	99	1296	102	18.45	24.48	211	1679	338	0	49.5
Hilleshög HIL9920	122	342.4	98	8783	106	1.19	51.54	97	1321	104	18.31	25.72	227	1883	338	0	50.8
Hilleshög HM4448RR	120	349.0	100	9495	114	1.11	53.42	100	1452	114	18.57	27.32	161	1706	348	0	57.4
Hilleshög HM9528RR	125	345.1	99	8828	106	1.11	52.29	98	1332	105	18.36	25.64	178	1721	341	0	56.3
Maribo MA504	118	336.4	97	9057	109	1.17	49.80	93	1338	105	17.99	26.94	229	1754	359	0	49.9
Maribo MA717	113	352.1	101	9743	117	1.15	54.31	102	1497	118	18.75	27.76	230	1732	346	0	61.0
SV 265	121	336.3	96	8418	101	1.25	49.78	93	1252	99	18.06	24.89	225	1871	387	0	44.7
SV 268	111	342.2	98	8310	100	1.21	51.46	97	1251	99	18.32	24.14	195	1827	384	0	34.0
SV 333	114	342.7	98	8769	105	1.20	51.62	97	1314	104	18.34	25.81	207	1834	365	0	34.9
SV 375	104	345.4	99	8575	103	1.14	52.39	98	1301	103	18.41	24.82	166	1841	333	0	37.6
SX 1887	110	333.0	96	8391	101	1.25	48.84	92	1229	97	17.89	25.18	251	1834	388	0	39.9
SX 1888	106	340.1	98	8047	97	1.22	50.87	95	1203	95	18.22	23.66	186	1883	378	0	35.4
SX Marathon	115	333.5	96	8682	104	1.25	48.99	92	1275	100	17.93	26.13	231	1880	382	0	47.4
Crystal 355RR(Check)	127	343.9	99	7787	94	1.21	51.96	98	1178	93	18.41	22.60	185	1810	393	0	59.1
Crystal 578RR (Check)	128	342.1	98	9160	110	1.15	51.45	97	1374	108	18.25	26.91	182	1804	344	0	54.2
BTS 8572 (Check)	129	351.6	101	8267	99	1.18	54.16	102	1275	100	18.76	23.45	177	1754	383	56	42.4
AP SUS RR#5	130	326.7	94	8260	99	1.28	47.04	88	1190	94	17.62	25.27	289	1918	379	0	31.0
AP CHK MOD RES RR#4	131	339.0	97	8639	104	1.17	50.56	95	1294	102	18.12	25.37	227	1821	339	0	46.2
Root Aphid Susc Chk#3	132	345.3	99	6860	82	1.23	52.36	98	1043	82	18.49	19.72	249	1722	404	0	41.7
Experimental Trial (Comm status)																	
BTS 8007	236	337.4	97	9051	109	1.22	50.04	94	1348	106	18.09	26.78	224	1902	381	0	49.6
BTS 8009	218	351.3	101	7969	96	1.12	54.09	102	1233	97	18.71	22.61	179	1705	386	0	41.7
BTS 8013	228	369.5	106	9015	108	1.05	59.37	111	1456	115	19.50	24.33	139	1672	341	0	63.9
BTS 8018	247	347.7	100	10013	120	1.11	53.03	100	1535	121	18.47	28.63	189	1667	368	0	64.2
BTS 8034	211	347.3	100	10106	122	1.15	52.92	99	1541	121	18.54	29.16	178	1901	353	0	65.4
BTS 8042	227	342.6	98	8425	101	1.22	51.56	97	1267	100	18.34	24.66	208	1954	376	0	56.3
BTS 8055	250	343.9	99	8410	101	1.17	51.92	97	1268	100	18.37	24.60	167	1894	373	0	53.2
BTS 8073	246	358.5	103	10095	121	1.11	56.17	105	1583	125	19.03	28.15	155	1726	370	0	55.2
BTS 8090	224	350.9	101	8370	101	1.17	53.98	101	1295	102	18.72	23.73	156	1793	402	0	45.8
BTS 8092	233	344.6	99	9171	110	1.01	52.13	98	1384	109	18.23	26.58	157	1652	317	0	45.9
BTS 8927	238	368.8	106	8416	101	1.04	59.19	111	1350	106	19.48	22.85	145	1645	338	0	62.1
BTS 8938	237	341.0	98	8244	99	1.11	51.08	96	1236	97	18.15	24.23	209	1704	353	0	46.2
BTS 8961	203	333.7	96	9517	114	1.19	48.96	92	1387	109	17.90	28.73	200	1890	387	0	57.7
BTS 8976	212	345.3	99	8296	100	1.16	52.33	98	1261	99	18.41	23.85	184	1836	371	0	50.5
Crystal 021	201	336.8	97	9497	114	1.21	49.86	94	1409	111	18.04	28.09	221	1849	399	0	39.6
Crystal 022	217	365.5	105	9712	117	1.03	58.22	109	1549	122	19.30	26.58	139	1643	339	0	57.6
Crystal 024	209	331.5	95	8916	107	1.23	48.32	91	1304	103	17.80	26.86	200	1905	401	0	44.6
Crystal 025	243	350.1	100	7569	91	1.14	53.75	101	1159	91	18.67	21.53	204	1808	364	0	32.3
Crystal 026	234	354.8	102	9584	115	1.11	55.13	103	1500	118	18.87	26.87	175	1944	305	0	56.0
Crystal 027	239	350.4	101	8279	100	1.24	53.84	101	1273	100	18.78	23.72	228	1778	438	0	46.5
Crystal 029	220	351.4	101	9295	112	1.12	54.12	102	1435	113	18.68	26.39	151	1750	380	0	52.3
Crystal 803	242	336.7	97	8611	104	1.16	49.84	94	1280	101	17.99	25.52	183	1722	406	0	65.8
Crystal 804	215	324.1	93	8804	106	1.24	46.16	87	1256	99	17.46	27.14	204	1916	410	0	47.8
Crystal 808	207	339.1	97	9470	114	1.19	50.52	95	1420	112	18.13	27.79	223	1914	358	0	62.8
Crystal 912	230	336.6	97	10098	121	1.11	49.81	94	1488	117	17.95	30.18	189	1718	369	0	58.4
Crystal 913	245	347.5	100	9063	109	1.22	52.97	99	1387	109	18.59	26.13	218	1767	420	0	54.7
Crystal 916	206	329.9	95	9174	110	1.25	47.85	90	1331	105	17.72	27.71	214	1943	396	0	72.2
Hilleshög HIL2233	213	354.8	102	9922	119	1.07	55.12	103	1531	121	18.84	28.10	167	1674	360	0	68.4
Hilleshög HIL2317	226	355.4	102	9052	109	1.11	55.28	104	1410	111	18.90	25.51	200	1847	323	0	57.6
Hilleshög HIL2320	221	348.2	100	9274	112	1.16	53.17	100	1421	112	18.57	26.60	179	1786	386	0	66.4
Hilleshög HIL2366	240	336.6	97	8805	106	1.11	49.81	94	1291	102	17.99	26.31	200	1763	360	0	66.8
Hilleshög HIL2367	244	355.4	102	8998	108	1.14	55.30	104	1404	111	18.91	25.14	204	1762	366	0	52.7
Hilleshög HIL2368	214	366.2	105	7381	89	1.07	58.42	110	1181	93	19.34	20.15	168	1762	316	0	53.3
Hilleshög HIL2369	241	344.7	99	7178	86	1.18	52.17	98	1090	86	18.40	20.66	180	1806	393	0	26.0
Hilleshög HIL2370	216	334.8	96	9236	111	1.14	49.25	92	1368	108	17.87	27.50	182	1832	358	0	58.3
Maribo MA902	223	353.8	102	9814	118	1.10	54.80	103	1522	120	18.75	27.72	171	1731	344	0	51.3
Maribo MA903	219	364.1	104	9835	118	1.06	57.81	109	1564	123	19.26	27.03	146	1669	351	0	69.1
Maribo MA922	225	335.4	96	9791	118	1.32	49.45	93	1443	114	18.08	29.13	253	1940	445	0	50.2
Maribo MA923	249	336.5	97	8457	102	1.23	49.77	93	1255	99	18.07	25.11	209	1871	416	0	36.8
SV 201	229	352.3	101	8578	103	1.11	54.35	102	1320	104	18.72	24.45	190	1803	340	0	37.8
SV 202	232	326.2	94	8477	102	1.26	46.76	88	1220	96	17.58	25.92	314	1877	392	0	24.4
SV 203	204	339.6	97	9325	112	1.16	50.66	95	1391	110	18.17	27.45	195	1905	361	0	40.9
SV 204	208	351.9	101	8190	98	1.11	54.26	102	1264	100	18.71	23.22	193	1866	319	0	41.2
SV 285	235	352.6	101	8969	108	1.10	54.45	102	1390	110	18.72	25.35	148	1889	323	0	40.4
SV 393	248	334.8	96	8484	102	1.14	49.27	92	1244	98	17.93	25.35	241	1894	334	0	36.5
SX 1801	210	337.9	97	7225	87	1.22	50.17	94	1076	85	18.14	21.38	239	1928	383	0	33.7
SX 1802	222	330.0	95	10015	120	1.25	47.87	90	1452	114	17.78	30.43	219	1828	430	0	56.2
SX 1803	231	340.2	98	9633	116	1.18	50.84	95	1444	114	18.25	28.28	176	1915	379	0	49.2
SX 1804	202	339.4	97	8924	107	1.26	50.62	95	1331	105	18.26	26.39	190	1965	410	0	49.5
SX 1898	205	358.5	103	9907	119	1.05	56.17	105	1549	122	19.01	27.72	167	1870	287	0	56.4
Crystal 355RR(Check)	251	349.7	100	8361	101	1.23	53.61	101	1283	101	18.72	23.77	193	1849	425	0	55.9
BTS 8572 (Check)	252	350.7	101	8394	101	1.15	53.93	101	1295	102	18.69	23.88	162	1743	401	0	46.5
BTS 8337 (Check)	253	359.3	103	7525	90	1.13	56.41	106	1177	93	19.10	21.15	154	1817	370	0	49.5
Crystal 578RR (Check)	254	334.2	96	8989	108	1.23	49.13	92	1321	104	17.93	26.87	211	1945	381	0	58.7
Comm Benchmark Mean		348.5		8317		1.19	53.27		1269		18.61	23.92	180	1839	394		52.6
Comm Trial Mean		339.3		8696		1.19	50.65		1297		18.16	25.66	208	1811	367		47.9
Coeff. of Var. (%)		3.4		6.6		7.3	6.5		8.8		2.9	5.5	22.4	4.5	12.4		15.4
Mean LSD (0.05)		14.4		722		0.11	4.11		141		0.65	1.80	58	102	57		9.4
Mean LSD (0.01)		19.0		954		0.15	5.43		186		0.86	2.38	77	135	76		12.4
Sig Lvl		**		**		**	**		**		**	**	**	**	*		**

2020 Data from Bathgate ND   Bolters based upon 60,000 seed per acre.   Created 10/20/2020

%Bnch = percentage of four benchmark varieties.

@ Experimental trial data adjusted to commercial status. Statistics are from commercial trial.   Trial # = 208313

++ Revenue estimates are based on a $45.12 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

Table 16.

Calculation for Approval of Sugarbeet Varieties for ACSC Market for 2021

Description	Approval Status		Rec/Ton 2019	Rec/Ton 2020	Rec/Ton 2 Yr	Rec/Ton % Bench		Rev/Acre 2019	Rev/Acre 2020	Rev/Acre 2 Yr	Rev/Acre % Bench	R/T + $/A Bench	Cercospora Rating + 2018	Cercospora Rating + 2019	Cercospora Rating + 2020	Cercospora Rating + 2 Yr Mean	Cercospora Rating + 3 Yr Mean
Previously Approved (3 Yr)																	**<=5.30**
BTS 8337	Approved		326.6	341.4	334.0	101.9		1442	1300	1371	102.8	204.7	4.64	4.40	4.46	4.43	4.50
BTS 8500	Approved		310.9	314.2	312.6	95.3		1418	1307	1363	102.2	197.5	4.40	4.00	4.38	4.19	4.26
BTS 8524	Approved		304.0	317.4	310.7	94.8		1408	1279	1344	100.8	195.6	4.50	4.52	4.38	4.45	4.47
BTS 8606	Approved		315.9	322.7	319.3	97.4		1404	1284	1344	100.8	198.2	4.80	4.69	4.79	4.74	4.76
BTS 8629	Approved		309.0	317.4	313.2	95.5		1445	1406	1426	106.9	202.5	4.52	4.66	4.55	4.60	4.57
BTS 8767	Approved		317.4	321.2	319.3	97.4		1447	1317	1382	103.7	201.1	4.32	4.26	4.38	4.32	4.32
BTS 8815	Approved		325.5	328.6	327.1	99.8		1458	1307	1383	103.7	203.5	4.65	4.61	4.86	4.73	4.71
BTS 8882	Approved		316.0	314.8	315.4	96.2		1445	1381	1413	106.0	202.2	4.53	4.18	4.71	4.44	4.47
Crystal 572	Approved		331.7	340.6	336.2	102.5		1476	1405	1441	108.1	210.6	4.45	4.68	4.46	4.57	4.53
Crystal 574	Approved		313.3	316.5	314.9	96.1		1436	1396	1416	106.2	202.3	4.42	4.28	4.64	4.46	4.44
Crystal 684	Approved		310.3	316.7	313.5	95.6		1429	1432	1431	107.3	202.9	4.41	4.12	4.44	4.28	4.33
Crystal 793	Approved		325.5	335.2	330.4	100.8		1555	1514	1535	115.1	215.9	4.26	4.04	4.31	4.18	4.20
Crystal 796	Approved		315.0	321.7	318.4	97.1		1530	1372	1451	108.8	205.9	4.74	4.74	4.95	4.85	4.81
Crystal 803	Approved		329.5	333.6	331.6	101.1		1493	1444	1469	110.2	211.3	4.01	3.88	3.93	3.90	3.94
Crystal 804	Approved		319.2	312.5	315.9	96.3		1472	1383	1428	107.1	203.4	4.42	4.46	4.77	4.61	4.55
Crystal 808	Approved		315.4	323.1	319.3	97.4		1456	1417	1437	107.8	205.1	4.86	4.78	5.07	4.92	4.90
Hilleshög HM4448RR	Not Approved		315.5	317.5	316.5	96.5		1455	1358	1407	105.5	202.0	5.26	5.48	5.61	5.54	5.45
Hilleshög HM9528RR	Approved		317.7	323.5	320.6	97.8		1455	1362	1409	105.7	203.4	4.79	4.93	4.84	4.88	4.85
Hilleshög HIL9708	Approved		316.3	330.0	323.2	98.6		1433	1369	1401	105.1	203.7	4.71	4.96	4.97	4.96	4.88
Hilleshög HIL9920	Approved		325.2	333.4	329.3	100.4		1430	1398	1414	106.1	206.5	4.79	4.95	4.82	4.88	4.85
Maribo MA504	Approved		307.1	317.5	312.3	95.3		1420	1368	1394	104.6	199.8	4.98	5.34	5.35	5.34	5.22
Maribo MA717	Approved		319.8	329.0	324.4	99.0		1476	1454	1465	109.9	208.8	4.78	5.11	5.11	5.11	5.00
SX 1887	Approved		326.6	326.6	326.6	99.6		1421	1334	1378	103.3	203.0	4.89	4.89	5.09	4.99	4.95
SX 1888	Approved		323.2	327.9	325.6	99.3		1475	1345	1410	105.8	205.1	4.92	4.89	4.67	4.78	4.83
SX Marathon	Approved		318.2	327.6	322.9	98.5		1380	1396	1388	104.1	202.6	5.27	4.79	4.85	4.82	4.97
SV 285	Approved		324.2	335.6	329.9	100.6		1422	1373	1398	104.8	205.5	4.52	4.84	4.50	4.67	4.62
SV 265	Approved		319.7	332.4	326.1	99.5		1422	1396	1409	105.7	205.1	4.48	4.28	4.55	4.41	4.44
SV 268	Approved		319.8	328.3	324.1	98.8		1408	1317	1363	102.2	201.0	4.70	4.82	4.78	4.80	4.77
SV 333	Approved		322.9	327.7	325.3	99.2		1408	1391	1400	105.0	204.2	4.78	4.49	4.69	4.59	4.66
SV 375	Approved		323.6	327.5	325.6	99.3		1431	1352	1392	104.4	203.7	4.96	4.11	4.78	4.44	4.62
Candidates for Approval (2 Yr)																**<=5.00**	
BTS 8927	Approved		337.8	347.7	342.8	104.5		1583	1482	1533	115.0	219.5	--	4.35	4.42	4.39	--
BTS 8938	Approved		329.2	329.2	329.2	100.4		1487	1409	1448	108.6	209.0	--	4.35	4.66	4.51	--
BTS 8961	Approved		315.7	321.4	318.6	97.2		1475	1415	1445	108.4	205.6	--	4.27	4.69	4.48	--
BTS 8976	Approved		332.4	335.5	334.0	101.9		1524	1351	1438	107.8	209.7	--	3.83	4.15	3.99	--
Crystal 912	Approved		316.1	322.7	319.4	97.4		1595	1520	1558	116.8	214.3	--	4.62	4.75	4.69	--
Crystal 913	Approved		332.5	332.9	332.7	101.5		1620	1490	1555	116.6	218.1	--	4.11	4.13	4.12	--
Crystal 916	Approved		318.2	320.6	319.4	97.4		1575	1410	1493	112.0	209.4	--	4.26	4.49	4.38	--
Hilleshög HIL2233	Not Approved		324.6	333.9	329.3	100.4		1508	1429	1469	110.2	210.6	4.87	5.26	5.23	5.24	5.12
Hilleshög HIL2317	Approved		332.2	334.3	333.3	101.7		1502	1385	1444	108.3	209.9	--	4.90	5.05	4.97	--
Hilleshög HIL2320	Not Approved		331.1	333.4	332.3	101.3		1550	1467	1509	113.2	214.5	--	4.92	5.11	5.02	--
Maribo MA902	Approved		319.2	332.7	326.0	99.4		1425	1393	1409	105.7	205.1	--	4.91	4.96	4.94	--
Maribo MA903	Not Approved		321.8	338.1	330.0	100.6		1520	1425	1473	110.5	211.1	--	5.25	5.15	5.20	--
SX 1898	Approved		325.3	337.2	331.3	101.0		1433	1510	1472	110.4	211.4	--	4.68	4.73	4.70	--
SV 393	Not Approved		325.0	326.5	325.8	99.4		1387	1325	1356	101.7	201.1	--	4.94	4.87	4.90	--
Benchmark Varieties		2018	2019	2020			2018	2019	2020								
BTS 80RR52(Check)	Benchmark	347.1					1562										
Crystal 101RR (Check)	Benchmark	337.5	308.2				1593	1342									
Crystal 355RR(Check)	Benchmark	348.3	321.2	333.5			1548	1379	1203								
BTS 8572 (Check)	Benchmark	352.2	329.8	336.3			1636	1404	1303								
BTS 8337 (Check)	Benchmark		329.6	342.6				1452	1262								
Crystal 578RR (Check)	Benchmark			321.5					1319								
Benchmark mean		346.3	322.2	333.5	327.8	334.0	1585	1394	1272	1333	1417						

+ All Cercospora ratings 2018-2020 were adjusted to 1982 basis. Created 10-29-2020

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 2020 added Crystal 578 and dropped Crystal 101 (Check).

To maintain approval, the 3-year Cercospora rating must not exceed 5.30 (1982 adjusted data).

Table 17							
Projected Calculation for Approval of Sugarbeet Varieties for ACSC Market for 2021							
		Rec/Ton		Rev/Acre		R/T +	CR Rating ^^
	Approval ^		%		%	$/A	
Description	Likely	2020	Bench	2020	Bench	Bench	2020
Candidates for Retesting (1 Yr)							
BTS 8007	Not On Track	322.3	96.6	1433	112.7	209.3	4.27
BTS 8009	On Track	336.0	100.8	1354	106.4	207.2	4.27
BTS 8013	On Track	343.5	103.0	1391	109.4	212.4	3.88
BTS 8018	On Track	332.8	99.8	1501	118.0	217.8	2.41
BTS 8034	On Track	327.3	98.1	1534	120.6	218.7	2.70
BTS 8042	On Track	333.1	99.9	1399	110.0	209.9	4.50
BTS 8055	On Track	332.1	99.6	1386	109.0	208.5	4.16
BTS 8073	On Track	337.0	101.1	1537	120.8	221.9	4.68
BTS 8090	On Track	334.7	100.4	1380	108.5	208.9	4.35
BTS 8092	On Track	329.9	98.9	1474	115.9	214.8	4.26
Crystal 021	On Track	326.6	97.9	1489	117.1	215.0	2.20
Crystal 022	On Track	348.5	104.5	1536	120.8	225.3	4.71
Crystal 024	Not On Track	322.5	96.7	1443	113.4	210.2	4.70
Crystal 025	On Track	332.8	99.8	1444	113.5	213.3	4.56
Crystal 026	On Track	329.1	98.7	1491	117.2	215.9	4.76
Crystal 027	On Track	348.7	104.6	1425	112.0	216.6	4.38
Crystal 029	On Track	333.7	100.1	1477	116.1	216.2	4.67
Hilleshög HIL2366	On Track	328.2	98.4	1383	108.7	207.1	4.94
Hilleshög HIL2367	Not On Track	334.8	100.4	1440	113.2	213.6	5.08
Hilleshög HIL2368	On Track	345.2	103.5	1301	102.3	205.8	4.69
Hilleshög HIL2369	Not On Track	324.4	97.3	1366	107.4	204.7	5.55
Hilleshög HIL2370	Not On Track	317.9	95.3	1392	109.4	204.8	4.79
Maribo MA922	Not On Track	314.2	94.2	1388	109.1	203.3	4.77
Maribo MA923	Not On Track	316.3	94.8	1259	99.0	193.8	4.81
SX 1801	On Track	330.8	99.2	1327	104.3	203.5	4.63
SX 1802	Not On Track	319.3	95.7	1467	115.3	211.1	5.54
SX 1803	Not On Track	321.8	96.5	1325	104.2	200.7	4.87
SX 1804	On Track	329.9	98.9	1393	109.5	208.4	4.76
SV 201	On Track	333.0	99.9	1361	107.0	206.9	4.83
SV 202	Not On Track	324.1	97.2	1230	96.7	193.9	4.12
SV 203	Not On Track	333.5	100.0	1466	115.3	215.3	5.03
SV 204	On Track	332.1	99.6	1347	105.9	205.5	4.88
Benchmarks							
Crystal 355RR(Check)		333.5	100.0	1203	94.6		
BTS 8572 (Check)		336.3	100.8	1303	102.5		
BTS 8337 (Check)		342.6	102.7	1262	99.2		
Crystal 578RR (Check)		321.5	96.4	1319	103.7		
Benchmark Mean		333.5		1272			

^ Not on Track = not on track for approval. On Track = data is tracking for potential approval. Created 10-29-2020

^^ All Cercospora ratings 2020 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 adjuste
3a) R/T >= 100% of Bench or 3b) R/T >= 97% and R/T + $/A equal to 202% of Bench.

Bench for 2020 added Crystal 578 and dropped Crystal 101 (Check).

Table 18.

Calculation for Approval of Sugarbeet Varieties for ACSC Aphanomyces Specialty Market for 2021

Trial		Approval	Root Aph. Rating						Cercospora Rating +				
Yrs	Description	Status	2018	2019	2020	2 Yr	3 Yr		2018	2019	2020	2 Yr	3 Yr
	Previously Approved (3 Yrs)						**<=4.70**						**<=5.30**
8	BTS 8337	Approved	3.74	3.45	3.48	3.47	3.56		4.64	4.40	4.46	4.43	4.50
6	BTS 8500	Approved	4.43	4.30	4.16	4.23	4.30		4.40	4.00	4.38	4.19	4.26
6	BTS 8524	Approved	4.08	4.51	4.21	4.36	4.27		4.50	4.52	4.38	4.45	4.47
5	BTS 8629	Approved	3.89	5.32	3.92	4.62	4.38		4.52	4.66	4.55	4.61	4.58
4	BTS 8767	Approved	4.28	4.32	4.46	4.39	4.35		4.32	4.26	4.38	4.32	4.32
6	Crystal 574	Approved	4.32	3.99	4.11	4.05	4.14		4.42	4.28	4.64	4.46	4.45
5	Crystal 684	Approved	3.83	4.33	3.97	4.15	4.04		4.41	4.12	4.44	4.28	4.32
4	Crystal 793	Approved	3.32	3.72	3.87	3.80	3.64		4.26	4.04	4.31	4.18	4.20
4	Crystal 796	Approved	3.61	3.97	3.85	3.91	3.81		4.74	4.74	4.95	4.85	4.81
3	Crystal 803	Approved	3.86	4.45	3.96	4.21	4.09		4.01	3.88	3.93	3.91	3.94
3	Crystal 804	Approved	3.58	4.30	3.61	3.96	3.83		4.42	4.46	4.77	4.62	4.55
3	Crystal 808	Approved	3.60	3.57	4.02	3.80	3.73		4.86	4.78	5.07	4.93	4.90
4	Maribo MA717	Approved	4.15	4.42	3.77	4.10	4.11		4.78	5.11	5.11	5.11	5.00
5	SV 268	Approved	4.21	5.08	4.49	4.79	4.59		4.70	4.82	4.78	4.80	4.77
3	SV 285	Approved	3.98	4.47	4.28	4.38	4.24		4.52	4.84	4.50	4.67	4.62
8	SV 333	Approved	4.06	4.70	4.09	4.40	4.28		4.78	4.49	4.69	4.59	4.65
3	SX 1888	Approved	4.03	4.65	3.99	4.32	4.22		4.92	4.89	4.67	4.78	4.76
	Candidates for Approval					**<=4.40**						**<=5.00**	
5	BTS 8606	NO	4.43	5.11	4.56	4.84	4.70		4.80	4.69	4.79	4.74	4.76
3	BTS 8815	NO	3.97	5.24	4.17	4.71	4.46		4.65	4.61	4.86	4.74	4.71
3	BTS 8882	NO	4.98	5.17	4.33	4.75	4.83		4.53	4.18	4.71	4.45	4.47
2	BTS 8927	Approved	--	4.06	3.87	3.97	--		--	4.35	4.42	4.39	--
2	BTS 8938	Approved	--	3.75	3.86	3.81	--		--	4.35	4.66	4.51	--
2	BTS 8961	Approved	--	3.89	4.04	3.97	--		--	4.27	4.69	4.48	--
2	BTS 8976	Approved	--	3.55	3.55	3.55	--		--	3.83	4.15	3.99	--
6	Crystal 572	NO	4.47	4.98	4.28	4.63	4.58		4.45	4.68	4.46	4.57	4.53
2	Crystal 912	Approved	--	3.91	3.67	3.79	--		--	4.62	4.75	4.69	--
2	Crystal 913	Approved	--	3.58	3.75	3.67	--		--	4.11	4.13	4.12	--
2	Crystal 916	Approved	--	4.17	3.85	4.01	--		--	4.26	4.49	4.38	--
3	Hilleshög HIL2233	NO	4.02	4.43	3.77	4.10	4.07		4.87	5.26	5.23	5.25	5.12
2	Hilleshög HIL2317	Approved	--	3.96	3.86	3.91	--		--	4.90	5.05	4.98	--
2	Hilleshög HIL2320	NO	--	4.58	3.55	4.07	--		--	4.92	5.11	5.02	--
6	Hilleshög HIL9708	Approved	4.25	4.61	3.96	4.29	4.27		4.71	4.96	4.97	4.97	4.88
4	Hilleshög HIL9920	Approved	4.09	5.05	3.65	4.35	4.26		4.79	4.95	4.82	4.89	4.85
8	Hilleshög HM4448RR	NO	4.53	4.86	4.09	4.48	4.49		5.26	5.48	5.61	5.55	5.45
7	Hilleshög HM9528RR	Approved	4.22	4.56	3.72	4.14	4.17		4.79	4.93	4.84	4.89	4.85
6	Maribo MA504	NO	5.30	6.17	5.06	5.62	5.51		4.98	5.34	5.35	5.35	5.22
2	Maribo MA902	NO	--	5.31	4.01	4.66	--		--	4.91	4.96	4.94	--
2	Maribo MA903	NO	--	4.56	3.42	3.99	--		--	5.25	5.15	5.20	--
5	SV 265	NO	4.16	5.47	3.98	4.73	4.54		4.48	4.28	4.55	4.42	4.44
4	SV 375	NO	3.83	5.03	4.04	4.54	4.30		4.96	4.11	4.78	4.45	4.62
2	SV 393	NO	--	5.03	4.02	4.53	--		--	4.94	4.87	4.91	--
3	SX 1887	Approved	4.49	4.67	3.92	4.30	4.36		4.89	4.89	5.09	4.99	4.96
2	SX 1898	Approved	--	4.74	3.76	4.25	--		--	4.68	4.73	4.71	--
6	SX Marathon	NO	4.72	5.15	4.12	4.64	4.66		5.27	4.79	4.85	4.82	4.97
	Approval Criteria new varieties					4.40						5.00	
	Criteria to Maintain Approval						4.70						5.30

+ All Cercospora ratings 2018-2020 were adjusted to 1982 basis.

Created 10/30/2020

Aphanomyces approval criteria include: 1) Cercospora rating 2 year mean must not exceed 5.00 (1982 adjusted data), 2) Aph root rating 2 year mean <= 4.40.

Three years 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 3 year mea

Table 19.

Calculation for Approval of Sugarbeet Varieties for ACSC Rhizoctonia Specialty Market for 2021

Description	Approval Status	Disease Index + 2018	2019	2020	2 Yr Mn	3 Yr Mn	Cercospora Rating 2018	2019	2020	2 Yr Mn	3 Yr Mn
Previously Approved (3 Yr)											
Hilleshög HIL9708	Approved	3.71	3.87	3.83	3.85	3.80	4.71	4.96	4.97	4.97	4.88
Candidates for Approval (2 Yr)					**<=3.82**						
BTS 8337	Not Approved	4.07	3.62	4.43	4.03	4.04	4.64	4.40	4.46	4.43	4.50
BTS 8500	Not Approved	4.36	4.28	4.64	4.46	4.43	4.40	4.00	4.38	4.19	4.26
BTS 8524	Not Approved	4.23	4.00	4.14	4.07	4.12	4.50	4.52	4.38	4.45	4.47
BTS 8606	Not Approved	4.24	4.60	4.75	4.68	4.53	4.80	4.69	4.79	4.74	4.76
BTS 8629	Not Approved	4.02	3.89	4.30	4.10	4.07	4.52	4.66	4.55	4.61	4.58
BTS 8767	Not Approved	4.10	4.14	4.68	4.41	4.31	4.32	4.26	4.38	4.32	4.32
BTS 8815	Not Approved	3.88	4.03	3.92	3.98	3.94	4.65	4.61	4.86	4.74	4.71
BTS 8882	Not Approved	4.37	4.27	4.26	4.27	4.30	4.53	4.18	4.71	4.45	4.47
BTS 8927	Not Approved	--	3.93	4.37	4.15	--	--	4.35	4.42	4.39	--
BTS 8938	Approved	--	3.47	3.90	3.69	--	--	4.35	4.66	4.51	--
BTS 8961	Not Approved	--	3.79	4.11	3.95	--	--	4.27	4.69	4.48	--
BTS 8976	Not Approved	--	4.02	4.52	4.27	--	--	3.83	4.15	3.99	--
Crystal 572	Not Approved	4.54	4.14	4.21	4.18	4.30	4.45	4.68	4.46	4.57	4.53
Crystal 574	Not Approved	4.36	4.45	4.18	4.32	4.33	4.42	4.28	4.64	4.46	4.45
Crystal 684	Not Approved	4.39	4.01	4.15	4.08	4.18	4.41	4.12	4.44	4.28	4.32
Crystal 793	Not Approved	4.11	4.18	4.84	4.51	4.38	4.26	4.04	4.31	4.18	4.20
Crystal 796	Not Approved	3.97	3.85	4.45	4.15	4.09	4.74	4.74	4.95	4.85	4.81
Crystal 803	Not Approved	4.67	4.54	5.00	4.77	4.74	4.01	3.88	3.93	3.91	3.94
Crystal 804	Approved	4.02	3.72	3.90	3.81	3.88	4.42	4.46	4.77	4.62	4.55
Crystal 808	Not Approved	3.83	4.09	3.88	3.99	3.93	4.86	4.78	5.07	4.93	4.90
Crystal 912	Approved	--	3.58	3.54	3.56	--	--	4.62	4.75	4.69	--
Crystal 913	Not Approved	--	4.31	4.58	4.45	--	--	4.11	4.13	4.12	--
Crystal 916	Not Approved	--	4.26	4.56	4.41	--	--	4.26	4.49	4.38	--
Hilleshög HIL2233	Not Approved	4.04	3.78	4.43	4.11	4.08	4.87	5.26	5.23	5.25	5.12
Hilleshög HIL2317	Not Approved	--	4.19	4.95	4.57	--	--	4.90	5.05	4.98	--
Hilleshög HIL2320	Not Approved	--	4.04	4.64	4.34	--	--	4.92	5.11	5.02	--
Hilleshög HIL9920	Not Approved	4.65	4.68	5.12	4.90	4.82	4.79	4.95	4.82	4.89	4.85
Hilleshög HM4448RR	Not Approved	4.38	4.04	4.76	4.40	4.39	5.26	5.48	5.61	5.55	5.45
Hilleshög HM9528RR	Not Approved	4.04	4.10	4.57	4.34	4.24	4.79	4.93	4.84	4.89	4.85
Maribo MA504	Not Approved	4.25	4.69	4.83	4.76	4.59	4.98	5.34	5.35	5.35	5.22
Maribo MA717	Not Approved	4.35	4.15	4.61	4.38	4.37	4.78	5.11	5.11	5.11	5.00
Maribo MA902	Not Approved	--	3.97	3.93	3.95	--	--	4.91	4.96	4.94	--
Maribo MA903	Not Approved	--	3.89	3.97	3.93	--	--	5.25	5.15	5.20	--
SV 265	Not Approved	4.32	4.25	4.21	4.23	4.26	4.48	4.28	4.55	4.42	4.44
SV 268	Not Approved	4.21	4.21	5.24	4.73	4.55	4.70	4.82	4.78	4.80	4.77
SV 285	Not Approved	4.35	4.38	4.03	4.21	4.25	4.52	4.84	4.50	4.67	4.62
SV 333	Not Approved	4.23	4.08	4.61	4.35	4.31	4.78	4.49	4.69	4.59	4.65
SV 375	Not Approved	4.13	4.05	4.54	4.30	4.24	4.96	4.11	4.78	4.45	4.62
SV 393	Not Approved	--	4.33	4.96	4.65	--	--	4.94	4.87	4.91	--
SX 1887	Not Approved	4.16	4.18	4.80	4.49	4.38	4.89	4.89	5.09	4.99	4.96
SX 1888	Not Approved	4.57	4.19	4.17	4.18	4.31	4.92	4.89	4.67	4.78	4.83
SX 1898	Not Approved	--	4.21	4.16	4.19	--	--	4.68	4.73	4.71	--
SX Marathon	Not Approved	4.19	4.36	4.26	4.31	4.27	5.27	4.79	4.85	4.82	4.97
Susceptible Checks											
RH CK#08 CRYS539		4.68	4.67	5.79							
RH CK#21 CRYS768		4.52	4.66	4.50							
RH CK#25 HILL4043RR		4.83	4.66	4.89							
RH CK#36 BTS85RR02		4.46	4.56	5.10							
RH CK#40 CRYS101		4.50	4.73	4.52							
RH CK#49 CRYS247		4.62	4.16	4.41							
RH CK#51 SXWinchester		4.50	4.30	4.25							
RH CK#52 CRYS573		4.48	4.20	5.31							
RH CK#53 BTS8500		4.32	4.63	4.39							
Susceptible Hybrid Mean		4.53	4.50	4.80	4.65	4.61				**5.00**	**5.30**
Approval Criteria ++		3.82	3.82	3.82	**3.82**	3.82					
Disapproval Criteria						**4.15**					

Rhc and CR ratings were adjusted based upon check performance. Created 10/30/2020

+ Disease Index is based on a scale of 0 (healthy) to 7 (dead).

++ Candidates must have 2yr Rhizoctonia rating less than or equal to 3.82 or the mean of the susceptable check * 80% (if greater than 3.82) .

To maintain approval, 3 yr Rhizoctonia rating must be less than or equal to the susceptable check mean * 90%.

Previously approved varieties not meeting current approval standards may be sold in 2021.

Table 20.
2020 Aphanomyces Ratings for Official Trial Entries
Grandin, ND - Shakopee, MN - Glyndon, MN

			Unadjusted ^^			Adjusted ^^								
			Gran	Shak	Glyn	Gran	Shak	Glyn						Trial
Chk++	Code	Description	8/24	8/28	8/25	8/24	8/28	8/25	2020	2 Yr	3 Yr	2019^^	2018 ^^	Yrs $$
	518	BTS 8007	3.21	3.94	3.90	4.31	4.24	3.61	4.06	--	--	--	--	1
	513	BTS 8009	2.78	3.61	4.19	3.74	3.89	3.88	3.83	--	--	--	--	1
	549	BTS 8013	3.01	4.22	4.62	4.04	4.55	4.28	4.29	--	--	--	--	1
	521	BTS 8018	2.61	3.60	4.57	3.51	3.88	4.23	3.87	--	--	--	--	1
	546	BTS 8034	3.05	3.76	5.33	4.10	4.05	4.93	4.36	--	--	--	--	1
	550	BTS 8042	2.88	3.71	3.67	3.87	4.00	3.40	3.75	--	--	--	--	1
	570	BTS 8055	2.64	3.04	4.34	3.55	3.28	4.02	3.61	--	--	--	--	1
	571	BTS 8073	2.53	3.21	3.76	3.40	3.46	3.48	3.45	--	--	--	--	1
	520	BTS 8090	3.01	3.73	4.48	4.04	4.02	4.15	4.07	--	--	--	--	1
	505	BTS 8092	2.99	3.62	3.91	4.02	3.90	3.62	3.85	--	--	--	--	1
	510	BTS 8337	2.71	3.21	3.62	3.64	3.46	3.35	3.48	3.46	3.56	3.45	3.74	8
	573	BTS 8500	3.58	3.67	4.00	4.81	3.95	3.70	4.16	4.23	4.30	4.30	4.43	6
	552	BTS 8524	2.94	4.17	4.52	3.95	4.49	4.18	4.21	4.36	4.27	4.51	4.08	6
	564	BTS 8606	3.21	4.56	4.81	4.31	4.91	4.45	4.56	4.84	4.70	5.11	4.43	5
	524	BTS 8629	2.76	4.03	4.00	3.71	4.34	3.70	3.92	4.62	4.38	5.32	3.89	5
	536	BTS 8767	3.20	4.29	4.81	4.30	4.62	4.45	4.46	4.39	4.35	4.32	4.28	4
	575	BTS 8815	2.85	4.22	4.48	3.83	4.55	4.15	4.17	4.71	4.46	5.24	3.97	3
	543	BTS 8882	3.28	4.21	4.38	4.41	4.54	4.06	4.33	4.75	4.83	5.17	4.98	3
	532	BTS 8927	2.82	3.55	4.33	3.79	3.82	4.01	3.87	3.96	--	4.06	--	2
	563	BTS 8938	2.91	3.67	4.00	3.91	3.95	3.70	3.86	3.80	--	3.75	--	2
	531	BTS 8961	2.90	4.12	4.10	3.90	4.44	3.80	4.04	3.97	--	3.89	--	2
	555	BTS 8976	2.78	3.26	3.67	3.74	3.51	3.40	3.55	3.55	--	3.55	--	2
	554	Crystal 021	2.83	3.11	3.48	3.80	3.35	3.22	3.46	--	--	--	--	1
	556	Crystal 022	2.69	3.64	4.19	3.61	3.92	3.88	3.81	--	--	--	--	1
	567	Crystal 024	2.65	3.38	4.05	3.56	3.64	3.75	3.65	--	--	--	--	1
	515	Crystal 025	2.68	3.07	3.57	3.60	3.31	3.31	3.40	--	--	--	--	1
	506	Crystal 026	2.79	3.33	4.24	3.75	3.59	3.93	3.75	--	--	--	--	1
	527	Crystal 027	2.78	3.62	3.81	3.74	3.90	3.53	3.72	--	--	--	--	1
	542	Crystal 029	2.73	2.98	4.24	3.67	3.21	3.93	3.60	--	--	--	--	1
	547	Crystal 572	3.32	4.55	3.76	4.46	4.90	3.48	4.28	4.63	4.57	4.98	4.47	6
	514	Crystal 574	3.24	3.61	4.43	4.35	3.89	4.10	4.11	4.05	4.14	3.99	4.32	6
	509	Crystal 684	2.86	3.76	4.33	3.84	4.05	4.01	3.97	4.15	4.04	4.33	3.83	5
	565	Crystal 793	2.91	3.66	4.05	3.91	3.94	3.75	3.87	3.79	3.64	3.72	3.32	4
	516	Crystal 796	2.83	3.89	3.85	3.80	4.19	3.56	3.85	3.91	3.81	3.97	3.61	4
	533	Crystal 803	3.06	3.76	4.00	4.11	4.05	3.70	3.96	4.20	4.09	4.45	3.86	3
	503	Crystal 804	2.57	3.68	3.67	3.45	3.96	3.40	3.61	3.95	3.83	4.30	3.58	3
	560	Crystal 808	2.78	4.03	4.29	3.74	4.34	3.97	4.02	3.79	3.73	3.57	3.60	3
	569	Crystal 912	2.58	3.52	4.05	3.47	3.79	3.75	3.67	3.79	--	3.91	--	2
	511	Crystal 913	2.59	3.56	4.24	3.48	3.84	3.93	3.75	3.66	--	3.58	--	2
	558	Crystal 916	2.75	3.45	4.48	3.69	3.72	4.15	3.85	4.01	--	4.17	--	2
	519	Hilleshög HIL2233	2.84	3.92	3.52	3.82	4.22	3.26	3.77	4.10	4.07	4.43	4.02	3
	557	Hilleshög HIL2317	3.21	3.76	3.48	4.31	4.05	3.22	3.86	3.91	--	3.96	--	2
	528	Hilleshög HIL2320	2.69	3.51	3.52	3.61	3.78	3.26	3.55	4.06	--	4.58	--	2
	544	Hilleshög HIL2366	2.93	3.80	3.67	3.94	4.09	3.40	3.81	--	--	--	--	1
	517	Hilleshög HIL2367	2.83	3.87	2.76	3.80	4.17	2.56	3.51	--	--	--	--	1
	502	Hilleshög HIL2368	2.75	3.88	3.47	3.69	4.18	3.21	3.70	--	--	--	--	1
	534	Hilleshög HIL2369	2.80	3.86	3.14	3.76	4.16	2.91	3.61	--	--	--	--	1
	553	Hilleshög HIL2370	3.04	4.47	3.86	4.08	4.82	3.57	4.16	--	--	--	--	1
	574	Hilleshög HIL9708	2.76	4.18	3.95	3.71	4.50	3.66	3.96	4.28	4.27	4.61	4.25	6
	559	Hilleshög HIL9920	2.57	3.84	3.62	3.45	4.14	3.35	3.65	4.35	4.26	5.05	4.09	4
	508	Hilleshög HM4448RR	2.94	4.35	3.91	3.95	4.69	3.62	4.09	4.47	4.49	4.86	4.53	8
	526	Hilleshög HM9528RR	2.61	3.88	3.76	3.51	4.18	3.48	3.72	4.14	4.17	4.56	4.22	7
	535	Maribo MA504	3.03	5.96	5.05	4.07	6.42	4.68	5.06	5.61	5.51	6.17	5.30	6
	561	Maribo MA717	2.61	4.38	3.33	3.51	4.72	3.08	3.77	4.10	4.12	4.42	4.15	4

	538	Maribo MA902	2.81	4.13	4.10		3.78	4.45	3.80	4.01	4.66	--	5.31	--	2
	537	Maribo MA903	2.55	3.45	3.38		3.43	3.72	3.13	3.42	3.99	--	4.56	--	2
	529	Maribo MA922	2.84	3.70	3.52		3.82	3.99	3.26	3.69	--	--	--	--	1
	541	Maribo MA923	3.08	4.81	4.81		4.14	5.18	4.45	4.59	--	--	--	--	1
	562	SV 201	3.04	3.82	3.86		4.08	4.12	3.57	3.92	--	--	--	--	1
	523	SV 202	3.21	3.85	5.81		4.31	4.15	5.38	4.61	--	--	--	--	1
	572	SV 203	3.23	4.33	4.33		4.34	4.67	4.01	4.34	--	--	--	--	1
	568	SV 204	3.01	3.98	4.62		4.04	4.29	4.28	4.20	--	--	--	--	1
	539	SV 285	3.04	4.16	4.62		4.08	4.48	4.28	4.28	4.38	4.25	4.47	3.98	3
	501	SV 393	2.92	4.11	4.00		3.92	4.43	3.70	4.02	4.53	--	5.03	--	2
	548	SV 265	3.07	3.71	4.14		4.12	4.00	3.83	3.98	4.73	4.54	5.47	4.16	5
	551	SV 268	3.24	4.20	4.95		4.35	4.53	4.58	4.49	4.78	4.59	5.08	4.21	5
	504	SV 333	3.08	4.25	3.85		4.14	4.58	3.56	4.09	4.40	4.29	4.70	4.06	8
	576	SV 375	3.15	3.88	4.00		4.23	4.18	3.70	4.04	4.54	4.30	5.03	3.83	4
	540	SX 1801	3.04	4.10	5.19		4.08	4.42	4.80	4.44	--	--	--	--	1
	545	SX 1802	3.24	4.35	5.14		4.35	4.69	4.76	4.60	--	--	--	--	1
	507	SX 1803	3.37	4.28	4.76		4.53	4.61	4.41	4.52	--	--	--	--	1
	530	SX 1804	2.75	3.95	4.43		3.69	4.26	4.10	4.02	--	--	--	--	1
	566	SX 1887	3.16	3.87	3.62		4.25	4.17	3.35	3.92	4.30	4.36	4.67	4.49	3
	512	SX 1888	2.98	4.17	3.76		4.00	4.49	3.48	3.99	4.32	4.22	4.65	4.03	3
	522	SX 1898	2.70	3.95	3.67		3.63	4.26	3.40	3.76	4.25	--	4.74	--	2
	525	SX Marathon	3.01	4.21	4.09		4.04	4.54	3.79	4.12	4.64	4.66	5.15	4.72	6
1	1001	AP CK-32 CRYS981	3.02	3.29	4.71		4.06	3.54	4.36	3.99	3.43	3.55	2.87	3.79	12
1	1002	AP CK-33 CRYS768	3.72	4.38	5.29		5.00	4.72	4.90	4.87	4.86	4.76	4.85	4.56	14
1	1003	AP CK-35 BETA87RR58	3.63	4.12	5.09		4.88	4.44	4.71	4.68	5.03	5.25	5.39	5.68	14
1	1004	AP CK-41 CRYS765	4.08	5.19	6.76		5.48	5.59	6.26	5.78	5.87	5.91	5.96	5.99	10
1	1005	AP CK-43 BTS80RR32	3.55	4.85	5.14		4.77	5.23	4.76	4.92	4.71	4.67	4.50	4.60	11
1	1006	AP CK-44 SX VISION RR	3.47	5.11	5.72		4.66	5.51	5.30	5.15	5.11	5.08	5.06	5.03	12
1	1007	AP CK-45 CRYS986	3.67	4.44	4.76		4.93	4.78	4.41	4.71	4.65	4.44	4.60	4.01	12
1	1008	AP CK-47 CRYS101	3.10	3.27	4.19		4.17	3.52	3.88	3.86	3.39	3.52	2.92	3.79	10
1	1009	AP CK-49 BTS82RR33	4.23	4.97	5.95		5.68	5.35	5.51	5.52	5.39	5.36	5.26	5.32	9
1	1010	AP CK-51 CRYS246	3.54	4.68	5.05		4.76	5.04	4.68	4.82	4.88	4.99	4.94	5.22	9
1	1011	AP CK-52 HILL4094RR	3.13	4.24	4.24		4.21	4.57	3.93	4.23	4.99	4.85	5.74	4.57	13
1	1012	AP CK-55 CRYS247	3.96	4.81	5.57		5.32	5.18	5.16	5.22	5.06	5.15	4.90	5.33	9
1	1013	AP CK-56 BTS8363	3.65	4.72	5.38		4.90	5.09	4.98	4.99	5.12	5.13	5.25	5.15	8
1	1014	AP CK-57 CRYS578	3.43	4.40	5.00		4.61	4.74	4.63	4.66	4.62	4.58	4.58	4.50	6
1	1015	AP CK-58 CRYS572	3.37	4.31	4.86		4.53	4.64	4.50	4.56	4.84	4.72	5.13	4.47	6
	1016	AP CHK MOD RES RR	3.16	4.18	5.48		4.25	4.50	5.07	4.61	5.00	4.95	5.39	4.84	14
	1017	AP CHK RES RR#6	2.77	3.50	4.05		3.72	3.77	3.75	3.75	3.73	3.59	3.72	3.32	4
	1018	AP CHK SUS HYB#3	4.37	5.19	6.86		5.87	5.59	6.35	5.94	5.91	5.88	5.88	5.83	14
	1019	AP CHK SUS HYB#4	3.81	5.07	6.33		5.12	5.46	5.86	5.48	5.77	5.85	6.06	6.02	14
	1020	AP SUS RR#5	4.49	4.89	5.00		6.03	5.27	4.63	5.31	5.37	5.36	5.44	5.32	4
		Check Mean	3.57	4.45	5.18		4.80	4.80	4.80	4.80					
15		Trial Mean	3.06	4.01	4.35		4.11	4.32	4.03	4.32					
		Coeff. of Var. (%)	10.9	9.1	14.1		10.9	9.1	14.1						
		Mean LSD (0.05)	0.49	0.48	0.99		0.66	0.52	0.92						
		Mean LSD (0.01)	0.64	0.64	1.30		0.86	0.69	1.20						
		Sig Lvl	**	**	**		**	**	**						
		Adjustment Factor	1.344	1.077	0.926										

^^ 2020 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.

Green highlighted ratings indicate specialty resistance.

Red highlighted ratings indicate a level of concern.

Table 21.
2020 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	2020	2 Yr	3 Yr	2019	2018	Yrs $$
			6 Dates+	6 Dates+	4 Dates+	6 Dates+	6 Dates+	4 Dates+	3 loc					
	518	BTS 8007	3.97	3.22	3.71	4.24	4.32	4.25	4.27	--	--	--	--	1
	513	BTS 8009	3.59	3.36	3.91	3.83	4.50	4.48	4.27	--	--	--	--	1
	549	BTS 8013	3.65	2.76	3.54	3.90	3.70	4.05	3.88	--	--	--	--	1
	521	BTS 8018	2.35	1.78	2.05	2.51	2.39	2.35	2.41	--	--	--	--	1
	546	BTS 8034	2.95	1.96	2.02	3.15	2.63	2.31	2.70	--	--	--	--	1
	550	BTS 8042	4.47	3.37	3.67	4.77	4.52	4.20	4.50	--	--	--	--	1
	570	BTS 8055	3.85	3.00	3.81	4.11	4.02	4.36	4.16	--	--	--	--	1
	571	BTS 8073	4.08	3.57	4.27	4.35	4.78	4.89	4.68	--	--	--	--	1
	520	BTS 8090	3.89	3.24	3.98	4.15	4.34	4.56	4.35	--	--	--	--	1
	505	BTS 8092	4.23	3.06	3.63	4.51	4.10	4.16	4.26	--	--	--	--	1
	510	BTS 8337	4.20	3.21	4.00	4.48	4.30	4.58	4.46	4.43	4.50	4.40	4.64	8
	573	BTS 8500	4.50	2.95	3.84	4.80	3.95	4.40	4.38	4.19	4.26	4.00	4.40	6
	552	BTS 8524	4.41	3.00	3.86	4.71	4.02	4.42	4.38	4.45	4.47	4.52	4.50	6
	564	BTS 8606	4.80	3.22	4.31	5.12	4.32	4.94	4.79	4.74	4.76	4.69	4.80	5
	524	BTS 8629	4.28	3.28	4.08	4.57	4.40	4.67	4.55	4.60	4.57	4.66	4.52	5
	536	BTS 8767	4.51	2.90	3.88	4.81	3.89	4.44	4.38	4.32	4.32	4.26	4.32	4
	575	BTS 8815	4.61	3.60	4.21	4.92	4.82	4.82	4.86	4.73	4.71	4.61	4.65	3
	543	BTS 8882	4.70	3.35	4.03	5.02	4.49	4.62	4.71	4.44	4.47	4.18	4.53	3
	532	BTS 8927	3.89	3.30	4.09	4.15	4.42	4.68	4.42	4.39	--	4.35	--	2
	563	BTS 8938	4.49	3.56	3.85	4.79	4.77	4.41	4.66	4.51	--	4.35	--	2
	531	BTS 8961	4.39	3.39	4.23	4.68	4.54	4.85	4.69	4.48	--	4.27	--	2
	555	BTS 8976	4.03	3.13	3.44	4.30	4.19	3.94	4.15	3.99	--	3.83	--	2
	554	Crystal 021	2.32	1.64	1.67	2.48	2.20	1.91	2.20	--	--	--	--	1
	556	Crystal 022	4.24	3.56	4.22	4.52	4.77	4.83	4.71	--	--	--	--	1
	567	Crystal 024	4.64	3.29	4.14	4.95	4.41	4.74	4.70	--	--	--	--	1
	515	Crystal 025	4.17	3.21	4.29	4.45	4.30	4.91	4.56	--	--	--	--	1
	506	Crystal 026	4.53	3.49	4.17	4.83	4.68	4.78	4.76	--	--	--	--	1
	527	Crystal 027	3.84	3.58	3.70	4.10	4.80	4.24	4.38	--	--	--	--	1
	542	Crystal 029	4.07	3.61	4.21	4.34	4.84	4.82	4.67	--	--	--	--	1
	547	Crystal 572	4.20	3.28	3.94	4.48	4.40	4.51	4.46	4.57	4.53	4.68	4.45	6
	514	Crystal 574	4.61	3.23	4.07	4.92	4.33	4.66	4.64	4.46	4.44	4.28	4.42	6
	509	Crystal 684	4.33	3.12	3.94	4.62	4.18	4.51	4.44	4.28	4.33	4.12	4.41	5
	565	Crystal 793	3.88	2.97	4.21	4.14	3.98	4.82	4.31	4.18	4.20	4.04	4.26	4
	516	Crystal 796	4.74	3.62	4.32	5.06	4.85	4.95	4.95	4.85	4.81	4.74	4.74	4
	533	Crystal 803	3.17	3.11	3.69	3.38	4.17	4.23	3.93	3.90	3.94	3.88	4.01	3
	503	Crystal 804	4.55	3.25	4.44	4.86	4.36	5.09	4.77	4.61	4.55	4.46	4.42	3
	560	Crystal 808	4.72	3.67	4.59	5.04	4.92	5.26	5.07	4.92	4.90	4.78	4.86	3
	569	Crystal 912	4.36	3.23	4.59	4.65	4.33	5.26	4.75	4.69	--	4.62	--	2
	511	Crystal 913	3.75	3.12	3.68	4.00	4.18	4.22	4.13	4.12	--	4.11	--	2
	558	Crystal 916	4.47	3.07	4.01	4.77	4.11	4.59	4.49	4.38	--	4.26	--	2
	519	Hilleshög HIL2233	4.94	3.63	4.85	5.27	4.86	5.56	5.23	5.24	5.12	5.26	4.87	3
	557	Hilleshög HIL2317	4.51	3.68	4.71	4.81	4.93	5.39	5.05	4.97	--	4.90	--	2
	528	Hilleshög HIL2320	4.90	3.52	4.69	5.23	4.72	5.37	5.11	5.02	--	4.92	--	2
	544	Hilleshög HIL2366	4.85	3.21	4.67	5.18	4.30	5.35	4.94	--	--	--	--	1
	517	Hilleshög HIL2367	4.87	3.58	4.58	5.20	4.80	5.25	5.08	--	--	--	--	1
	502	Hilleshög HIL2368	4.53	3.10	4.44	4.83	4.15	5.09	4.69	--	--	--	--	1
	534	Hilleshög HIL2369	5.06	4.30	4.78	5.40	5.76	5.48	5.55	--	--	--	--	1
	553	Hilleshög HIL2370	4.57	3.43	4.27	4.88	4.60	4.89	4.79	--	--	--	--	1
	574	Hilleshög HIL9708	4.82	3.54	4.39	5.14	4.74	5.03	4.97	4.96	4.88	4.96	4.71	6
	559	Hilleshög HIL9920	4.51	3.33	4.52	4.81	4.46	5.18	4.82	4.88	4.85	4.95	4.79	4
	508	Hilleshög HM4448RR	4.99	4.26	5.05	5.33	5.71	5.78	5.61	5.54	5.45	5.48	5.26	8
	526	Hilleshög HM9528RR	4.79	3.32	4.32	5.11	4.45	4.95	4.84	4.88	4.85	4.93	4.79	7
	535	Maribo MA504	4.94	3.94	4.81	5.27	5.28	5.51	5.35	5.34	5.22	5.34	4.98	6
	561	Maribo MA717	4.86	3.74	4.49	5.19	5.01	5.14	5.11	5.11	5.00	5.11	4.78	4
	538	Maribo MA902	4.67	3.51	4.53	4.98	4.70	5.19	4.96	4.94	--	4.91	--	2
	537	Maribo MA903	4.81	3.75	4.63	5.13	5.03	5.30	5.15	5.20	--	5.25	--	2
	529	Maribo MA922	4.36	3.80	3.99	4.65	5.09	4.57	4.77	--	--	--	--	1
	541	Maribo MA923	4.31	3.84	4.10	4.60	5.15	4.70	4.81	--	--	--	--	1
	562	SV 201	4.63	3.45	4.30	4.94	4.62	4.93	4.83	--	--	--	--	1
	523	SV 202	3.86	3.04	3.63	4.12	4.07	4.16	4.12	--	--	--	--	1
	572	SV 203	4.56	4.11	4.12	4.87	5.51	4.72	5.03	--	--	--	--	1
	568	SV 204	4.60	3.54	4.35	4.91	4.74	4.98	4.88	--	--	--	--	1
	539	SV 285	4.38	3.32	3.82	4.67	4.45	4.38	4.50	4.67	4.62	4.84	4.52	3
	501	SV 393	4.56	3.75	4.11	4.87	5.03	4.71	4.87	4.90	--	4.94	--	2
	548	SV 265	4.43	3.43	3.77	4.73	4.60	4.32	4.55	4.41	4.44	4.28	4.48	5
	551	SV 268	4.64	3.40	4.22	4.95	4.56	4.83	4.78	4.80	4.77	4.82	4.70	5
	504	SV 333	4.44	3.64	3.90	4.74	4.88	4.47	4.69	4.59	4.66	4.49	4.78	8
	576	SV 375	4.83	3.42	4.01	5.15	4.58	4.59	4.78	4.44	4.62	4.11	4.96	4

	540	SX 1801	4.44	3.32	4.11		4.74	4.45	4.71		4.63	--	--	--	--	1
	545	SX 1802	5.08	4.44	4.58		5.42	5.95	5.25		5.54	--	--	--	--	1
	507	SX 1803	4.78	3.61	4.07		5.10	4.84	4.66		4.87	--	--	--	--	1
	530	SX 1804	4.64	3.51	4.04		4.95	4.70	4.63		4.76	--	--	--	--	1
	566	SX 1887	4.94	3.70	4.39		5.27	4.96	5.03		5.09	4.99	4.95	4.89	4.89	3
	512	SX 1888	4.60	3.43	3.94		4.91	4.60	4.51		4.67	4.78	4.83	4.89	4.92	3
	522	SX 1898	4.75	3.20	4.21		5.07	4.29	4.82		4.73	4.70	--	4.68	--	2
	525	SX Marathon	4.68	3.55	4.20		4.99	4.76	4.81		4.85	4.82	4.97	4.79	5.27	6
1	1101	CR CK#19 CRYS539RR	4.90	3.84	4.48		5.23	5.15	5.13		5.17	5.21	5.27	5.25	5.39	16
1	1102	CR CK#24 HILL4012RR	4.56	4.31	4.58		4.87	5.78	5.25		5.30	5.31	5.40	5.33	5.56	15
1	1103	CR CK#28 HILL4010RR	4.60	4.09	4.21		4.91	5.48	4.82		5.07	5.05	5.13	5.04	5.27	15
1	1104	CR CK#41 CRYS981RR	4.73	3.62	4.56		5.05	4.85	5.22		5.04	5.06	5.04	5.08	5.00	12
1	1105	CR CK#43 CRYS246RR	4.48	3.55	4.08		4.78	4.76	4.67		4.74	4.71	4.73	4.69	4.78	9
1	1106	CR CK#44 BETA80RR32	4.77	3.53	3.99		5.09	4.73	4.57		4.80	4.89	4.95	4.99	5.06	11
1	1107	CR CK#45 HILL4448RR	5.01	4.31	4.92		5.35	5.78	5.64		5.59	5.60	5.45	5.62	5.14	9
1	1108	CR CK#47 HILL4094RR	3.93	3.15	3.70		4.19	4.22	4.24		4.22	4.25	4.32	4.28	4.46	13
1	1109	CR CK#48 MARI504	5.02	3.90	4.99		5.36	5.23	5.72		5.43	5.41	5.27	5.38	4.99	6
1	1110	CR CK#49 CRYS578RR	4.77	3.34	4.18		5.09	4.48	4.79		4.78	4.76	4.77	4.73	4.80	6
1	1111	CR CK#50 CRYS101RR	4.64	3.27	4.10		4.95	4.38	4.70		4.68	4.64	4.61	4.61	4.53	10
1	1112	CR CK#51 CRYS355RR	4.36	3.50	4.17		4.65	4.69	4.78		4.71	4.61	4.58	4.51	4.53	8
	1113	CR CK MOD SUS HYB#3	4.93	4.02	4.48		5.26	5.39	5.13		5.26	5.28	5.33	5.29	5.44	16
	1114	CR CK MOD RES HYB#4	4.40	3.49	4.09		4.70	4.68	4.68		4.69	4.47	4.43	4.26	4.35	13
	1115	CR CK MOD RES HYB#4	4.27	3.14	3.98		4.56	4.21	4.56		4.44	4.38	4.37	4.31	4.35	13
	1116	CR CK MOD SUS HYB#5	4.89	3.97	5.04		5.22	5.32	5.77		5.44	5.40	5.37	5.37	5.29	14
12		Check Mean	4.65	3.70	4.33		4.96	4.96	4.96		4.96					
		Trial Mean	4.42	3.42	4.12		4.72	4.58	4.72		4.67					
		Coeff. of Var. (%)	4.1	8.8	5.8		4.1	8.8	5.8							
		Mean LSD (0.05)	0.22	0.45	0.30		0.23	0.60	0.34							
		Mean LSD (0.01)	0.29	0.60	0.40		0.31	0.80	0.46							
		Sig Mrk	**	**	**		**	**	**							
		Adj Factor					1.06715	1.34013	1.14540							
	* 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.															
	+ Average rating based upon multiple rating dates.															
	Green highlighted ratings indicate good resistance.											Created 10/26/2020				
	Red highlighted ratings indicate a level of concern.															

Table 22
2020 Rhizoctonia Ratings for OVT Entries
Rhizoctonia Nursery - TSC E and TSC W Moorhead MN

Sus Chk ^	Chk @	Code	Description	Unadjusted BSDF +	Unadjusted TSC-E 8/25	Unadjusted TSC-W 8/5	Unadjusted NWROC +	Adjusted @ BSDF +	Adjusted @ TSC-E 8/25	Adjusted @ TSC-W 8/5	Adjusted @ NWROC +	2020	2 Yr	3 Yr	2019	2018	Years
		518	BTS 8007		2.53	3.91			4.31	4.60		4.45	--	--	--	--	1
		513	BTS 8009		2.73	3.46			4.65	4.07		4.36	--	--	--	--	1
		549	BTS 8013		2.69	3.66			4.58	4.30		4.44	--	--	--	--	1
		521	BTS 8018		2.33	3.70			3.97	4.35		4.16	--	--	--	--	1
		546	BTS 8034		2.94	3.51			5.00	4.13		4.56	--	--	--	--	1
		550	BTS 8042		2.29	3.49			3.90	4.10		4.00	--	--	--	--	1
		570	BTS 8055		2.29	3.85			3.90	4.53		4.21	--	--	--	--	1
		571	BTS 8073		2.25	3.73			3.83	4.38		4.11	--	--	--	--	1
		520	BTS 8090		2.28	3.48			3.88	4.09		3.99	--	--	--	--	1
		505	BTS 8092		2.14	3.39			3.64	3.99		3.81	--	--	--	--	1
		510	BTS 8337		2.84	3.42			4.83	4.02		4.43	4.02	4.04	3.62	4.07	8
		573	BTS 8500		2.68	4.01			4.56	4.71		4.64	4.46	4.43	4.28	4.36	6
		552	BTS 8524		2.61	3.27			4.44	3.84		4.14	4.07	4.12	4.00	4.23	6
		564	BTS 8606		2.87	3.93			4.88	4.62		4.75	4.67	4.53	4.60	4.24	5
		524	BTS 8629		2.64	3.49			4.49	4.10		4.30	4.10	4.07	3.89	4.02	5
		536	BTS 8767		3.17	3.37			5.39	3.96		4.68	4.41	4.30	4.14	4.10	4
		575	BTS 8815		2.34	3.29			3.98	3.87		3.92	3.98	3.94	4.03	3.88	3
		543	BTS 8882		2.46	3.68			4.19	4.33		4.26	4.26	4.30	4.27	4.37	3
		532	BTS 8927		2.71	3.52			4.61	4.14		4.37	4.15	--	3.93	--	2
		563	BTS 8938		2.27	3.35			3.86	3.94		3.90	3.69	--	3.47	--	2
		531	BTS 8961		2.50	3.38			4.25	3.97		4.11	3.95	--	3.79	--	2
		555	BTS 8976		2.50	4.07			4.25	4.78		4.52	4.27	--	4.02	--	2
		554	Crystal 021		2.18	3.44			3.71	4.04		3.88	--	--	--	--	1
		556	Crystal 022		2.10	2.90			3.57	3.41		3.49	--	--	--	--	1
		567	Crystal 024		2.08	3.26			3.54	3.83		3.69	--	--	--	--	1
		515	Crystal 025		2.22	3.12			3.78	3.67		3.72	--	--	--	--	1
		506	Crystal 026		2.14	2.97			3.64	3.49		3.57	--	--	--	--	1
		527	Crystal 027		2.25	3.80			3.83	4.47		4.15	--	--	--	--	1
		542	Crystal 029		2.66	3.49			4.53	4.10		4.31	--	--	--	--	1
		547	Crystal 572		2.58	3.43			4.39	4.03		4.21	4.17	4.30	4.14	4.54	6
		514	Crystal 574		2.38	3.67			4.05	4.31		4.18	4.32	4.33	4.45	4.36	6
		509	Crystal 684		2.54	3.39			4.32	3.99		4.15	4.08	4.18	4.01	4.39	5
		565	Crystal 793		3.05	3.82			5.19	4.49		4.84	4.51	4.38	4.18	4.11	4
		516	Crystal 796		2.71	3.65			4.61	4.29		4.45	4.15	4.09	3.85	3.97	4
		533	Crystal 803		2.97	4.20			5.05	4.94		5.00	4.77	4.73	4.54	4.67	3
		503	Crystal 804		2.24	3.39			3.81	3.99		3.90	3.81	3.88	3.72	4.02	3
		560	Crystal 808		2.30	3.27			3.91	3.84		3.88	3.98	3.93	4.09	3.83	3
		569	Crystal 912		2.15	2.91			3.66	3.42		3.54	3.56	--	3.58	--	2
		511	Crystal 913		2.62	4.00			4.46	4.70		4.58	4.44	--	4.31	--	2
		558	Crystal 916		2.71	3.83			4.61	4.50		4.56	4.41	--	4.26	--	2
		519	Hilleshög HIL2233		2.78	3.51			4.73	4.13		4.43	4.11	4.08	3.78	4.04	3
		557	Hilleshög HIL2317		3.06	3.99			5.21	4.69		4.95	4.57	--	4.19	--	2
		528	Hilleshög HIL2320		3.07	3.45			5.22	4.06		4.64	4.34	--	4.04	--	2
		544	Hilleshög HIL2366		2.52	3.57			4.29	4.20		4.24	--	--	--	--	1
		517	Hilleshög HIL2367		2.61	3.47			4.44	4.08		4.26	--	--	--	--	1
		502	Hilleshög HIL2368		2.05	3.02			3.49	3.55		3.52	--	--	--	--	1
		534	Hilleshög HIL2369		2.80	3.82			4.77	4.49		4.63	--	--	--	--	1
		553	Hilleshög HIL2370		2.82	3.57			4.80	4.20		4.50	--	--	--	--	1
		574	Hilleshög HIL9708		2.26	3.24			3.85	3.81		3.83	3.85	3.80	3.87	3.71	6
		559	Hilleshög HIL9920		3.38	3.81			5.75	4.48		5.12	4.90	4.82	4.68	4.65	4
		508	Hilleshög HM4448RR		2.77	4.08			4.71	4.80		4.76	4.40	4.39	4.04	4.38	8
		526	Hilleshög HM9528RR		2.70	3.87			4.59	4.55		4.57	4.33	4.24	4.10	4.04	7
		535	Maribo MA504		2.96	3.94			5.04	4.63		4.83	4.76	4.59	4.69	4.25	6
		561	Maribo MA717		2.84	3.73			4.83	4.38		4.61	4.38	4.37	4.15	4.35	4
		538	Maribo MA902		2.22	3.47			3.78	4.08		3.93	3.95	--	3.97	--	2
		537	Maribo MA903		2.35	3.35			4.00	3.94		3.97	3.93	--	3.89	--	2
		529	Maribo MA922		2.72	4.28			4.63	5.03		4.83	--	--	--	--	1
		541	Maribo MA923		2.93	4.32			4.99	5.08		5.03	--	--	--	--	1
		562	SV 201		2.74	4.01			4.66	4.71		4.69	--	--	--	--	1
		523	SV 202		3.60	4.82			6.13	5.67		5.90	--	--	--	--	1
		572	SV 203		2.42	3.80			4.12	4.47		4.29	--	--	--	--	1
		568	SV 204		2.81	3.75			4.78	4.41		4.60	--	--	--	--	1

		539	SV 285	2.49	3.26	4.24	3.83	4.03	4.21	4.26	4.38	4.35	3
		501	SV 393	2.95	4.17	5.02	4.90	4.96	4.65	--	4.33	--	2
		548	SV 265	2.59	3.41	4.41	4.01	4.21	4.23	4.26	4.25	4.32	5
		551	SV 268	3.09	4.45	5.26	5.23	5.24	4.73	4.55	4.21	4.21	5
		504	SV 333	2.51	4.21	4.27	4.95	4.61	4.34	4.31	4.08	4.23	8
		576	SV 375	2.72	3.79	4.63	4.46	4.54	4.30	4.24	4.05	4.13	4
		540	SX 1801	3.37	3.99	5.74	4.69	5.21	--	--	--	--	1
		545	SX 1802	2.88	3.42	4.90	4.02	4.46	--	--	--	--	1
		507	SX 1803	2.62	3.56	4.46	4.19	4.32	--	--	--	--	1
		530	SX 1804	2.52	3.80	4.29	4.47	4.38	--	--	--	--	1
		566	SX 1887	3.00	3.83	5.11	4.50	4.80	4.49	4.38	4.18	4.16	3
		512	SX 1888	2.46	3.53	4.19	4.15	4.17	4.18	4.31	4.19	4.57	3
		522	SX 1898	2.58	3.34	4.39	3.93	4.16	4.19	--	4.21	--	2
		525	SX Marathon	2.67	3.39	4.54	3.99	4.26	4.31	4.27	4.36	4.19	6
1	1	1301	RH CK#08 CRYS539	3.57	4.68	6.08	5.50	5.79	5.23	5.05	4.67	4.68	12
1	1	1302	RH CK#21 CRYS768	2.75	3.67	4.68	4.31	4.50	4.58	4.56	4.66	4.52	12
1	1	1303	RH CK#25 HILL4043RR	2.86	4.18	4.87	4.91	4.89	4.78	4.80	4.66	4.83	12
	1	1304	RH CK#35 SES36812RR	2.67	3.73	4.54	4.38	4.46	4.38	4.35	4.29	4.29	13
1	1	1305	RH CK#36 BTS85RR02	2.90	4.48	4.94	5.27	5.10	4.83	4.71	4.56	4.46	16
	1	1306	RH CK#37 SES36918RR	2.71	3.46	4.61	4.07	4.34	4.54	4.47	4.75	4.32	12
1	1	1307	RH CK#40 CRYS101	2.60	3.93	4.42	4.62	4.52	4.63	4.58	4.73	4.50	10
	1	1308	RH CK#45 BTS82RR33	2.15	3.29	3.66	3.87	3.76	3.92	4.18	4.09	4.70	9
	1	1309	RH CK#47 SES36272RR	2.47	3.84	4.20	4.51	4.36	4.31	4.33	4.26	4.36	9
	1	1310	RH CK#48 HILL4094RR	2.01	3.23	3.42	3.80	3.61	3.79	3.77	3.98	3.72	13
1	1	1311	RH CK#49 CRYS247	2.56	3.79	4.36	4.46	4.41	4.28	4.39	4.16	4.62	9
1	1	1312	RH CK#51 SXWinchester	2.45	3.69	4.17	4.34	4.25	4.28	4.35	4.30	4.50	8
1	1	1313	RH CK#52 CRYS573	3.23	4.35	5.50	5.11	5.31	4.75	4.66	4.20	4.48	6
1	1	1314	RH CK#53 BTS8500	2.49	3.86	4.24	4.54	4.39	4.51	4.45	4.63	4.32	6
	1	1315	RH CK#54 CRYS574	2.31	3.33	3.93	3.91	3.92	4.19	4.24	4.45	4.36	6
		1316	MOD RHC #9	2.72	3.90	4.63	4.58	4.61	4.53	4.47	4.45	4.36	6
		1317	RES RHC #1	1.89	2.75	3.22	3.23	3.22	3.64	3.59	4.06	3.49	15
		1318	RES RHC #3	1.94	3.26	3.30	3.83	3.57	3.73	3.61	3.90	3.36	7
		1319	SUS RHC #10	3.15	4.11	5.36	4.83	5.10	4.70	4.63	4.30	4.51	12
		1320	SUS RHC #3	3.91	4.12	6.65	4.84	5.75	5.17	5.01	4.58	4.71	16
	15		Mean of Check Varieties	2.65	3.83	4.51	4.51	4.51	4.47	4.46	4.43	4.44	
9			Mean of Susc Checks	2.82	4.07	4.66	4.63	4.65	4.55	4.56	4.46	4.57	
			Trial Mean	2.63	3.67	4.48	4.31						
			Coeff. of Var. (%)	15.7	10.3	15.7	10.3						
			Mean LSD (0.05)	0.56	0.54	0.95	0.63						
			Mean LSD (0.01)	0.74	0.71	1.26	0.83						
			Sig Lvl	**	**	**	**						
			Adjustment Factor	1.7018	1.1756								
			Approval Limit (80% of susc chec	2.26	3.26	3.73	3.70	3.72	3.64	3.65	3.57	3.66	
			++ Adjustment is based upon check varieties.										
			+ Data not adequate in 2020.										
			@ 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 x 0.80 (approval option 1) or 3.82 (approval option 2).										
			Green highlighted ratings indicate good resistance.										
			Red highlighted ratings indicate a level of concern.										

Table 23.

2020 Fusarium Ratings for Official Trial Entries

ACSC Nurseries - (Two Moorhead, MN Sites)

Chk			Unadjusted		Adjusted							
			N Mhd	S Mhd	N Mhd	S Mhd						
@	Code	Description	4 Dates+	4 Dates+	4 Dates+	4 Dates+	2020	2 Yr	3 Yr	2019	2018	Years
	518	BTS 8007	2.01	2.70	2.30	2.66	2.48	--	--	--	--	1
	513	BTS 8009	2.71	3.70	3.10	3.64	3.37	--	--	--	--	1
	549	BTS 8013	1.94	2.42	2.22	2.38	2.30	--	--	--	--	1
	521	BTS 8018	2.16	2.51	2.47	2.47	2.47	--	--	--	--	1
	546	BTS 8034	1.75	2.56	2.00	2.52	2.26	--	--	--	--	1
	550	BTS 8042	2.02	2.64	2.31	2.60	2.46	--	--	--	--	1
	570	BTS 8055	1.79	2.53	2.05	2.49	2.27	--	--	--	--	1
	571	BTS 8073	1.97	2.96	2.26	2.91	2.58	--	--	--	--	1
	520	BTS 8090	2.10	2.69	2.40	2.65	2.53	--	--	--	--	1
	505	BTS 8092	3.09	3.92	3.54	3.86	3.70	--	--	--	--	1
	510	BTS 8337	3.10	3.77	3.55	3.71	3.63	3.60	3.79	3.57	4.18	8
	573	BTS 8500	2.01	2.49	2.30	2.45	2.38	2.32	2.37	2.27	2.46	6
	552	BTS 8524	2.69	2.99	3.08	2.94	3.01	3.08	3.36	3.14	3.93	6
	564	BTS 8606	2.24	3.23	2.57	3.18	2.87	2.78	3.07	2.68	3.66	5
	524	BTS 8629	3.22	3.94	3.69	3.88	3.78	3.75	3.96	3.71	4.40	5
	536	BTS 8767	1.93	2.74	2.21	2.70	2.45	2.45	2.77	2.45	3.41	4
	575	BTS 8815	2.19	2.69	2.51	2.65	2.58	2.63	2.97	2.69	3.64	3
	543	BTS 8882	1.84	2.15	2.11	2.11	2.11	2.51	2.80	2.91	3.39	3
	532	BTS 8927	2.00	2.93	2.29	2.88	2.59	2.68	--	2.77	--	2
	563	BTS 8938	3.07	3.87	3.52	3.81	3.66	3.36	--	3.06	--	2
	531	BTS 8961	1.85	2.30	2.12	2.26	2.19	2.37	--	2.55	--	2
	555	BTS 8976	2.35	3.20	2.69	3.15	2.92	3.30	--	3.68	--	2
	554	Crystal 021	2.26	3.17	2.59	3.12	2.85	--	--	--	--	1
	556	Crystal 022	1.92	3.06	2.20	3.01	2.60	--	--	--	--	1
	567	Crystal 024	1.98	2.64	2.27	2.60	2.43	--	--	--	--	1
	515	Crystal 025	2.06	2.71	2.36	2.67	2.51	--	--	--	--	1
	506	Crystal 026	2.08	2.27	2.38	2.23	2.31	--	--	--	--	1
	527	Crystal 027	2.00	2.64	2.29	2.60	2.44	--	--	--	--	1
	542	Crystal 029	2.00	2.60	2.29	2.56	2.42	--	--	--	--	1
	547	Crystal 572	1.92	2.57	2.20	2.53	2.36	2.37	2.81	2.39	3.70	6
	514	Crystal 574	1.75	2.56	2.00	2.52	2.26	2.15	2.39	2.03	2.87	6
	509	Crystal 684	1.86	2.55	2.13	2.51	2.32	2.21	2.46	2.10	2.96	5
	565	Crystal 793	2.10	2.87	2.40	2.82	2.61	2.66	2.97	2.71	3.59	4
	516	Crystal 796	1.90	2.26	2.18	2.22	2.20	2.33	2.67	2.45	3.36	4
	533	Crystal 803	2.07	2.72	2.37	2.68	2.52	2.61	3.11	2.70	4.11	3
	503	Crystal 804	1.99	2.33	2.28	2.29	2.29	2.28	2.54	2.28	3.05	3
	560	Crystal 808	1.95	2.50	2.23	2.46	2.35	2.37	2.62	2.39	3.12	3
	569	Crystal 912	3.13	3.69	3.58	3.63	3.61	3.49	--	3.37	--	2
	511	Crystal 913	2.01	2.93	2.30	2.88	2.59	2.57	--	2.56	--	2
	558	Crystal 916	1.96	2.67	2.24	2.63	2.44	2.46	--	2.49	--	2
	519	Hilleshög HIL2233	4.22	4.12	4.83	4.05	4.44	4.40	4.69	4.35	5.28	3
	557	Hilleshög HIL2317	5.33	5.93	6.10	5.83	5.97	5.63	--	5.30	--	2
	528	Hilleshög HIL2320	3.94	4.69	4.51	4.61	4.56	4.47	--	4.37	--	2
	544	Hilleshög HIL2366	3.94	4.67	4.51	4.59	4.55	--	--	--	--	1
	517	Hilleshög HIL2367	3.97	4.40	4.55	4.33	4.44	--	--	--	--	1
	502	Hilleshög HIL2368	3.31	3.99	3.79	3.92	3.86	--	--	--	--	1
	534	Hilleshög HIL2369	4.01	5.06	4.59	4.98	4.78	--	--	--	--	1
	553	Hilleshög HIL2370	1.88	2.38	2.15	2.34	2.25	--	--	--	--	1
	574	Hilleshög HIL9708	3.12	3.77	3.57	3.71	3.64	3.76	4.05	3.89	4.61	6
	559	Hilleshög HIL9920	5.62	6.22	6.44	6.12	6.28	5.85	5.74	5.42	5.51	4
	508	Hilleshög HM4448RR	4.08	4.57	4.67	4.50	4.58	4.69	4.87	4.80	5.23	8
	526	Hilleshög HM9528RR	4.35	4.46	4.98	4.39	4.68	4.42	4.60	4.16	4.95	7
	535	Maribo MA504	3.48	4.59	3.98	4.52	4.25	4.43	4.55	4.61	4.80	6
	561	Maribo MA717	4.21	4.50	4.82	4.43	4.62	4.72	4.77	4.81	4.86	4
	538	Maribo MA902	3.20	4.43	3.66	4.36	4.01	3.86	--	3.71	--	2

	537	Maribo MA903	4.51	4.65	5.16	4.57	4.87	4.73	--	4.60	--	2
	529	Maribo MA922	3.84	4.24	4.40	4.17	4.28	--	--	--	--	1
	541	Maribo MA923	5.12	5.43	5.86	5.34	5.60	--	--	--	--	1
	562	SV 201	4.18	5.12	4.79	5.04	4.91	--	--	--	--	1
	523	SV 202	2.42	2.86	2.77	2.81	2.79	--	--	--	--	1
	572	SV 203	4.68	5.24	5.36	5.15	5.26	--	--	--	--	1
	568	SV 204	3.72	4.30	4.26	4.23	4.24	--	--	--	--	1
	539	SV 285	4.93	5.24	5.65	5.15	5.40	5.08	5.19	4.76	5.42	3
	501	SV 393	3.60	4.30	4.12	4.23	4.18	4.71	--	5.24	--	2
	548	SV 265	5.18	5.56	5.93	5.47	5.70	5.67	5.59	5.64	5.44	5
	551	SV 268	3.37	4.29	3.86	4.22	4.04	4.48	4.69	4.92	5.12	5
	504	SV 333	4.98	5.66	5.70	5.57	5.64	5.19	5.17	4.74	5.14	8
	576	SV 375	4.88	4.99	5.59	4.91	5.25	5.11	5.24	4.97	5.51	4
	540	SX 1801	2.92	4.12	3.34	4.05	3.70	--	--	--	--	1
	545	SX 1802	2.29	2.84	2.62	2.79	2.71	--	--	--	--	1
	507	SX 1803	4.35	4.71	4.98	4.63	4.81	--	--	--	--	1
	530	SX 1804	5.11	5.35	5.85	5.26	5.56	--	--	--	--	1
	566	SX 1887	3.50	4.66	4.01	4.58	4.30	4.49	4.77	4.68	5.35	3
	512	SX 1888	5.01	5.43	5.74	5.34	5.54	5.52	5.51	5.51	5.47	3
	522	SX 1898	5.02	5.16	5.75	5.08	5.41	5.28	--	5.14	--	2
	525	SX Marathon	4.96	5.14	5.68	5.06	5.37	5.53	5.53	5.70	5.51	6
1	1201	FS CK #08 HILL4000	5.66	6.58	6.48	6.47	6.48	6.22	6.08	5.96	5.81	13
1	1202	FS CK #09 HILL4010	6.55	6.93	7.50	6.82	7.16	6.90	6.57	6.64	5.91	15
1	1203	FS CK #12 HILL4012	5.77	6.39	6.61	6.29	6.45	6.04	5.92	5.63	5.68	15
1	1204	FS CK #13 HILL4043	4.58	5.16	5.24	5.08	5.16	5.52	5.59	5.87	5.73	14
1	1205	FS CK #18 CRYS768	3.53	4.45	4.04	4.38	4.21	4.33	4.50	4.45	4.85	12
1	1206	FS CK #28 SES3691	4.35	5.37	4.98	5.28	5.13	4.92	5.08	4.71	5.39	12
1	1207	FS CK #29 CRYS875	4.41	4.71	5.05	4.63	4.84	4.92	4.97	5.01	5.07	13
1	1208	FS CK #30 BTS8337	2.98	3.85	3.41	3.79	3.60	3.58	3.85	3.56	4.39	8
1	1209	FS CK #31 SXMarath	4.64	5.37	5.31	5.28	5.30	5.38	5.21	5.46	4.88	6
1	1210	FS CK #32 CRYS574	1.90	2.84	2.18	2.79	2.48	2.26	2.46	2.03	2.87	6
	1211	FS CHK MOD RR RE	3.65	4.10	4.18	4.03	4.11	4.09	4.24	4.07	4.53	14
	1212	FS CHK MOD RR SU	3.85	5.21	4.41	5.13	4.77	4.91	4.98	5.04	5.14	8
	1213	FS CHK RES RR #2	2.26	2.88	2.59	2.83	2.71	2.59	2.79	2.46	3.20	9
	1214	FS CHK SUS RR #10	4.29	5.01	4.91	4.93	4.92	5.03	5.08	5.15	5.17	7
	1215	FS CHK SUS RR #11	4.70	5.60	5.38	5.51	5.45	5.45	5.42	5.45	5.36	8
	1216	FS CHK SUS RR #2	6.03	6.63	6.90	6.52	6.71	6.30	6.13	5.89	5.80	10
10		Check Mean	4.44	5.17	5.08	5.08	5.08					
		Trial Mean	3.30	3.93	3.78	3.87	3.82					
		Coeff. of Var. (%)	11.1	11.9	11.1	11.9						
		Mean LSD (0.05)	0.45	0.57	0.52	0.56						
		Mean LSD (0.01)	0.59	0.75	0.68	0.74						
		Sig Mrk	**	**	**	**						
		Adj Factor			1.14510	0.98370						

@ 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).

Green highlighted ratings indicate good resistance.

Red highlighted ratings indicate a level of concern.

Table 24. Herbicides and Fungicides Applied to ACSC Official Trials

	Herbicide			Fungicide		
Location	**Herbicide & Rate**	**Spray Dates**	**Method**	**Fungicide Used**	**Spray Dates**	**Method**
Casselton	RU1, RU2	6/1, 6/23	Ground	CR1/CR2/CR3/CR4	7/7,7/17,7/31,8/22	Ground
Glyndon	RU1, RU2	6/2, 6/23	Ground	CR1/CR2/CR3/CR4	7/7,7/17,7/31,8/22	Ground
Perley	RU1, RU2	6/24, 7/14	Ground	CR2/CR4	7/30,8/22	Ground
Ada	RU1, RU2	6/2, 6/23	Ground	Air/CR2/CR3/CR4	7/6,7/17,7/31,8/22	Air/Ground
Grandin	RU1, RU2	6/24, 7/14	Ground	CR2/CR4	7/30,8/22	Ground
Grand Forks	RU1, RU2, RU2	6/4, 6/25, 8/3	Ground	CR2/CR3/CR4	7/15,7/30,8/22	Ground
Scandia	RU1, RU2	6/12, 7/6	Ground	CR2/CR3/CR4	7/10,7/29,8/22	Ground
Climax	RU1, RU2	6/12, 7/6	Ground	CR2/CR3/CR4	7/10,7/28,8/22	Ground
East Grand Forks	RU1, RU2	6/12, 7/14	Ground	CR2/CR3/CR4	7/15,7/28,8/22	Ground
St. Thomas	RU1, Outlook	6/19, 6/20	Ground	CR2/CR4	7/28,8/22	Ground
Bathgate	RU1, RU2	6/19, 7/6	Ground	CR2/CR4	7/28,8/22	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). CR1=Insire XT + Manzate

RU2 = Roundup Powermax (22 oz./A), Event (1 gal./100 gal water). CR2=Agritin + Incognito

Counter 20G applied at 8.9 lbs./A at all locations. CR3=Proline+Manzate

AZteroid infurrow was used at all locations. CR4=Priaxor + Agritin

Quadris was applied to 4-8 leaf beets at all locations

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