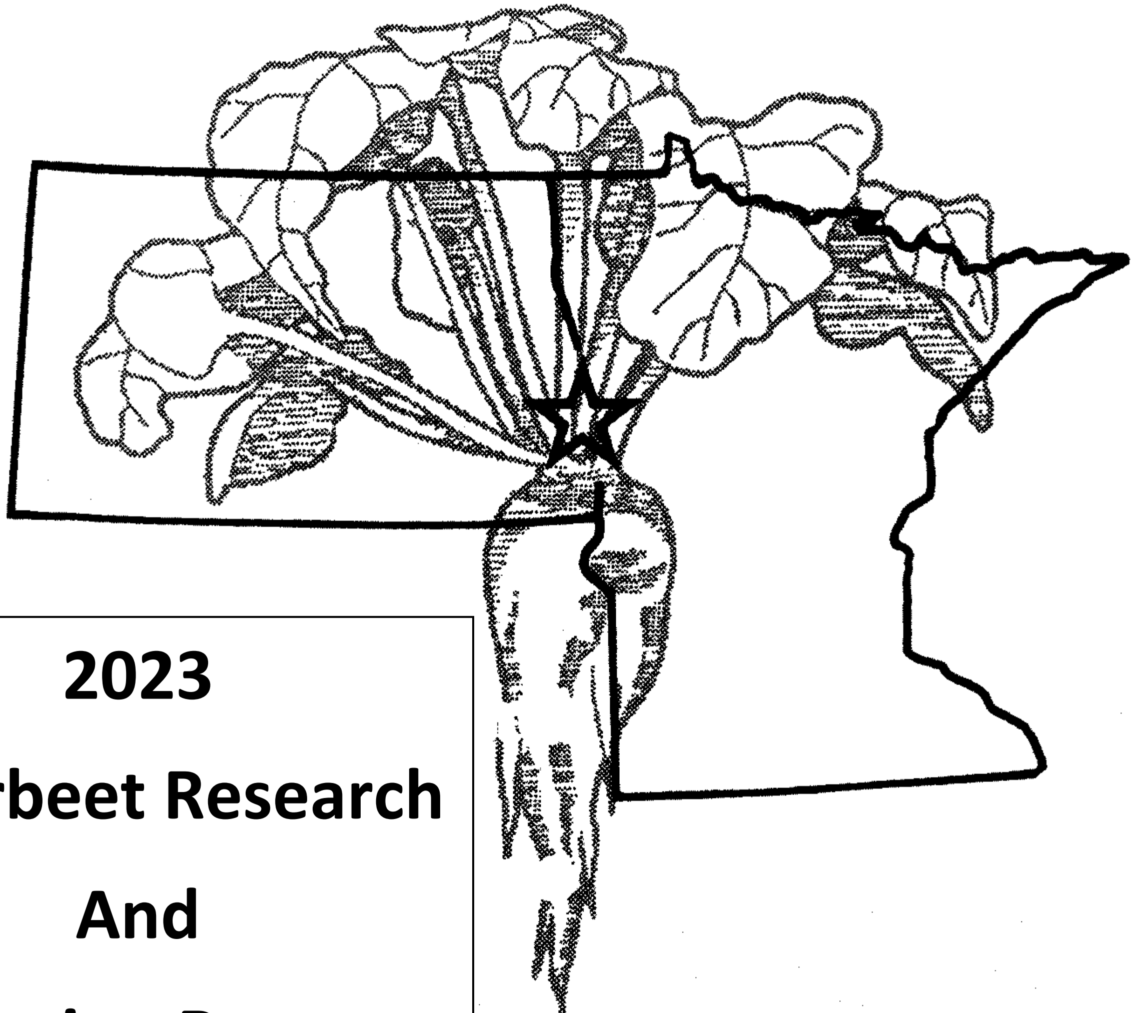
Volume 54 **April 2024**



2023 Sugarbeet Research And Extension Reports

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

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TURNING POINT SURVEY OF WEED CONTROL AND PRODUCTION PRACTICES IN SUGARBEET IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2023

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The eighth annual weed control and production practices live polling questionnaire was conducted using Turning Point Technology at the 2024 winter Sugarbeet Grower Seminars. Responses are based on production practices from the 2023 growing season. The survey focuses on responses from growers in attendance at the Fargo, Grafton, Grand Forks, Wahpeton, ND, and Willmar, MN, Grower Seminars. Respondents from seminars in North Dakota and Minnesota indicated the county in which the majority of their sugarbeet were produced (Tables 1, 2, 3, 4, 5). Survey results represent approximately 210,364 acres reported by 246 respondents (Table 6) compared with 207,360 acres represented in 2022. The average sugarbeet acreage per respondent grown in 2023 was calculated from Table 6 at 855 acres compared with 843 acres in 2022.

Survey participants were asked a series of questions regarding their production practices used in sugarbeet in 2023. Growers were asked about their tillage practices for sugarbeet in 2023 (Table 7). Ninety-six percent of all respondents indicated conventional tillage as their primary with 3% practicing strip tillage and 1% using no tillage. Across locations, 59% of respondents indicated wheat was the crop preceding sugarbeet (Table 8), 27% indicated corn (field or sweet), and 7% indicated soybean. Preceding crop varied by location with 94% of Grand Forks growers indicating wheat preceded sugarbeet and 86% of Willmar growers indicated corn as their preceding crop. Seventy-five percent of growers who participated in the winter meetings used a nurse or cover crop in 2023 (Table 9) which remained the same percentage compared with last year. Cover crop species varied widely by location with spring barley being used by 54% and 51% of growers at the Grand Forks and Wahpeton meeting, respectively, and oat being used by 45% of growers at the Willmar meeting.

Growers indicated weeds were their most serious production problem in sugarbeet for the third year in a row (Table 10) with 54% of participants in 2023 as compared with 55% of participants in 2022. In 2023, emergence or stand was the most serious problem overall for 28% of respondents. Cercospora leaf spot (CLS) was named as most serious overall by 6% of respondents across locations; however, CLS was the most serious problem for 13% of participants in the Grand Forks location.

Waterhemp was named as the most serious weed problem in sugarbeet for the fourth year in a row by 76% of respondents in 2023 (Table 11) compared with 73% in 2022 and 73% in 2021. Sixteen percent of respondents indicated kochia, 2% said common ragweed, and 2% of respondents indicated common lambsquarters was their most serious weed problem in 2023. The increased presence of glyphosate-resistant waterhemp and kochia, along with a dry growing season in 2023, are likely the reasons for these weeds being named as the worst weeds. Troublesome weeds varied by location with 96%, 90%, and 75% of Willmar, Wahpeton, and Fargo respondents, respectively, indicating waterhemp was most problematic weed. Kochia was the worst weed for respondents of the Grafton meeting with 58% of responses in 2023.

Preplant incorporated (PPI) or preemergence (PRE) herbicides were applied by 82% of survey respondents in 2023 (Table 12) compared with 71% in 2022. Forty percent of Grafton survey participants applied a PPI or PRE herbicide compared with 37% in 2022. Conversely, 99% of Wahpeton survey participants applied a PPI or PRE herbicide in sugarbeet in 2023 compared with 98% in 2022. Once again, a likely reason for this variation is the more common presence of glyphosate-resistant waterhemp in the southern sugarbeet growing areas of the Red River Valley compared with the north end of the Valley; however, the prevalence of these troublesome weeds continues to move north, which has been reflected in sugarbeet growers' weed control practices. The most commonly used soil-applied herbicide was *S*-metolachlor with 28% of all responses (Table 12). The second most commonly used soil-applied herbicide was either ethofumesate alone or a combination of *S*-metolachlor plus ethofumesate with each herbicide option having 26% of responses.

Over the last few springs, growers' in the Red River Valley have experienced delayed planting dates; however, when they are able to get sugarbeet planted, rainfall has been severely lacking. Growers' have started to opt into mechanical activation of ethofumesate rather than take a chance on receiving a 1-inch, penetrating rainfall which is needed to activate ethofumesate PRE. We surveyed the growers on activation method of ethofumesate applied PPI or PRE in 2023. Of the growers who applied ethofumesate across locations, 38% elected to apply as a PRE; however, 12% used a field cultivator and 6% used other means to activate ethofumesate.

Regardless of herbicide used and method of activation, of the growers who indicated using a soil-applied herbicide, 54% indicated excellent to good weed control from that herbicide (calculated from Table 14).

The application of soil-residual herbicides applied 'lay-by' to the 2023 sugarbeet crop was indicated by 88% of respondents (Table 15). *S*-metolachlor and Outlook were the most commonly applied lay-by herbicides with 47% and 35%, respectively, of responses. The majority of growers responding at the Willmar meeting indicated using Outlook (74% of responses), while *S*-metolachlor was more commonly applied by growers of the Fargo (80% of responses) and Grand Forks (66% of responses) meetings.

Glyphosate was most commonly applied with a chloroacetamide herbicide postemergence (lay-by) in 2023 with 47% of responses indicating this herbicide combination was used (Table 16). Glyphosate applied with a broadleaf herbicide postemergence was the second most common herbicide used in sugarbeet in 2023 with 36% of responses. Glyphosate alone and glyphosate plus a grass herbicide were the third and fourth most common at 10% and 4% of the responses, respectively.

Growers' were asked about additional POST weed control methods used in 2023 (Table 17). Seventeen percent of growers, across all locations, applied Ultra Blazer under the Section 18 Emergency Exemption label and 16% of growers left escapes in their fields. The majority of growers opted to hand-weed in 2023 with 41% of responses.

Sixty-two percent of growers utilized hand-weeding in 2023 (Table 18). Forty-two percent of respondents had less than ten percent of their acres hand-weeded, 11% had 10-50 percent hand-weeded, and 5% had 100 or more acres hand-weeded in 2023.

Thirty-three percent of participants reported row-crop cultivation (calculated from Table 19). However, most respondents indicated less than ten percent of their acres were cultivated. Conversely, 4% reported row-crop cultivation on 100% of their acres.

It is important for us to promote the maintenance and stewardship of our weed control tools in sugarbeet. One way to do this is to understand what growers are doing which will aid us in our areas of promotion. In 2024, we surveyed sugarbeet growers on their best management practices to protect the viability of current sugarbeet pesticides in 2023. Twenty-five percent of respondents utilize rotating herbicides by planting a diverse crop rotation (Table 20). Growers also protect herbicides by applying herbicides at full label rates with 24% of responses and tank mixing two or more different modes of action with 23% of responses.

Table 1. 2024 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2023.

County	Number of Responses	Percent of Responses
Barnes	1	6
Becker	1	6
Cass	4	23
Clay	6	35
Norman[1]	5	30
Total	17	100

[1]Includes Mahnomen County

Table 2. 2024 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2023.

County	Number of Responses	Percent of Responses
Cavalier	1	3
Grand Forks	2	6
Kittson	3	10
Marshall	1	3
Pembina	13	39
Walsh	13	39
Total	33	100

Table 3. 2024 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2023.

County	Number of Responses	Percent of Responses
Grand Forks	16	24
Marshall	6	9
Polk	29	44
Traill	6	9
Walsh	3	5
Other	6	9
Total	66	100

Table 4. 2024 Wahpeton Grower Seminar - Number of survey respondents by county growing sugarbeet in

2023.

County	Number of Responses	Percent of Responses
Cass	6	8
Clay	11	14
Grant	7	9
Otter Tail	1	1
Richland	13	16
Roberts	1	1
Traverse	3	4
Wilkin	37	47
Total	79	100

Table 5. 2024 Willmar Grower Seminar - Number of survey respondents by county growing sugarbeet in 2023.

County	Number of Responses	Percent of Responses
Chippewa	20	32
Kandiyohi	7	11
Pope	1	2
Redwood	4	6
Renville	19	31
Stevens	4	6
Swift	6	10
Other	1	2
Total	62	100

Table 6. Total sugarbeet acreage operated by respondents in 2023.

Location	Responses	Acres of sugarbeet <99	100-199	200-299	300-399	400-599	600-799	800-999	1000-1499	1500-1999	2000+
		-------------------------------------% of responses-----------------------------									
Fargo	15	13	13	7	13	27	20	0	7	0	0
Grafton	30	0	10	0	7	13	10	7	36	10	7
Grand Forks	65	11	9	5	11	17	10	12	12	5	8
Wahpeton	71	3	8	10	13	22	15	6	15	8	0
Willmar	65	8	5	6	14	14	14	12	15	11	1
Total	246	7	8	6	11	17	13	9	17	8	4

Table 7. Tillage system used in sugarbeet in 2023.

Location	Responses	Conventional Tillage	Strip Tillage	No Tillage
		--------------------% of responses-----------------		
Fargo	17	100	0	0
Grafton	35	100	0	0
Grand Forks	67	96	3	1
Wahpeton	74	96	4	0
Willmar	62	94	5	1
Total	255	96	3	1

Table 8. Crop grown in 2022 that preceded sugarbeet in 2023.

Location	Responses	Previous Crop Sweet Corn	Field Corn	Dry Bean	Peas	Soybean	Wheat
		-------------------------------% of responses---------------------------------------					
Fargo	17	0	18	0	0	6	76
Grafton	30	0	0	10	0	3	87
Grand Forks	65	0	2	2	0	2	94
Wahpeton	77	2	23	0	0	10	65
Willmar	66	14	72	1	1	12	0
Total	255	27	4	2	1	7	59

Table 9. Nurse or cover crop used in sugarbeet in 2023.

Location	Responses	Spring Barley	Spring Oat	Winter Rye	Spring Wheat	Winter Wheat	Other[1]	None
		--------------------------------% of responses------------------------------------						
Fargo	16	6	0	6	19	6	0	63
Grafton	32	50	9	0	13	0	0	28
Grand Forks	66	54	0	6	16	2	2	20
Wahpeton	76	51	0	11	13	1	1	23
Willmar	66	0	45	5	21	5	0	24
Total	256	36	14	6	16	2	1	25

[1]Includes Mustard and ‘Other’.

Table 10. Most serious production problem in sugarbeet in 2023.

Location	Responses	CLS[1]	Rhizo-mania	Aph[2]	Rhizoc-tonia	Herbicide Injury	Root Maggot	Weeds	Stand[3]
		----------------------------------% of responses--							
Fargo	15	7	0	0	0	0	13	53	27
Grafton	32	9	0	0	3	0	3	47	38
Grand Forks	65	13	1	0	1	3	0	51	31
Wahpeton	82	3	1	0	5	5	1	53	32
Willmar	65	1	0	1	10	1	0	67	20
Total	259	6	1	1	5	3	2	54	28

[1]Cercospora Leaf Spot

[2]Aphanomyces

[3]Emergence/Stand

[4]Includes all root diseases.

Table 11. Most serious weed problem in sugarbeet in 2023.

Location	Responses	grasses	colq[1]	cora	kochia	gira	rrpw	RR Canola	wahe	other
		-----------------------------------% of responses---								
Fargo	16	0	6	0	19	0	0	0	75	0
Grafton	36	0	0	0	58	0	3	0	39	0
Grand Forks	64	0	3	9	20	2	2	0	62	2
Wahpeton	77	0	1	0	9	0	0	0	90	0
Willmar	62	2	2	0	0	0	0	0	96	0
Total	255	1	2	2	16	1	1	0	76	1

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

Table 12. Preplant incorporated or preemergence herbicides used in sugarbeet in 2023.

		PPI or PRE Herbicides Applied					
Location	Responses	*S*-metolachlor	ethofumesate	Ro-Neet SB	*S*-metolachor +ethofumesate	Other	None
		---------------------------------------% of responses-----------------------------------					
Fargo	19	26	37	0	26	11	0
Grafton	37	16	22	0	2	0	60
Grand Forks	65	45	13	0	8	0	34
Wahpeton	91	33	23	0	42	1	1
Willmar	70	13	42	0	34	4	7
Total	282	28	26	0	26	2	18

Table 13. Activation method of ethofumesate applied preplant incorporated in 2023.

Location	Responses	Field Cultivator	Multi-weeder	Harrow-packer	Vertical Tillage	Other	Etho PRE	Did not apply etho
		--------------------------------% of responses-------------------------------------						
Fargo	16	44	0	25	12	12	0	7
Grafton	35	0	6	6	0	2	23	63
Grand Forks	66	5	3	5	0	3	15	69
Wahpeton	79	11	5	4	4	6	51	19
Willmar	70	19	1	0	0	7	62	11
Total	266	12	3	4	2	6	38	35

Table 14. Satisfaction in weed control from preplant incorporated and preemergence herbicides in 2023.

		PPI or PRE Weed Control Satisfaction					
Location	Responses	Excellent	Good	Fair	Poor	Unsure	None Used
		-----------------------------% of responses--------------------------					
Fargo	16	13	74	13	0	0	0
Grafton	35	0	29	20	6	0	45
Grand Forks	63	8	40	16	3	5	28
Wahpeton	78	13	55	27	4	0	1
Willmar	63	3	47	43	2	0	5
Total	255	7	47	26	4	1	15

Table 15. Soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2023.

		Lay-by Herbicides Applied			
Location	Responses	*S*-metolachlor	Outlook	Warrant	None
		-------------------------------------% of responses----------------------			
Fargo	15	80	7	7	7
Grafton	33	40	12	3	45
Grand Forks	64	66	8	0	26
Wahpeton	91	64	34	2	0
Willmar	76	8	74	18	0
Total	279	47	35	6	12

Table 16. Herbicides used in a weed control systems approach in sugarbeet in 2023.

		Glyphosate Application Tank-Mixes					
Location	Responses	Gly Alone	Gly+Lay-by	Gly+Broadleaf	Gly+Grass	Other	None Used
		------------------------------------% of responses----------------------------------					
Fargo	21	5	47	38	5	5	0
Grafton	37	30	18	43	3	3	3
Grand Forks	74	14	32	48	3	3	0
Wahpeton	98	6	65	25	2	2	0
Willmar	78	5	51	35	8	1	0
Total	308	10	47	36	4	2	1

Table 17. Other POST weed control methods used in 2023.

Location	Responses	Row-Cultivation	Ultra Blazer	Hand Weeding	Electric Weeder	Left Escapes	No Escapes
		--------------------------------------% of responses------------------------------------					
Fargo	14	7	0	29	7	36	21
Grafton	38	8	8	55	0	3	26
Grand Forks	75	1	19	53	3	11	13
Wahpeton	89	16	34	19	1	20	10
Willmar	92	11	5	49	12	18	5
Total	308	9	17	41	5	16	12

Table 18. Percent of sugarbeet acres hand-weeded in 2023.

		% Acres Hand-Weeded				
Location	Responses	0	< 10	10-50	51-100	>100
		------------------------------------% of responses------------------------------				
Fargo	17	53	41	6	0	0
Grafton	38	39	53	5	0	3
Grand Forks	64	25	64	6	5	0
Wahpeton	72	58	31	10	1	0
Willmar	62	24	26	21	11	18
Total	253	38	42	11	4	5

Table 19. Percent of sugarbeet acres row-crop cultivated in 2023.

		% Acres Row-Cultivated				
Location	Responses	0	< 10	10-50	51-100	>100
		-----------------------------------% of responses-----------------------------				
Fargo	17	88	12	0	0	0
Grafton	34	68	24	5	3	0
Grand Forks	63	71	24	5	0	0
Wahpeton	75	67	15	13	4	1
Willmar	60	55	8	12	8	17
Total	249	67	16	10	4	4

Table 20. Best management practices used to protect the viability of current sugarbeet pesticides in 2023.

Location	Responses	Full Herbicide Rates	Tank Mixing	Herbicide Rotation across Crops	Herbicide Layering	Integrated Pest Management[1]	Other
		--------------------------------------% of responses------------------------------------					
Fargo	25	28	20	16	16	20	0
Grafton	47	23	45	23	2	7	0
Grand Forks	93	29	26	27	6	11	1
Wahpeton	122	19	16	30	16	19	0
Willmar	101	27	17	19	18	16	3
Total	388	24	23	25	12	15	1

[1]Includes a combination of chemical, cultural, and mechanical practices, etc.

A COMPENDIUM OF OUR ETHOFUMESATE KNOWLEDGE

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Summary

1. Ethofumesate might be our most important sugarbeet herbicide; however, it is our least understood sugarbeet herbicide.
2. Ethofumesate applied at greater than 2 pt/A will reduce stands of nurse crops including spring barley.
3. Early season waterhemp control from ethofumesate is dependent on rainfall or mechanical tillage for activation. Rainfall provides the best quality activation but has been unreliable, especially in years with late sugarbeet planting.
4. Our research supports ethofumesate alone applied either at 4 or 6 pt/A or tank mixed with Dual Magnum for early season waterhemp control.

Introduction

We have designed and conducted many ethofumesate experiments. Our experiments consider many facets of ethofumesate including reduced rates combined with Dual Magnum for waterhemp control, potential to injure nurse crops, and amount of rainfall required for activation. More recently we have compared ethofumesate preplant and preemergence, especially since spring rainfall for activation has been inconsistent. This compilation completes a series of five experiments conducted from 2020 to 2023 comparing waterhemp control and spring barley injury from ethofumeste applied up to 12 pt/A preplant or preemergence.

<u>Nurse crop safety.</u> Growers frequently ask if ethofumesate can be used safely with a nurse crop. Nurse crops are used as companion crops to reduce effect of blowing soil on sugarbeet. Stated another way, growers want to know the trade-off between using a soil residual herbicide for waterhemp control versus a successful establishment of nurse crops. We learned nurse crops respond differently to ethofumesate and Dual Magnum, that spring wheat and barley are more sensitive than oat (Peters et al. 2015). Second, nurse crops tolerate Dual Magnum better than ethofumesate, although both Dual Magnum and ethofumesate inhibit the root and apical meristem in susceptible species. The difference is Dual Magnum is metabolized faster than ethofumesate by cereals. However, there are situations where Dual Magnum and ethofumesate cause minimal stand loss to cover crops; situations where rainfall fails to incorporate herbicides into the soil for uptake by emerging shoots or developing roots. We have received questions regarding winter rye as a cover crop (fall seeded) and winter rye as a nurse crop (spring seeded). To be clear, we have not evaluated rye tolerance to ethofumesate; however, I anticipate no injury from fall-seeded rye and less injury from spring-seeded rye as compared with oat, spring wheat, or barley.

<u>Activation.</u> Challenges with activating soil residual herbicides have been commonplace since 2021. Conditions were so poor that the experiment at Moorhead was abandoned due to erratic emergence of spring barley and we observed very poor overall control of waterhemp at the Fargo location in 2021. Waterhemp escapes were either small or big plants, depending on treatment, suggesting control of either early or late emerging waterhemp. Ethofumesate preplant provided no control of early emerging waterhemp, but 56% control of late emerging waterhemp. Conversely, ethofumesate preemergence provided 55% control of early emerging waterhemp, but only 28% control of late emerging waterhemp. We hypothesize that ethofumesate incorporated into the soil was bound to soil colloids and unavailable for waterhemp uptake early in the season due to sub-optimal soil moisture conditions (Figure 1). Ethofumesate moved into the soil solution following rain events in early June and was partially effective at controlling later emerging waterhemp. Ethofumesate PRE likely was bound to the soil surface and may have moved into the soil following these rainfall events in late May and early June, providing some early season control. However, degradation likely reduced control of late emerging waterhemp.

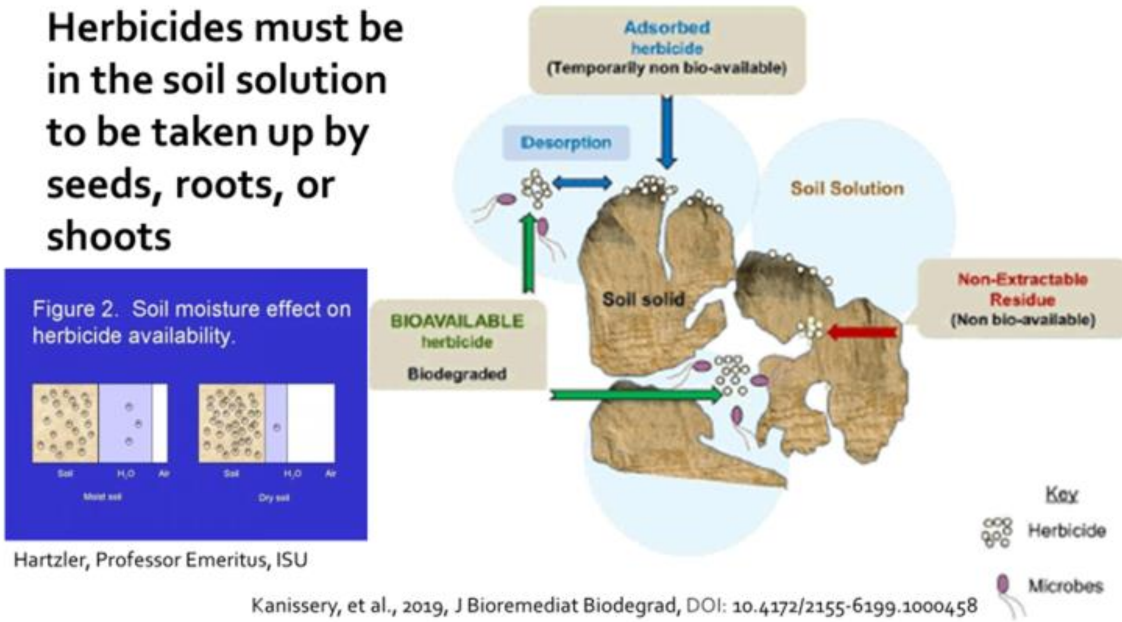

Figure 1. Illustration depicting ethofumesate bound to soil colloids when soil water content is low and in the soil solution when the soil water content is greater.

Our hypothesis is supported by the physical properties of ethofumesate compared with other herbicides (Table 1). KOC value of 350 for ethofumesate means that it has a high affinity for soil colloids and would rather be bound to soil than be in the soil solution as compared with other chloroacetamide herbicides. Second, water solubility value of 110 means ethofumesate is less water soluble than other chloroacetamide herbicides and requires more rainfall (quantity and intensity) to be incorporated into the soil. Further, we believe rainfall and soil moisture (above and below) are a predictor of waterhemp control from ethofumesate and at least partially explains the inconsistent results growers have experienced when ethofumesate has been applied preemergence in some fields in previous years. Finally, ethofumesate controls waterhemp best following timely, adequate, and penetrating rainfall events to move ethofumesate off the soil surface and into the water solution and/or spaces between colloids.

Table 1. Herbicide absorptivity (KOC) and water solubility (ppm).

Herbicide	Absorptivity	Water Solubility
	---K_{OC}^{a}---	---ppm---
Treflan	7,000	0.3
Dicamba	2	4,500
Acetochlor	200	233
Outlook	155	1,174
S-metolachlor	200	488
Ethofumesate	340	110

[a]The K value represents the ratio of herbicide bound to soil collides versus what is free in the water. Thus, the higher the K value, the greater the adsorption to soil colloids.

Waterhemp control. Ethofumesate has not provided season-long waterhemp control in our, or previous NDSU, sugarbeet research. Further, growers are reluctant to use full rates preplant or preemergence due to price, specter of carryover to grass crops planted in sequence with sugarbeet, and injury potential to nurse crops. Rather, growers have adopted an integrated strategy whereby chloroacetamide herbicides applied POST to sugarbeet and PRE to waterhemp in a single or split application at the V2 and/or V6 sugarbeet stage precede application PRE. Ethofumesate alone or ethofumesate mixed with Dual Magnum are applied PRE at less than full rates. We teach that PRE is not providing season long control, but rather is a layer to protect sugarbeet against early germinating waterhemp until the chloroacetamides are applied. However, we have wondered about waterhemp control from less than labeled rates. That is, are less than labeled rates providing full control for a short duration or are less than labeled rates providing substandard control for short duration?

Waterhemp control was dependent on ethofumesate PRE rate and evaluation timing (Figure 2). We believe our target must be 85% to 90% waterhemp control for 30 to 40 days or until chloroactamide herbicides can be applied and are activated by rainfall. The 85% waterhemp control threshold was accomplished when ethofumesate was applied at 4.5, 6.0, or 7.5 pt/A. The 90% waterhemp control threshold was accomplished when ethofumesate was applied at 6.0 or 7.5 pt/A. Ethofumsate PRE at 7.5 pt/A provided 85% waterhemp control, 54 days after application, indicating ethofumesate at the full rate does not provide season long waterhemp control. Sub-lethal rates or ethofumesate at 1.5 or 3.0 pt/A did not meet our 85% to 90% waterhemp control threshold. These data suggest sub-lethal rates are providing insufficient waterhemp control, even for a short duration.

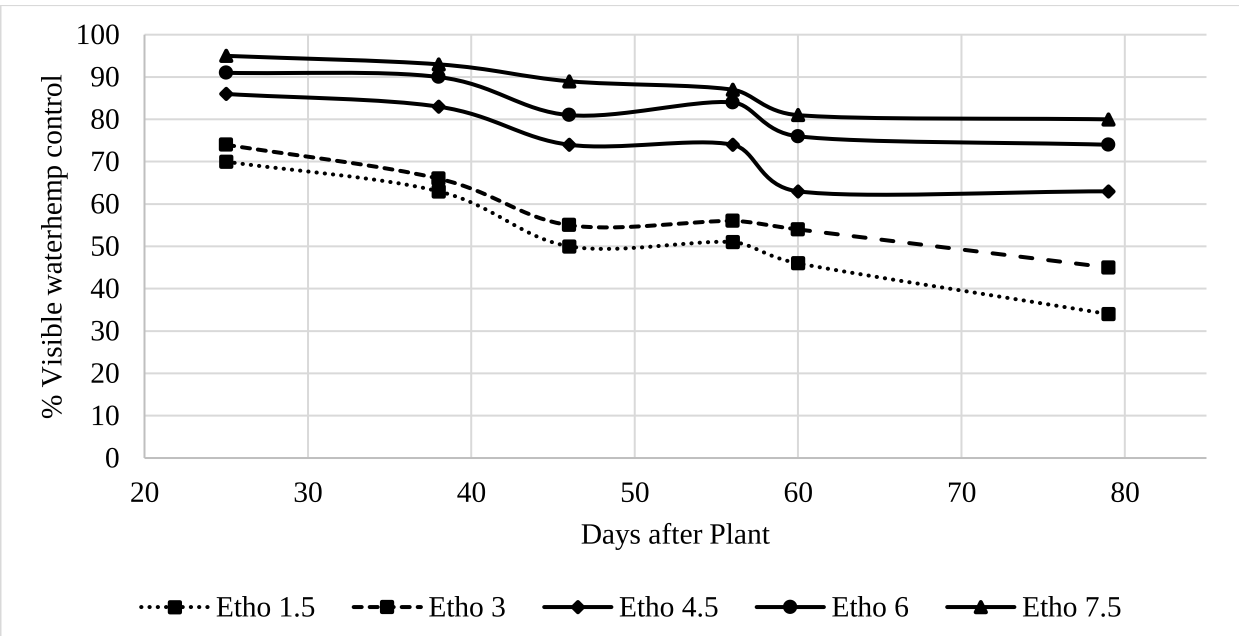

Figure 2. Waterhemp control from ethofumesate PRE across rates, Blomkest, MN, 2020.

We continued to evaluate the fate of ethofumesate on both nurse crops and waterhemp control (Peters et al. 2022). Our results suggest ethofumesate rate alone does not overcome environmental challenges when timely, adequate, and penetrating rainfall fails to occur. Thus, mixing Dual Magnum with ethofumesate is a strategy to reduce risk, as Dual Magnum adsorbs less to soil and is more water soluble, providing short duration control until sufficient rainfall occurs for ethofumesate activation. Incorporating ethofumesate is a risk-aversion strategy, provided ethofumesate is incorporated 0.5- or 1-inch (tillage at 1-inch or 2-inch) with tillage equipment that enables movement of ethofumesate into the soil, thereby maximizing pigweed control.

The objective of this 2023 experiment was to 1) demonstrate crop safety to nurse crop spring barley and 2) determine the duration of waterhemp control from ethofumesate.

Materials and Methods

An experiment was conducted near Moorhead, MN in 2023. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on May 24 at Moorhead, MN in 2023. Sugarbeet was seeded in 22-inch rows at approximately 62,000 seeds per acre with 4.5 inch spacing between seeds. Herbicide treatments are found in Table 2.

Treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length. Spring barley was seeded perpendicular to sugarbeet rows using a Land Pride grain drill (Great Plains Manufacturing, Salina, KS). Ethofumesate applied preplant and spring barley was incorporated into soil parallel to sugarbeet rows using a Kongskilde s-tine field cultivator with rolling baskets set approximately 2-inch deep and operated at approximately 5 mph.

Table 2. Herbicide treatment, application timing, and rate, Moorhead, MN, 2023.

Herbicide Treatment	Application timing	Rate (pt/A)
Ethofumesate	Preplant	2
Ethofumesate	Preplant	4
Ethofumesate	Preplant	6
Ethofumesate	Preplant	8
Ethofumesate	Preplant	10
Ethofumesate	Preplant	12
Ethofumesate	Preemergence	2
Ethofumesate	Preemergence	4
Ethofumesate	Preemergence	6
Ethofumesate	Preemergence	8
Ethofumesate	Preemergence	10
Ethofumesate	Preemergence	12

Spring barley nurse crop ground coverage was evaluated using a numeric scale of 1 to 9 (1-3=poor ground coverage, 4-6=good ground coverage, and 7-9=excellent ground coverage). Visible waterhemp control (0 to 100% control, 0% indicating no control, and 100% indicating complete control) was collected 34, 42, 49, 54, and 67 days after treatment (DAT). Experimental design was randomized complete block design with four replications in a factorial arrangement, with factors being herbicide application method and herbicide rate. Data were analyzed with the ANOVA procedure of ARM, version 2023.6 software package.

Results and Discussion

Herbicide activation technique did not interact with ethofumesate rate (P-value=0.3202, 0.6570, 0.8676; 13, 19, 26 days after planting (DAP), respectively) so assessment of ground coverage was averaged across activation technique. However, we observed improved spring barley ground coverage across rates when ethofumesate was applied PRE as compared with ethofumesate machine incorporated into soil (data not shown). The site received 0.8-inch rainfall, 5 and 7 DAP, which should have been plenty of rainfall to both activate ethofumesate PRE into the soil and further distribute ethofumesate incorporated with tillage.

Spring barley stands decreased as ethofumesate rate increased (Figure 3). We observed what was considered 'poor nurse crop ground cover' following ethofumesate at 12 pt/A. We observed 'good nurse crop ground coverage' following ethofumesate rates of 4 to10 pt/A and 'excellent nurse crop ground coverage' following ethofumesate at 2 pt/A. These evaluations were consistent between 12 and 25 DAP; however, we observed numerically improved spring barley ground coverage over time. This could be due to continued growth and tillering as the spring barley established.

Ultimately, what is considered acceptable nurse crop ground cover is up to the producer. Our experiment indicates ethofumesate applied for waterhemp control at greater than 2 pt/A significantly reduced nurse crop ground coverage.

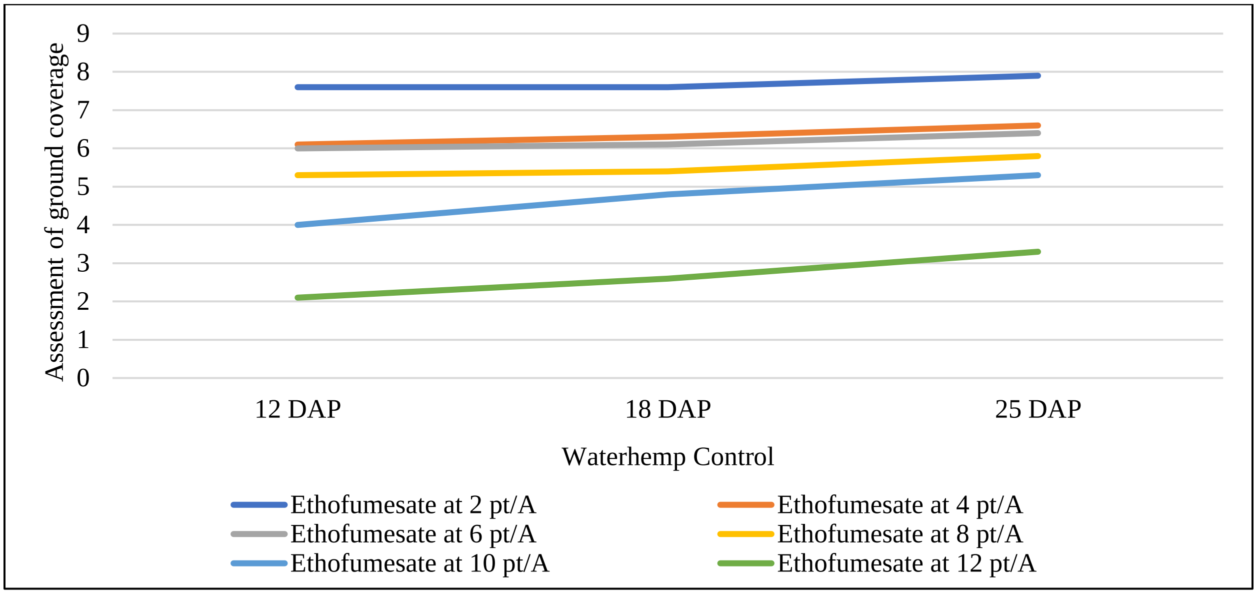

Figure 3. Spring barley ground coverage 12, 18, and 25 days after planting (DAP) in response to ethofumesate rate, Moorhead, MN, 2023.

Herbicide activation technique did not interact with ethofumesate rate (P-value >0.10) 34 to 67 DAP so assessment of waterhemp control was averaged across herbicide application method. Overall, waterhemp control was slightly greater when ethofumesate was rainfall activated as compared with tillage incorporation (Table 3). Improved waterhemp control PRE ranged from 14% to 20% across evaluation timing. Depth of incorporation for preplant incorporated (PPI) treatments may have contributed to decreased waterhemp control as compared with PRE treatments. We have often cautioned producers on pushing ethofumesate too deep into the soil with tillage since waterhemp germinates from the surface to 1-inch deep in soil. Ethofumesate PRE provided greater and longer lasting control as compared with ethofumesate PPI, which is likely due to the uniformity and consistency from rainfall activation.

Table 3. Waterhemp control in response to herbicide application method, averaged across ethofumesate rate, Moorhead, MN, 2023.[a]

	Waterhemp Control				
Herbicide Application Method	34 DAP[b]	42 DAP	49 DAP	54 DAP	67 DAP
	---------------------------------------%---------------------------------------				
Preplant Incorporated	63 b	54 b	47 b	47 b	31 b
Preemergence	77 a	74 a	61 a	64 a	54 a
LSD (0.10)	6	6	7	6	8

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.

[b] DAP=days after planting.

Waterhemp control and length of waterhemp control was dependent on rate (Table 4). Ethofumesate at 10 and 12 pt/A provided the greatest waterhemp control across all evaluation timings. However, ethofumesate at 10 and 12 pt/A are not labeled rates in sugarbeet. Ethofumesate at 4 to 8 pt/A provided similar waterhemp control up to 34 days after planting. Waterhemp control from ethofumesate at 6 and 8 pt/A was the same up to 67 days after application (DAA). Ethofumesate at 4 pt/A provided greater waterhemp control across evaluation timings in this experiment.

Table 4. Waterhemp control in response to ethofumesate rate, averaged across activation technique, Moorhead, MN, 2023.[a]

		Waterhemp Control				
Herbicide Treatment	Rate	34 DAP[b]	42 DAP	49 DAP	54 DAP	67 DAP
	---pt/A---	--------------------------------------%--				
Ethofumesate	2	45 c	32 d	15 e	19 d	10 e
Ethofumesate	4	66 b	54 c	34 d	38 c	29 d
Ethofumesate	6	70 b	72 ab	64 bc	61 b	49 bc
Ethofumesate	8	74 ab	66 bc	58 c	62 b	41 cd
Ethofumesate	10	82 a	77 ab	75 ab	74 a	59 ab
Ethofumesate	12	84 a	83 a	78 a	77 a	66 a
LSD (0.10)		10	11	11	11	13

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.

[b] DAP=days after planting.

Conclusions

Spring barley ground cover decreased as ethofumesate rate increased from 2 to 12 pt/A and loss of ground cover was greater from ethofumesate PPI than ethofumesate PRE. Ethofumesate at 2 pt/A caused negligible loss of ground cover; however, ethofumesate rates between 4 and 6 pt/A may cause up to 50% loss of nurse crop ground cover. Ground cover from nurse crops is a grower preference. Ultimately, the effect of ethofumesate rate and application method on cover crop will be dependent on conditions after application method and once herbicide rate is selected. Waterhemp control from ethofumesate was greatest PRE, indicating ethofumesate dilution occurs with mechanical tillage incorporation. Loss of control from mechanical activation as compared with rainfall activation averaged 18% across evaluation timings at Moorhead, MN in 2023. This outcome was in a season when there was timely rainfall for activation after application. Ultimately, the decision is about waterhemp control and a compromise between nurse crop ground cover and expectations for early season waterhemp control. Ethofumesate at 2 pt/A alone PRE does not accomplish early season waterhemp control and is discouraged (Figure 4). We encourage ethofumesate alone at 4 to 6 pt/A PRE or ethofumesate at 2 to 3 pt/A tank mixed with Dual Magnum PRE at 0.5 to 0.75 pt/A, targeting a minimum of 85% waterhemp control for 30 to 40 days or until chloroacetamide POST application.

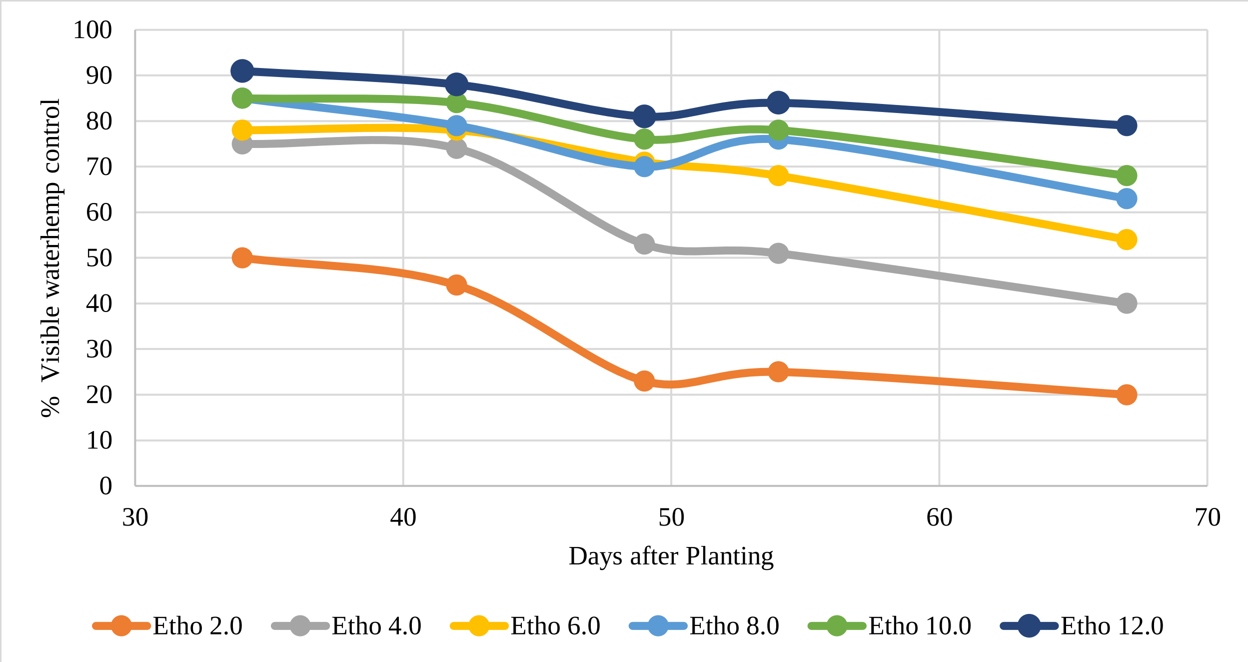

Figure 4. Waterhemp control from ethofumesate PRE across rates, Moorhead, MN, 2023.

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WATERHEMP CONTROL FROM SOIL RESIDUAL PREEMERGENCE AND POSTEMERGENCE HERBICIDES, CONTINUED IN 2023

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Summary

1. Outlook applied early postemergence reduced sugarbeet final stand.
2. PRE followed by split layby program improved waterhemp control as compared with the split layby program alone.

Introduction

Peters et al. (2023) concluded rainfall is critical for activating soil residual herbicides and achieving satisfactory waterhemp control from soil residual herbicides in previous reports. This research reinforces that a strategy to layer soil residual herbicides, starting at planting and after sugarbeet has emerged, is our best program for controlling waterhemp in sugarbeet. Finally, this research demonstrated excellent sugarbeet safety from the chloroacetamide herbicides. We have consistently stated the three chloroacetamide active ingredients commercially available in sugarbeet, Outlook, *S*-metolachlor products and Warrant, are equally effective at providing waterhemp control, and that the differences in waterhemp control among chloroacetamide products are minor. A continuation of this work was conducted in 2023. We wanted to incorporate our waterhemp control practices from the mid- to southern Red River Valley to the Northern Red River Valley.

Objective

The objective of this experiment was to demonstrate a weed control system for waterhemp control in sugarbeet in the Northern Red River Valley.

Materials and Methods

An experiment was conducted near Drayton, ND in 2023. Treatments are listed in Table 1. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on May 13, seeded in 22-inch rows at a population and seed spacing commercially accepted by sugarbeet growers in the Red River Valley. Treatments were applied with a bicycle sprayer in 17 gpa spray solution through XR8002 flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length.

Table 1. Herbicide treatment, rate, and application timing, Drayton, ND, 2023.

Herbicide Treatment PRE	Residual Herbicide Treatment POST[a]	Rate (fl oz/A)	Sugarbeet stage (lvs)
No	PowerMax3 + etho / Ultra Blazer[b]	25 + 6 / 16	2 / 6-8
No	Outlook / Outlook	12 / 12	2 / 6-8
No	Dual Magnum / Dual Magnum	17.6 / 17.6	2 / 6-8
No	Dual Magnum / Outlook	17.6 / 12	2 / 6-8
Yes[c]	PowerMax3 + etho / Ultra Blazer	25 + 6 / 16	PRE/ 2 / 6-8
Yes	Outlook / Outlook	12 / 12	PRE/ 2 / 6-8
Yes	Dual Magnum / Dual Magnum	17.6 / 17.6	PRE/ 2 / 6-8
Yes	Dual Magnum / Outlook	17.6 / 12	PRE/ 2 / 6-8

[a]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied with POST applications not containing Ultra Blazer.
[b]Ultra Blazer applied with Prime Oil Crop Oil Concentrate (COC) at 1.5 pt/A.
[c]Ethofumesate + Dual Magnum at 2.0+0.5 pt/A PRE.

Visible sugarbeet growth reduction injury was evaluated using a 0 to 100% scale (with 0% representing no visible injury and 100% as complete loss of plant / stand) approximately 14 and 21 days (+/- 3 days) following the 6-8 leaf application. Sugarbeet stand was measure by counting the number of sugarbeet in a 10 ft row in rows three and four of a six-row plot. Stand counts were collected June 14 or the same day as visible sugarbeet assessment. Visible waterhemp control was evaluated using a 0 to 100% scale (0% indicating no control and 100% indicating complete weed control) and was collected 30, 51, and 66 days after planting. Experimental design was randomized complete block with four replications in a factorial treatment arrangement, factors being use of PRE herbicide (no/yes) and POST herbicide treatments. Data were analyzed with the ANOVA procedure of ARM, version 2023.5 software package.

Results and Discussion

The experiment at Drayton, ND was planted to "dry" seedbed moisture. After planting, the site received 0.25-inch of rain over 12 days after planting (DAP) (Table 2). Rain events that followed both planting and herbicide applications were sporadic with low accumulation. As a result, sugarbeet stands were variable at this location. We elected to apply herbicide POST treatments prior to full sugarbeet stands since activating rainfall was sparse. Our logic was we would need a second rain event to activate soil residual herbicides if we waited for the initial rain event to enable completion of final stand. Further, this application timing also allowed us to evaluate how soil residual herbicides affect sugarbeet germination and stand.

Table 2. Herbicide application dates, sugarbeet growth stage and cumulative rainfall the first 10 days following herbicide application, Drayton, ND, 2023.

	Drayton, ND[a]		
Herbicide Treatment	**Herbicide Application Dates**	**Sugarbeet Growth Stage**	**Rainfall**
		--lvs--	--inch--
PRE Application	May 15	PRE	0.25
EPOST Application	May 31	2-4	0.49
POST Application	June 15	6-8	4.83[b]
		Total:	**5.57**

[a]Precipitation data collected from nearby weather stations operated by North Dakota Agricultural Weather Network (NDAWN).
[b]Rainfall amount of 4.53" reported on the 10th day following POST application.

Sugarbeet stand ranged from 80 to144 plants per 100-feet of row across plots, reflecting the dry conditions (Table 3). There was no significant sugarbeet stand differences from PRE or no PRE (125 vs.126 sugarbeet per 100-ft, no PRE vs. PRE, averaged across POST treatment). However, Outlook followed by Outlook POST significantly reduced stand or tended to reduce stand as compared with the other POST treatments, following no PRE and PRE treatments, respectively.

Sugarbeet injury ranged from 0% to 20%, 14 days after application B (DAAB) and 0% to 53%, 20 days after application C (DAAC) (Table 3). Injury assessment might have been influenced by stand challenges. However, the greatest sugarbeet injury observed was bronzing phenotype and growth reduction from applications with Ultra Blazer, with or without a PRE applied. Sugarbeet injury tended to increase POST treatments following a PRE; however, was not significantly different compared with no PRE. POST treatments with Outlook followed by Outlook resulted in sugarbeet injury statistically comparable to treatments with Ultra Blazer POST.

Table 3. Sugarbeet stand and visible injury in response to PRE and POST treatment, Drayton, ND, 2023.[a]

Herbicide Treatment PRE	Residual Herbicide Treatment POST[b]	Rate	Sugarbeet Stand	Sugarbeet Injury	
				14 DAAB[c]	20 DAAC
		----fl oz/A----	--per 100 ft--	---------%---------	
No	PowerMax3 + etho / Ultra Blazer[d]	25 + 6 / 16	135 a	0 a	38 bc
No	Outlook / Outlook	12 / 12	80 b	3 a	22 ab
No	Dual Magnum / Dual Magnum	17.6 / 17.6	140 a	4 a	0 a
No	Dual Magnum / Outlook	17.6 / 12	143 a	5 a	8 a
Yes[e]	PowerMax3 + etho / Ultra Blazer	25 + 6 / 16	144 a	0 a	53 c
Yes	Outlook / Outlook	12 / 12	100 ab	20 b	40 bc
Yes	Dual Magnum / Dual Magnum	17.6 / 17.6	123 ab	0 a	18 ab
Yes	Dual Magnum / Outlook	17.6 / 12	135 a	5 a	0 a
LSD (0.10)			**44**	**10**	**25**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied with POST application not containing Ultra Blazer.
[c]DAAB = Days after application B; DAAC = Days after application C.
[d]Ultra Blazer applied with Prime Oil Crop Oil Concentrate (COC) at 1.5 pt/A.
[e]Ethofumesate + Dual Magnum at 2+0.5 pt/A PRE.

Sugarbeet growers and agriculturalist frequently ask about applying Outlook mixed with glyphosate and ethofumesate when the majority of sugarbeet in field have reached the 2-lf stage, but when sugarbeet have not reached a full stand. In most situations, a rain event is in the weather forecast and the producer wants to "hook a rain." My reply is: "Are you satisfied with current stand in field, not knowing the fate of sugarbeet following Outlook application?" Outlook sprayed on the soil surface and not rainfall activated will not affect sugarbeet left to emerge. However, the fate of sugarbeet in the event that an activating rain occurred following Outlook application was not known. These data suggest that Outlook does affect sugarbeet germination and emergence. In contrast, *S*-metoachlor products have greater sugarbeet tolerance which is the reason why Dual Magnum is approved for use preemergence using the 24(c) local needs label in Minnesota and North Dakota.

Waterhemp control ranged from 85% to 99%, 14 DAAB and 87% to 97%, 20 DAAC (Table 4). Treatments with Outlook alone, Dual Magnum alone, or Dual Magnum followed by Outlook controlled waterhemp, even in a dry year. We did not observe waterhemp control differences between layby treatments. This could be contributed to the lack of rain following planting (Table 2).

Table 4. Waterhemp control in response to PRE and POST treatment, Drayton, ND, 2023.[a]

Herbicide Treatment PRE	Residual Herbicide Treatment POST[b]	Rate	Waterhemp Control	
			14 DAAB[c]	20 DAAC
		----fl oz/A----	-------------%------------	
No	PowerMax3 + etho / Ultra Blazer[c]	25 + 6 / 16	85 b	88 ab
No	Outlook / Outlook	12 / 12	95 ab	96 ab
No	Dual Magnum / Dual Magnum	17.6 / 17.6	93 ab	87 b
No	Dual Magnum / Outlook	17.6 / 12	96 a	94 ab
Yes[e]	PowerMax3 + etho / Ultra Blazer	25 + 6 / 16	98 a	95 ab
Yes	Outlook / Outlook	12 / 12	98 a	97 a
Yes	Dual Magnum / Dual Magnum	17.6 / 17.6	99 a	97 a
Yes	Dual Magnum / Outlook	17.6 / 12	99 a	94 ab
LSD (0.10)			**10**	**9**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]Roundup PowerMax3 at 25 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v applied POST application not containing Ultra Blazer.
[c]DAAB = Days after application B; DAAC = Days after application C.
[d]Ultra Blazer applied with Prime Oil Crop Oil Concentrate (COC) at 1.5 pt/A.
[e]Ethofumesate + Dual Magnum at 2+0.5 pt/A PRE.

We observed a significant increase in waterhemp control when a PRE was applied as compared with no PRE (Table 4). This has been a common observation in the southern Red River Valley, especially in years with May sugarbeet plantings. However, this experiment echoed our historical results that a PRE followed by the split layby program will provide increased waterhemp control across the Red River Valley as a whole, even in a dry year, as compared to the split layby program, alone.

Conclusion

There was a very high amount of variability across the experiment due to lack of rain; however, we did continue to observe that the best weed control strategy for waterhemp is layered soil residual herbicides, starting with a PRE followed by split layby application. The three chloroacetamide herbicides available in sugarbeet are equally effective at providing waterhemp control. We observed dry conditions creating open furrow with exposed sugarbeet seed, well past planting date, which provides difficulty in quantifying whether stand loss was due to lack of rainfall or herbicide application. We would like to further investigate the results from Outlook followed by Outlook and strengthen the findings of the impact it had on sugarbeet stand.

Acknowledgement

We wish to thank Steve and Julie Helm, Drayton, ND, for their collaboration with field research in 2023.

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SUGARBEET TOLERANCE AND WEED CONTROL FROM RO-NEET AND EPTAM IN 2023

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Summary

1. Ro-Neet, Eptam, or Ro-Neet mixed with Eptam at planting caused more sugarbeet injury than ethofumesate at planting.
2. Ro-Neet, Eptam, or Ro-Neet mixed with Eptam provided waterhemp control greater than ethofumesate, 15 and 23 days after planting (DAP).
3. Mixing ethofumesate with either Ro-Neet, Eptam, or Ro-Neet and Eptam might be a way to improve early season waterhemp control, especially when sugarbeet are planted in May or when rainfall is inconsistent.

Introduction

Waterhemp control is our most important weed management challenge in sugarbeet according to the annual growers' survey (Peters et al. 2022). The chloroacetamide herbicides applied at 2- and 6-lf sugarbeet stage are a critical component with our waterhemp control strategy; however, season-long waterhemp control ultimately is dependent on early season control from ethofumesate, Dual Magnum or ethofumesate mixed with Dual Magnum at planting. Some growers are incorporating ethofumesate mostly to ensure activation before waterhemp emergence and to prevent inconsistent waterhemp control (Peters et al. 2022). Ro-Neet, Pyramin, ethofumesate, and Eptam were applied preplant incorporated (PPI) or preemergence (PRE) for weed control in sugarbeet fields in the Red River Valley and Michigan from 1970 to the mid-1980s (Dale et al. 2006). However, use of soil-applied herbicides declined to less than 5% of sugarbeet acres in North Dakota and Minnesota in the mid-1980s because of reliance on POST herbicides and inter-row cultivation (Luecke and Dexter 2003). Stachler and Luecke (2011) reported Ro-Neet, ethofumesate, or Eptam, applied either PPI or PRE, controlled glyphosate-resistant waterhemp; however, they added, sugarbeet growers are reluctant to incorporate herbicides due to detrimental effects of tillage on seed bed moisture and sugarbeet stand.

Sugarbeet growers apply ethofumesate at 3 to 6 pt/A, Dual Magnum at 0.5 to 1 pt/A, or ethofumesate mixed with Dual Magnum at 2 to 3 pt plus 0.5 to 0.75 pt/A, respectively, PRE. These options have provided early season residual control but need to be rainfall activated. Sugarbeet planting was delayed in 2022 and 2023 due to environmental conditions and spring rains have been inconsistent for activating ethofumesate. Thus, growers have opted to incorporate ethofumesate before planting to lessen risk. Incorporating ethofumesate has shifted the mindset and growers are once again asking if Ro-Neet and/or Eptam incorporated might provide more consistent early season waterhemp control than ethofumesate.

Objective

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

Materials and Methods

Experiment was conducted on natural waterhemp populations near Blomkest, MN in 2023. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was planted on May 22, 2023, seeded in 22-inch rows at 60,271 seeds per acre with 4.8 inch spacing between seeds. Herbicide treatments containing Ro-Neet, Eptam, and Ro-Neet + Eptam were two pass incorporated to a 3-inch depth. The first pass was tillage parallel with sugarbeet rows immediately following herbicide application. The second pass was at a shallow angle across the whole trial. Herbicide treatments and rates are described (Table 1). For reasons unknown, Ro-Neet and Eptam rates historically were presented as lb/A rather than pt/A (Table 2).

All treatments were applied with a bicycle sprayer in 17 gpa spray solution through 11002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 35 feet in length. Herbicides were immediately incorporated for each plot with the rows using a field cultivator set 3 inches deep. A second tillage pass was conducted across the entire trial at a 15-degree angle to the rows.

Table 1. Herbicide treatments, rates, and application timing, Blomkest, MN in 2023.

Herbicide treatment	Rate (pt/A)	Timing of Application
Ro-Neet / Roundup PowerMax3 + etho[a,b] /	4.5 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Ro-Neet/ Roundup PowerMax3 + etho /	5.33 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Eptam / Roundup PowerMax3 + etho /	2.29 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Eptam / Roundup PowerMax3 + etho /	2.85 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Ro-Neet+ Eptam / Roundup PowerMax3 + etho /	3.33 + 1.71 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Ro-Neet+ Eptam / Roundup PowerMax3 + etho /	2.67 + 2.29 / 25 + 6 /	PPI/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Ethofumesate / Roundup PowerMax3 + etho /	6 / 25 + 6 /	PRE/EPOST/
Roundup PowerMax3 + etho	25 + 6	POST
Etho + Dual Magnum[c] / Outlook + Roundup PowerMax3 + etho[c] /	2.5 + 0.75 / 12 + 25 + 6 /	PRE/EPOST/
Warrant + Roundup PowerMax3 + etho	3 + 25 + 6	POST
Ro-Neet+ Eptam + / Warrant + Roundup PowerMax3 + etho /	2.67 + 1.14 / 3 + 25 + 6 /	PPI/EPOST/
Warrant + Roundup PowerMax3 + etho	3 + 25 + 6	POST
Roundup PowerMax3 + etho /	25 + 6 /	EPOST/
Roundup PowerMax3 + Ultra Blazer + Warrant	25 + 16 + 3	POST

[a]Roundup PowerMax3 plus ethofumesate, Outlook, or Warrant POST applied with HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v.
[b]etho = ethofumesate.
[c]Roundup PowerMax3, Ultra Blazer, and Warrant POST applied with non-ionic surfactant at 0.25% v/v and Amsol Liquid AMS at 2.5% v/v.

Visible sugarbeet growth reduction injury was evaluated using a 0 to 100% scale (0% representing no visible injury and 100% as complete loss of plant / stand) approximately 7 and 14 days (+/- 3 days) after sugarbeet emergence and 7 and 14 days (+/- 3 days) after early POST (EPOST) application. The combination of two-pass incorporation and dry soils created some gaps in stands. Estimates of stand were collected to separate effects from herbicides and lack of stand associated with dry soils. Visible waterhemp control was evaluated using a 0 to 100% scale (0% indicating no control and 100% indicating complete weed control) 14 and 21 days (+/- 3 days) after PPI/PRE (application A/B) and 7, 14, 21, and 40 days and after EPOST/POST (application C/D). Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2023.5 software package.

Table 2. Eptam and Ro-Neet treatments expressed as pt/A and lb/A.

Treatment	Rate	
	---pt/A---	---lb/A---
Ro-Neet	4.50	3.4
Ro-Neet	5.33	4.0
Eptam	2.29	2.0
Eptam	2.85	2.5
Ro-Neet + Eptam	3.32 + 1.71	2.5 + 1.5
Ro-Neet + Eptam	2.67 + 2.29	2.0 + 2.0
Ro-Neet + Eptam	2.67 + 1.14	1.0 + 1.0
Ethofumesate	6	3.0

Results and Discussion
Sugarbeet growth reduction ranged from 13% to 50%, 16 days after application A (DAAA) and 3% to 20%, 32 DAAA (Table 3). We observed the greatest sugarbeet growth reduction from treatments with Eptam alone and Eptam mixed with Ro-Neet. Sugarbeet injury 24 or 32 DAAA was less than sugarbeet injury 16 DAAA. These results are consistent with Dr. Alan Dexter's observations that Eptam may reduce sugarbeet stands and cause reduced sugarbeet stands and temporary early season growth reduction, especially on coarse textured and low organic matter soils (personal communication).

We observed minor sugarbeet growth reduction with ethofumesate mixed with Dual Magnum, our standard lay-by program (Table 3). However, we attribute observed lack of uniformity in stand to lack of rainfall throughout the growing season. Weekly rainfall totals collected weekly after planting from on-site instrumentation are in Table 4.

Table 3. Sugarbeet growth reduction from herbicide treatments, Blomkest, MN in 2023.[a]

		Sugarbeet Growth Reduction		
Herbicide treatment	**Rate**	**16 DAAA[b]**	**24 DAAA**	**32 DAAA**
	-------pt/A-------	------------------------%------------------------		
Ro-Neet / RUPM3[c] / RUPM3	4.5 / 25 / 25	29 abc	8 abcd	3 a
Ro-Neet/ RUPM3 / RUPM3	5.33 / 25 / 25	25 ab	0 a	5 ab
Eptam / RUPM3 / RUPM3	2.29 / 25 / 25	50 d	10 bcd	14 bcd
Eptam / RUPM3 / RUPM3	2.85 / 25 / 25	48 d	14 cd	20 d
Ro-Neet + Eptam / RUPM3 / RUPM3	3.33 + 1.71 / 25 / 25	36 bcd	3 ab	13 bcd
Ro-Neet + Eptam / RUPM3 / RUPM3	2.67 + 2.29 / 25 / 25	40 bcd	15 d	13 bcd
Ethofumesate / RUPM3 / RUPM3	6 / 25 / 25	24 ab	0 a	5 ab
Ethofumesate + Dual Magnum / Outlook + RUPM3[d] / Warrant + RUPM3	2.5 + 0.75 / 12 + 25 / 3 + 25	13 a	10 bcd	10 abc
Ro-Neet + Eptam / Warrant + RUPM3 / Warrant + RUPM3	2.67 + 1.14 / 3 + 25 / 3 + 25	45 cd	13 cd	15 cd
RUPM3 + etho / RUPM3 + Ultra Blazer + Warrant[e]	25 / 25 + 16 + 3	18 a	6 abc	3 a
LSD (0.10)		**17**	**8**	**9**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]DAAA = Days after application A.
[c]RUPM3=Roundup PowerMax3. POST Roundup PowerMax3 applied with ethofumesate at 6 fl oz/A.
[d]Roundup PowerMax3 plus ethofumesate, Outlook, or Warrant POST applied with HSMOC and Amsol Liquid AMS at 1.5 pt/A + 2.5% v/v.
[e]Roundup PowerMax3, Ultra Blazer, and Warrant POST applied with non-ionic surfactant at 0.25% v/v and Amsol Liquid AMS at 2.5% v/v.

We evaluated sugarbeet stand using a 1 to 9 scale; 1 representing little to no stand and 9 representing a complete stand and sugarbeet canopy on a percent ground cover basis using a 0% to 100% scale in our attempt to discern sugarbeet injury caused by herbicide from stand variation caused by dry moisture conditions. Overall, sugarbeet stands averaged roughly 7, which is classified as a good stand (Table 4). Sugarbeet canopy tended to be less from Eptam alone or Eptam mixtures (Figure 1).

Table 4. Weekly rainfall measurements beginning May 22, 2023, Blomkest, MN.[a]

Week	Herbicide Application	Rainfall (inch)
1: May 22	PPI and PRE	0.0
2: May 29		0.2
3: June 5	2-lf sugarbeet stage	1.0
4: June 12		0.3
5: June 19	8-lf sugarbeet stage	0.7
6: June 26		0.0
7: July 3		0.6
8: July 10		1.0
9: July 17		0.0
	Cumulative total:	**3.8**

[a]Blomkest precipitation data collected using weather station instrumentation by Campbell Scientific, Inc., Logan, UT.

Waterhemp control from herbicide treatments was observed weekly between June 7 and July 31, 2023, or 15 to 69 days following planting and 0 to 53 days following the first postemergence glyphosate application. This summary will focus on waterhemp and common lambsquarters control 23, 31, and 52 days after planting, or 7, 15, and 36 days after the first postemergence application, when waterhemp control across treatments averaged 81%, 82%, and 66%, respectively (Table 5). Our sugarbeet standard for waterhemp control, ethofumesate followed by (fb) Outlook+ RUPM3+etho fb Warrant+RUPM3+etho applied at planting and at the sugarbeet 2- and 6-lf stage fell below the experiment averages. We attribute this to the lack of activating rainfall after planting. In general, waterhemp control was best from treatments containing Ro-Neet, Eptam or Ro-Neet mixed with Eptam, 7 and 15 DAAC. Waterhemp control was similar across treatments 36 DAAC.

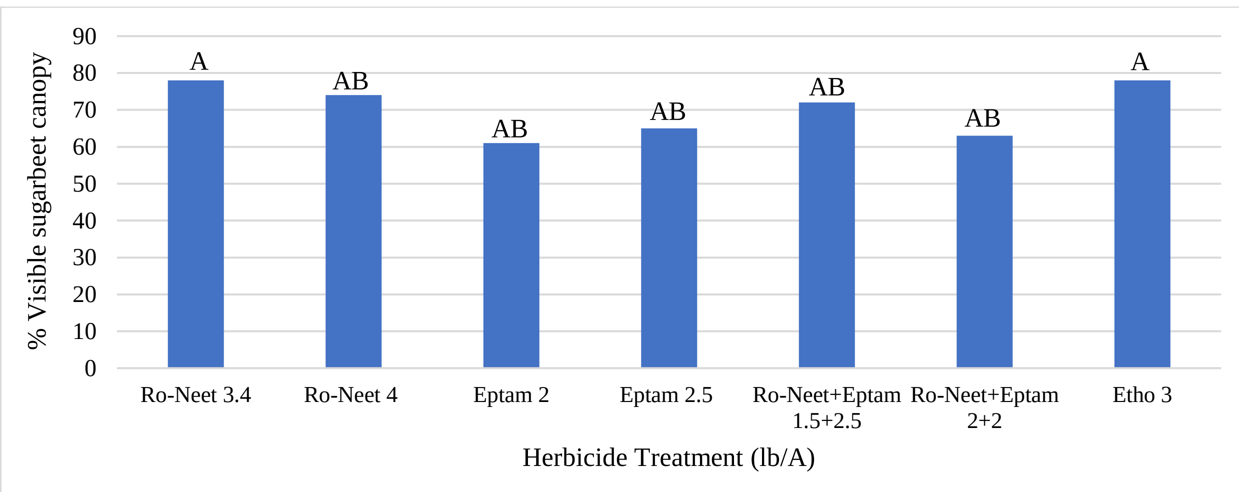

Figure 1. Sugarbeet canopy from selected treatments, 53 days after plant (DAP) or at canopy closure, Blomkest, 2023.

Treatment 9 was Ro-Neet + Eptam followed by Warrant at 3 pt/A applied at the 2-lf sugarbeet stage. Treatment 9 also contained glyphosate + ethofumesate applied at the 2- and 6-lf stage. Although it is difficult to observe benefits from the layby program in a dry year, we intend to continue to evaluate this concept in 2024.

We were able to evaluate common lambsquarters in the experiment; however, Roundup PowerMax3 provided complete control of all common lambsquarters in the POST applications.

Conclusions

We observed the greatest numeric waterhemp control from Eptam at 2.29 and 2.85 pt/A; however, these rates resulted in close to 50% growth reduction, 16 DAAA. Ethofumesate at planting followed by two times Roundup PowerMax3 and ethofumesate or ethofumesate followed by Outlook or Warrant with Roundup PowerMax3 and ethofumesate provided less waterhemp control compared with treatments containing Eptam, Ro-Neet, or both. We have stated ethofumesate probably did not provide at planting waterhemp control due to the dry conditions at and after planting. However, those are the conditions our growers planted into in 2023 and we need to develop reliable programs, regardless of environmental conditions. For the 2024 growing season, we intend to further evaluate Eptam and/or Ro-Neet mixed with ethofumesate to develop more consistent early season waterhemp control.

Table 5. Waterhemp control from herbicide treatments, Blomkest, MN in 2023.[a]

		Waterhemp Control		
Herbicide treatment	**Rate**	**7 DAAC[b]**	**15 DAAC**	**36 DAAC**
	----------pt/A----------	----------------------%----------------------		
Ro-Neet/ RUPM3[c] / RUPM3	4.5 / 25 / 25	89 a	88 a	68
Ro-Neet/ RUPM3 / RUPM3	5.33 / 25 / 25	79 bc	84 a	65
Eptam / RUPM3 / RUPM3	2.29 / 25 / 25	91 a	88 a	66
Eptam / RUPM3 / RUPM3	2.85 / 25 / 25	89 a	86 a	73
Ro-Neet+ Eptam / RUPM3 / RUPM3	3.33 + 1.71 / 25 / 25	90 a	89 a	68
Ro-Neet+ Eptam / RUPM3 / RUPM3	2.67 + 2.29 / 25 / 25	92 a	89 a	76
Ethofumesate / RUPM3 / RUPM3	6 / 25 / 25	63 d	63 b	49
Ethofumesate + Dual Magnum / Outlook + RUPM3[d] / Warrant + RUPM3	2.5 + 0.75 / 12 + 25 / 3 + 25	75 c	83 a	61
Ro-Neet+ Eptam / Warrant + RUPM3 / Warrant + RUPM3	2.67 + 1.14 / 3 + 25 / 3 + 25	85 ab	88 a	68
RUPM3 + etho / RUPM3 + Ultra Blazer + Warrant[e]	25 / 25 + 16 + 3	55 d	64 b	68
LSD (0.10)		**9**	**11**	**NS**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]DAAC = Days after application C.
[c]RUPM3=Roundup PowerMax3. POST Roundup PowerMax3 applied with ethofumesate at 6 fl oz/A.
[d]Roundup PowerMax3 plus ethofumesate, Outlook, or Warrant POST applied with HSMOC and Amsol Liquid AMS at 1.5 pt/A + 2.5% v/v.
[e]Roundup PowerMax3, Ultra Blazer, and Warrant POST applied with non-ionic surfactant at 0.25% v/v and Amsol Liquid AMS at 2.5% v/v.

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TOLERANCE AND WEED CONTROL FROM SPIN-AID IN SUGARBEET IN 2023

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Summary

1. No sugarbeet vegetative injury or yield component differences were observed across hybrids representing diverse sugarbeet genetics.
2. A single Spin-Aid application will not control kochia or common ragweed.
3. Apply ethofumesate PRE before Spin-Aid applications, especially for kochia control.
4. Time Spin-Aid applications according to weed size, rather than sugarbeet size. Spin-Aid at 16 fl oz/A plus ethofumesate on cotyledon to 2-lf sugarbeet followed by 24-32 fl oz/A Spin-Aid plus ethofumesate on 4- to 6-lf sugarbeet.

Introduction

Glyphosate resistant (GR) kochia is reemerging as an important weed management challenge in the Red River Valley and is spreading into west central Minnesota (Peters et al. 2022). We advise producers to grow crops (and select herbicides) that control kochia in the rotation since kochia seed is viable for up to two years (Dille et al. 2017). Wheat commonly grown before sugarbeet in the Red River Valley is competitive with kochia and enables use of herbicides enabling effective kochia control. However, adapting kochia biotypes and delayed spring planting has made kochia control challenging.

Growers lack effective herbicide options to control GR kochia in sugarbeet. Phenmedipham was registered in 1970 and sold under the trade name ‘Betanal’ from 1970 through 1981. Phenmedipham selectively controls small kochia by moving acropetally to the edges of leaves. Phenmedipham effectively controls kochia when applied in direct sunlight and when air temperatures are 70 F or greater.

Belchim Crop Protection USA markets phenmedipham using the trade name ‘Spin-Aid’ for control of broadleaf weeds POST on spinach and recently completed the acquisition of the sugarbeet registration from Bayer Crop Science. Belchim Crop Protection secured a 24 (c) local needs registration for Spin-Aid which provided Minnesota and North Dakota sugarbeet growers with a postemergence herbicide option for kochia and common lambsquarters control before the 2023 growing season.

Field and greenhouse experiments were conducted to determine how to best integrate Spin-Aid into a weed control program (Peters et al. 2023). Two-times Spin-Aid applications up to 32 fl oz/A partially controlled kochia less than 1-inch tall (Figure 1). Further, Spin-Aid use rate was determined by sugarbeet growth stage at timing of application. Finally, mixing Spin-Aid with ethofumesate seemed to improve kochia control as compared with Spin-Aid alone.

We learned from growers and academicians with previous experience with phenmedipham in sugarbeet. Betanal historically was applied as a single application or 2-times applications at up to 96 fl oz/A for kochia control. Sugarabeet injury was variety dependent and increased when ethofumesate was applied preemergence ahead of Betanal. The label and previous experience indicated improved control of common lambsquarters under moisture stress from Roundup PowerMax mixed with phenmedipham. The label also indicated phenmedipham might provide a second effective mode of action and mixture partner for common ragweed control with Stinger HL. Field experiments in 2023 and greenhouse experiments in 2023-24 were designed to fill in knowledge gaps.

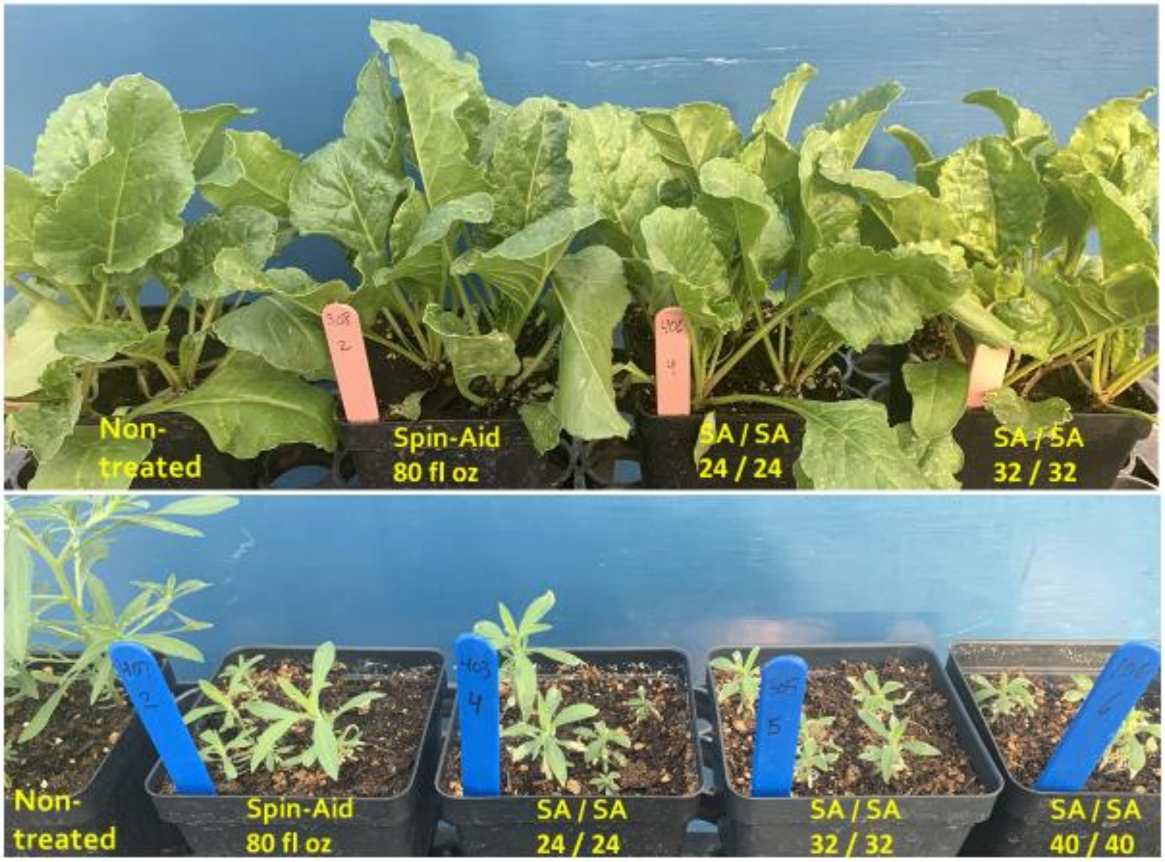

Figure 1. Sugarbeet tolerance or kochia control in response to Spin-Aid singly or repeat Spin-Aid applications after 7 days (sugarbeet) or after 6 days (kochia), greenhouse, 2023.

Objective

Determine selective kochia, common lambsquarters and common ragweed control from Spin-Aid alone, 2- or 3-times Spin-Aid applications, or Spin-Aid following ethofumesate applied PRE. Spin-Aid was applied singly or mixed with ethofumesate and/or Roundup PowerMax3.

Materials and Methods

Tolerance experiments. Sugarbeet tolerance experiments were conducted near Crookston, MN and Hickson, ND in 2023 to evaluate potential variety response from high rates of Spin-Aid. Primary tillage in the fall was followed by secondary tillage using a cultivator with rolling baskets to prepare the seedbed for sugarbeet planting at both locations. Fertilization followed local practices for sugarbeet. Sugarbeet was seeded in 22-inch rows at populations ranging from approximately 63,000 to 65,000 seeds per acre or approximately 4.5- to 4.4-inch spacing, respectively, between seeds. A soil residual herbicide was applied across the experimental area at both locations to control waterhemp. Treatments in Table 1 were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length. Weeds, insects and diseases were managed throughout the growing season.

Table 1. Sugarbeet hybrid and Spin-Aid rate at the 2- to 4-lf stage.

Factor A Sugarbeet Hybrid[a]	Factor B Spin-Aid rate (pt/A)[b]	Sugarbeet stage (lvs)
CR 137	PowerMax3/PowerMax3	2-4 /10 days
CR 793	4.5	2-4
CR 793	9	2-4
CR 130	4.5	2-4
CR 130	9	2-4
CR 137	4.5	2-4
CR 137	9	2-4

[a]Crystal Sugarbeet Seed
[b]Noble Methylated Seed Oil (MSO) at 1 pt/A with Spin-Aid or Prefer 90 NIS and Amsol liquid AMS at 0.25%+2.5% v/v with Spin-Aid or Roundup PowerMax3

Sugarbeet counts (middle 2 rows x 20' plot length) at 2- to 4-lf stage and preharvest and % visible necrosis and growth reduction injury (0 to 100% scale, 0 is no visible necrosis or growth reduction injury compared to a glyphosate control and 100% complete loss of plant / stand compared to the glyphosate control) were collected 7 days after 2-lf stage application and 3, 7, and 14 days after 2- to 4-lf stage application. Root yield, % sucrose, % purity, and recoverable sucrose were calculated after harvest.

Efficacy experiments. Weed control experiments were conducted near Manvel, ND and Beltrami, MN in 2023 to evaluate kochia, common ragweed, and common lambsquarters control in sugarbeet. Treatments are in Table 2. Experiments evaluated sugarbeet tolerance and efficacy from Spin-Aid plus ethofumesate either singly or two-times applications. Experiments near Manvel were prepared for planting and planted by our grower cooperator. The experimental area near Beltrami, MN was prepared for planting by applying the appropriate fertilizer and tillage. Sugarbeet was seeded in 22-inch rows at approximately 64,000 seeds per acre with 4.5 inch spacing between seeds. Dual Magnum at 1 pt/A was applied across the experimental area to control waterhemp. Treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length.

Sugarbeet growth reduction injury and kochia, common ragweed, and common lambsquaters control was evaluated approximately 7 and 14 days after treatment (DAT) with a 0 to 100% scale (0% denoting no sugarbeet injury or kochia, common ragweed, and common lambsquarters control and 100% denoting complete loss of sugarbeet stature/stand or kochia, common ragweed and lambsquaters control). All evaluations were a visible estimate of injury or control 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 in this report as a RCBD with the ANOVA procedure of ARM, version 2023.3 software package.

Table 1. Spin-Aid rate and weed species stage at application, 2023.

Herbicide treatment[a]	**Rate (fl oz/A)**	**Weed species stage (inch)**
Spin-Aid + etho[b]	16 + 4	<2
Spin-Aid + etho	24 + 4	<2
Spin-Aid + etho	32 + 4	<2
Spin-Aid + etho	48 + 5	<2
Spin-Aid + etho	72 + 8	<2
Spin-Aid + etho	96 + 11	<2
Spin-Aid + etho / Spin-Aid + etho	24 + 4 / 24 + 4	<2 + 7 days
Spin-Aid + etho / Spin-Aid + etho	32 + 4 / 32 + 4	<2 + 7 days
Spin-Aid + etho / Spin-Aid + etho	48 + 5 / 48 + 5	<2 + 7 days
Etho / Spin-Aid + etho	6 / 48 + 5	PRE/ 2
Etho / Spin-Aid + etho	6 / 96 + 11	PRE / 2

[a]Spin-Aid plus Noble methylated seed oil (MSO) at 1.25% v/v.
[b]Etho=ethofumesate.

Results and Discussion

Tolerance experiments. Betanal was used at rates up to 96 fl oz/A for kochia control in the 1970s. Extension Sugarbeet Agronomists observed varietal response from Betanal and suggested an experiment with hybrids representing germplasm diversity (personal communication with Drs. Dexter and Cattanach). Historical research with phenmedipham observed increased growth reduction amongst different sugarbeet varieties. Spin-Aid at 4.5 pt/A (72 fl oz) or 9.0 pt/A (144 fl oz/A) injured sugarbeet (Table 2). However, injury was not dependent on sugarbeet hybrid. Likewise, Spin-Aid rate did not influence yield components measured across diverse sugarbeet hybrids.

Table 2. Sugarbeet growth reduction and yield components in response to Spin-Aid and sugarbeet genetics, across two locations, 2023.

Factor A Sugarbeet Hybrid[a]	Factor B Spin-Aid rate[b]	Sugarbeet Growth Reduction				
		10 DAAA[c]	39 DAAA	Root Yield	Sucrose	Recoverable Sucrose
	-pt/A-	----------%----------		--TPA--	--%--	--lb/A--
CR 137	glyphosate	3	3	40.4	18.1	13,376
CR 137	4.5	31	7	37.2	17.8	12,208
CR 137	9	42	10	38.6	18.1	12,780
CR 793	4.5	28	11	38.7	17.7	12,838
CR 793	9	42	13	38.2	17.9	12,424
CR 130	4.5	24	5	40.0	18.1	13,337
CR 130	9	38	8	40.4	18.2	13,591
P-Value (0.05)		**0.0941**	**0.3462**	**0.1498**	**0.7457**	**0.1771**

[a]Crystal Sugarbeet Seed
[b]Spin-Aid applications applied with Noble (MSO) at 1.5 pt/A.
[c]DAAA= Days after application A.

Efficacy experiments. Sugarbeet injury ranged from 1% to 57%, 10 days after application C (DAAC) following Spin-Aid plus ethofumesate application at the 2-lf stage (Table 3). Sugarbeet injury was necrosis injury, sugarbeet stature reduction, and thinning of sugarbeet stand, especially at Spin-Aid rates in excess of 48 fl oz/A. Based on experience, sugarbeet injury greater than 35% likely will affect yield components. Two-times Spin-Aid and ethofumesate application at 24, 32, and 48 fl oz/A with ethofumesate at 4 fl oz/A did not or tended to not increase sugarbeet injury as compared with Spin-Aid and ethofumesate singly. Likewise, Spin-Aid following ethofumesate PRE did not cause additional sugarbeet injury, 10 DAAC.

Common lambsquarters control ranged from 42% to 95% and 25% to 96%, 10 and 20 DAAC, respectively (Table 3). Common lambsquarters control increased as Spin-Aid rate increased; however, common lambsquarters control was best when Spin-Aid was applied in repeat applications. Split Spin-Aid applications were the same Spin-Aid rate; however, were applied at the 2-lf sugarbeet stage plus 5-days in these experiments. We learned in the greenhouse that sugarbeet safety improves when Spin-Aid rate increases as sugarbeet stage increases (data not presented). The safe rate for cotyledon, 2-lf, and 4-lf sugarbeet is 16, 24, and 32 fl oz/A, respectively.

Table 3. Sugarbeet growth reduction and common lambsquarters control, 2023[a].

Herbicide treatment[b]	Rate	Sugarbeet Growth Reduction	Common Lambsquarters Control 10 DAAC[c]	20 DAAC
	--fl oz/A--	----------------------------------	%	----------------------------
Spin-Aid + etho	16 + 4	1 a	42 de	33 c
Spin-Aid + etho	24 + 4	5 ab	38 e	25 c
Spin-Aid + etho	32 + 4	23 bcd	60 cd	58 b
Spin-Aid + etho	48 + 5	22 bcd	69 bc	60 b
Spin-Aid + etho	72 + 8	57 f	89 ab	88 a
Spin-Aid + etho	96 + 11	55 f	94 a	95 a
Spin-Aid + etho / Spin-Aid + etho	24 + 4 / 24 + 4	33 cde	88 ab	93 a
Spin-Aid + etho / Spin-Aid + etho	32 + 4 / 32 + 4	30 cde	85 ab	84 a
Spin-Aid + etho / Spin-Aid + etho	48 + 5 / 48 + 5	40 def	95 a	96 a
Etho / Spin-Aid + etho	6 / 48 + 5	15 abc	71 bc	60 b
Etho / Spin-Aid + etho	6 / 96 + 11	45 ef	86 ab	81 a
P-Value (0.05)		**0.0005**	**0.0012**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]Spin-Aid applications applied with Noble (MSO) at 1.5 pt/A.
[c]DAAA= Days after application A.

Kochia control from Spin-Aid mixed with ethofumesate ranged from 30% to 90%, 10 DAAC (Table 4). Control tended to increase as Spin-Aid and ethofumesate rate increased, especially 20 DAAC. Kochia control was greatest or tended to be greatest from split Spin-Aid applications. We observed the greatest numeric control of kochia with ethofumesate PRE followed by a single Spin-Aid at 96 fl oz/A application (Table 4).

Table 4. Kochia and common ragweed control, 2023[a].

Herbicide treatment[b]	Rate	Kochia Control 10 DAAC[c]	Kochia Control 20 DAAC	Common Ragweed Control 10 DAAC	Common Ragweed Control 20 DAAC
	--fl oz/A--	-----------------------------------	%	-----------------------------------	
Spin-Aid + etho	16 + 4	40 cde	30 c	8 c	5 e
Spin-Aid + etho	24 + 4	30 e	15 c	18 c	0 e
Spin-Aid + etho	32 + 4	33 de	68 a	18 c	5 e
Spin-Aid + etho	48 + 5	71 abcd	63 ab	15 c	28 d
Spin-Aid + etho	72 + 8	73 abc	72 a	43 b	40 cd
Spin-Aid + etho	96 + 11	65 abcd	70 a	60 ab	58 abc
Spin-Aid + etho / Spin-Aid + etho	24 + 4 / 24 + 4	74 abc	83 a	58 ab	50 bc
Spin-Aid + etho / Spin-Aid + etho	32 + 4 / 32 + 4	80 ab	75 a	70 a	65 ab
Spin-Aid + etho / Spin-Aid + etho	48 + 5 / 48 + 5	90 a	78 a	68 a	74 a
Etho / Spin-Aid + etho	6 / 48 + 5	58 bcde	33 bc	.[d]	.
Etho / Spin-Aid + etho	6 / 96 + 11	88 a	80 a	.	.
P-Value (0.05)		**0.0027**	**0.0008**	**<0.0001**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]Spin-Aid applications applied with Noble (MSO) at 1.5 pt/A.
[c]DAAA= Days after application A.
[d]Data missing. This experiment was implemented later in the season, so we were unable to evaluate ethofumesate PRE.

The 1980 Sugarbeet Production Guide lists Betanal as providing fair to good control on common ragweed. Control was improved when ethofumesate was mixed with Betanal. We observed similar common ragweed control in the field; common ragweed control ranging from 0% to 74%, 20 DAAC. Common ragweed control increased as Spin-Aid rate increased, similar to common lambsquarters and kochia control. We observed greatest common ragweed control from split Spin-Aid applications, especially Spin-Aid at 32 to 48 fl oz/A plus ethofumesate.

Greenhouse research with Spin-Aid continues and has focused on one-, two-, or three-times Spin-Aid + ethofumesate applications for kochia control, starting on 5-lf kochia, less than 1-inch in diameter (we call it dime size) and cotyledon to 2-lf sugarbeet. It will be paramount that our producers target small kochia. Spin-Aid translocates acropetally from the targeted leaves to leaf margins but movement is greater in common lambsquarters and wild mustard than kochia or common ragweed (Hendrick et al. 1974). Conditions at application affect Spin-Aid selective control; activity is less during cool temperatures and low light conditions as compared with warm temperature and direct sunlight conditions (Abbaspoor and Streibig 2007). Risk of injury is increased by temperatures over 80 F and sudden changes from a cool, cloudy environment to a hot, sunny environment (Betamix Best Management Practices (BMPs)). Applications in late afternoon/early evening, when temperatures are decreasing improves sugarbeet safety (Betamix BMPs).

Further investigation suggests Spin-Aid applied three times may improve kochia control as compared with Spin-Aid applied 2-times (Figure 2). In the greenhouse, Spin-Aid at 16 fl oz/A plus ethofumesate at 4 fl oz/A on cotelydon sugarbeet followed by Spin-Aid at 24 fl oz/A plus ethofumesate at 4 fl oz/A, 5 days after application A (DAAA) followed by Spin-Aid at 32 fl oz/A plus ethofumesate at 4 fl oz/A, 5 days after application B (DAAB) provided 80% kochia control. Control was greater when Spin-Aid was applied at 32 or 40 fl oz/A the second or third application, respectively. Our greenhouse experiments were conducted with Spin-Aid and ethofumesate plus an MSO adjuvant. We recommend Roundup PowerMax3 integrated into the treatment the first (application A) and third (application C) applications to increase control. Further experiments will explore Spin-Aid mixed with Stinger HL for common ragweed control.

Figure 2. Selective control from Spin-Aid + ethofumesate in a 3-spray program, greenhouse, 2024.

Conclusion

Target kochia less than 1-inch tall kochia (dime size). Align Spin-Aid rate to sugarbeet growth stage, especially if kochia has emerged. Plan for repeat Spin-aid applications on 5-day intervals for GR kochia control. Account for ethofumesate applied PRE in POST program (Table 5).

Table 5. Kochia control in sugarbeet.

Sugarbeet Stage (leaf stage)	Alone Spin-Aid + ethofumesate (fl oz/A)	Following soil residual herbicide Spin-Aid + ethofumesate (fl oz/A)
Cotyledon	16 + 4	12 + 4
2 lf	24 + 4	16 + 4
4-lf	32 + 4	24 + 4
6-lf	40 + 4	32 + 4

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SUMMARY OF ULTRA BLAZER APPLIED IN SUGARBEET

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Summary
1. Environmental conditions at application and adjuvants influence sugarbeet tolerance and waterhemp control from Ultra Blazer.
2. Glyphosate (Roundup PowerMax/Roundup PowerMax3) mixed with Ultra Blazer consistently has improved waterhemp control from Ultra Blazer.
3. Roundup PowerMax3 mixed with Ultra Blazer increased necrosis and sugarbeet growth reduction injury and reduced root yield and recoverable sucrose as compared with Ultra Blazer alone.
4. Nozzle selection and 20 gpa spray volume improved waterhemp control, theoretically, by improving coverage.
5. Control escape waterhemp less than 4-inches tall with Ultra Blazer at 16 fl oz/A with NIS; control 'train-wreck' situations with Roundup PowerMax3 mixed with Ultra Blazer and AMS.

Introduction
I remember asking Dr. Dexter, Professor Emeritus and retired Extension Sugarbeet and Weed Control Specialist from 1969 to 2007, if he had any regrets; ideas he never got around to pursuing. Alan immediately replied that he wished he would have spent more time investigating Ultra Blazer in sugarbeet. I took that hint and invested seven years pursuing use of Ultra Blazer in sugarbeet. This will be our final report.

The first experiments were proof of concept; exploring sugarbeet injury from Ultra Blazer. We found that environment was important. Ultra Blazer was more active during hot and humid environments as compared with cooler or drier air. However, we learned that we could avoid the effects of environment by applying Ultra Blazer to sugarbeet greater than the 6-lf stage. Ms. Emma Burt's Master of Science thesis work focused on Ultra Blazer alone and with adjuvants and Ultra Blazer mixed with Roundup PowerMax and/or Stinger. We found that petroleum or vegetable oil-based adjuvants increased sugarbeet injury and waterhemp control. Sugarbeet injury was greater when Ultra Blazer was mixed with HSMOC (high surfactant methylated seed oil), MSO (methylated oil concentrate), or COC (crop oil concentrate) than with NIS (non-ionic surfactant). We also found sugarbeet injury from Ultra Blazer mixed with Roundup PowerMax was greater than from either Ultra Blazer or Roundup PowerMax alone. Sugarbeet injury was attributed to the formulated surfactant with glyphosate, not the salt of glyphosate. Further, adding Ultra Blazer with glyphosate and either *S*-metolachlor or Outlook, applied at the 6- to 8-lf sugarbeet stage in the layby program application, caused unacceptable injury. Finally, our original experiments were Ultra Blazer tank mixed with Roundup PowerMax. We believe Roundup PowerMax3 mixed with Ultra Blazer causes more sugarbeet injury than the Roundup PowerMax formulation mixed with Ultra Blazer.

Ultra Blazer was applied to approximately 80,000 acres in 2021 and 2022 to control escape waterhemp. The primary concern from producers was regrowth to waterhemp, especially when sugarbeet leaves partially covered waterhemp. Experiments in 2022 and 2023 were designed to improve waterhemp control by increasing either carrier volume or through nozzle selection to improve spray coverage. Second, in an effort to find the appropriate balance between efficacy and tolerance, we evaluated applying Ultra Blazer at 12 fl oz/A in a split application, Ultra Blazer at 16 fl oz/A with COC, or mixing Ultra Blazer plus Roundup PowerMax3 with Warrant as a safener. This report summarizes sugarbeet tolerance and waterhemp control experiments conducted in 2022 and 2023.

Materials and Methods
Sugarbeet tolerance experiments were conducted near Crookston, Hendrum, Kent, Lake Lillian, and Murdock, MN in 2023. Waterhemp efficacy experiments were conducted near Moorhead and Blomkest, MN. 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. We had started the Moorhead experiment in a sugarbeet area; however, due to challenges with waterhemp emergence and sugarbeet size, we moved the Moorhead experiment into a bulk fill soybean area to be consistent with waterhemp size at application.

Treatments shown in Table 1 were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length. Environmental conditions at application are in Table 2 and 3.

Table 1. Herbicide treatment, herbicide rate, and application timing across locations in 2023.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	6-8 lf
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	6-8 lf / A + 3-days
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	2 lf / 6 lf

Table 2. Application information for tolerance experiments.

	Crookston	Hendrum	Kent	Murdock	Lake Lillian
Plant Date	May 5	May 16	May 17	May 9	May 4
Application Date	June 8	June 15	June 21	June 9	June 6
Time of Day	10:30 AM	10:00 AM	6:00 PM	12:30 PM	8:00 AM
Air Temperature (F)	72	73	86	73	61
Relative Humidity (%)	56	62	43	57	83
Wind Velocity (mph)	8	3	8	7	6
Wind Direction	SSE	NE	NW	SW	E
Soil Temp. (F at 6”)	70	66	-	-	-
Soil Moisture	Good	Fair	-	-	-
Cloud Cover (%)	50	100	-	-	-

Table 3. Application information for efficacy experiments.

	Moorhead	Blomkest
Plant Date	May 24	May 22
Application Date	July 5	June 23
Time of Day	7:00 AM	7:00 AM
Air Temperature (F)	67	66
Relative Humidity (%)	43	94
Wind Velocity (mph)	2	2
Wind Direction	-	-
Soil Temp. (F at 6”)	70	70
Soil Moisture	Good	-
Cloud Cover (%)	90	20

Visible sugarbeet necrosis, malformation, and growth reduction were evaluated approximately 7 and 14 days after treatment (DAT) as sugarbeet injury using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. Visible weed control was evaluated 7, 14, and 21 days after the 2-lf stage application using a 0 to 100 scale (0 is no control and 100 is complete control). All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared with the adjacent untreated strip.

At harvest for tolerance experiments, sugarbeet was defoliated, harvested mechanically from the center two rows of each plot, and weighed. A root sample (about 20 lbs) was collected from each plot and analyzed for sucrose content and sugar loss to molasses by American Crystal Sugar Company (East Grand Forks, MN). Experimental design was randomized complete block with six replications. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2023.3 software package.

Results

Tolerance and Yield Components. Sugarbeet necrosis injury was evaluated as the percent of sugarbeet leaf area that was bronzed from Ultra Blazer application. All Ultra Blazer treatments caused necrosis injury; however, necrosis injury was greatest from Ultra Blazer at 16 fl oz/A plus crop oil concentrate (COC) at 1.25% v/v and was consistent across locations (Table 4). Similarly, an application of Roundup PowerMax3 mixed with Ultra Blazer plus AMS increased necrosis injury as compared with Ultra Blazer alone. Repeat Ultra Blazer applications of 12 fl oz/A followed by (fb) 12 fl oz/A gave slightly less necrosis injury than Ultra Blazer at 16 fl oz/A; however, the repeat Ultra Blazer application extended the duration of necrosis injury as compared with a single application.

Table 4. Sugarbeet visible injury from herbicide treatments, across locations, 2023.[a]

		Necrosis[b]	Sugarbeet Growth Reduction		
Herbicide Treatment	**Rate**	**3 DAAC[c]**	**3 DAAC**	**10 DAAC**	**20 DAAC**
	-----fl oz/A-----	---------------	---------------%	---------------	---------------
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	26 bc	25 b	22 b	13 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	21 b	22 b	33 bc	23 bc
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	49 d	43 c	46 d	34 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	48 d	44 c	43 cd	32 c
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	35 c	29 b	28 b	18 b
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	1 a	4 a	2 a	3 a
P-Value (0.05)		**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b] Nec. = Visual necrosis.
[c]DAAC = Days after application C.

Necrosis injury from Warrant mixed with Ultra Blazer, Roundup PowerMax3, and liquid AMS was less than injury from Ultra Blazer plus Roundup PowerMax3 and liquid AMS (Table 4). Sugarbeet necrosis and growth reduction injury from adding Warrant to Ultra Blazer and Roundup PowerMax3 was similar to the Ultra Blazer at 16 fl oz/A plus NIS standard treatment, across locations.

Sugarbeet growth reduction injury across treatments averaged 28%, 29%, and 21%, 3, 10, and 20 DAAC, respectively (Table 4). As with necrosis, growth reduction injury was greatest when COC or Roundup PowerMax3 with liquid AMS was mixed with Ultra Blazer. Sugarbeet growth reduction injury from Ultra Blazer at 16 fl oz/A with NIS was similar to sugarbeet injury from 2-times Roundup PowerMax3 applications with NIS and liquid AMS. Two-times Ultra Blazer application at 12 fl oz/A with NIS gave growth reduction injury similar to Ultra Blazer at 16 fl oz/A with NIS; however, injury was greater than injury from the Roundup PowerMax3 control.

Root yield, % sucrose, and recoverable sucrose from Ultra Blazer at 16 fl oz/A plus NIS were the same as two applications of glyphosate alone (Table 5). Root yield and % sucrose from two applications of Ultra Blazer at 12 fl oz/A with NIS were the same as Ultra Blazer at 16 fl oz/A. However, recoverable sucrose from two applications of Ultra Blazer applications at 12 fl oz/A was less than a single application of Ultra Blazer at 16 fl oz/A.

Warrant mixed with Ultra Blazer, Roundup PowerMax3, and liquid AMS appeared to reduce sugarbeet vegetative injury and yield components as compared with Ultra Blazer mixed with Roundup PowerMax3 and liquid AMS. This is consistent from results in Michigan (personal communication with Dr. Christy Sprague).

Table 5. Sugarbeet root yield, % sucrose, and recoverable sucrose in response to herbicide treatment across locations, 2023.[a]

Herbicide Treatment	Rate	Root Yield	Sucrose	Recoverable Sucrose
	-----fl oz/A-----	-Ton/A-	--%--	---lb/A---
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	35.5 ab	17.7	11,180 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	34.2 bc	17.7	10,611 c
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	33.3 c	17.7	10,417 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	33.3 c	17.8	10,430 c
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	34.9 bc	17.5	10,737 bc
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	37 a	17.8	11,639 a
P-Value (0.05)		**0.001**	**NS**	**0.001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.

Waterhemp Control. The waterhemp control experiment at Moorhead was terminated and reestablished in soybean. The efficacy experiment was in sugarbeet at Blomkest. Thus, we elected to consider each experiment singly due to the difference in crop species between the two experiments.

Waterhemp control ranged from 40 to 88% at Moorhead, MN and 68 to 93% at Blomkest, MN, 14 DAAC (Table 6). Waterhemp control was or tended to be best when Ultra Blazer was tank mixed with Roundup PowerMax3 plus AMS across locations and evaluations. These results are consistent with results from Ms. Emma Burt's Master of Science research and other results previously communicated. Ultra Blazer plus COC provided or tended to provide waterhemp control similar to Ultra Blazer mixed with Roundup PowerMax3 across locations and evaluations. Two applications of Ultra Blazer at 12 fl oz/A gave better waterhemp control at Blomkest than Moorhead. Conversely, Ultra Blazer plus Roundup PowerMax3 and Warrant plus AMS gave better control at Moorhead than Blomkest.

Table 6. Waterhemp control 7 and 14 days after herbicide treatments, two locations, 2023.[a]

		Waterhemp Control			
		Moorhead		**Blomkest**	
Herbicide Treatment	**Rate**	**7 DAAC[b]**	**14 DAAC**	**7 DAAC**	**14 DAAC**
	-----fl oz/A-----	-----%			-----
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	71 b	61 c	79 abc	81 abc
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	74 b	71 c	84 ab	89 ab
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	83 ab	73 bc	88 ab	81 abc
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	91 a	85 ab	93 a	93 a
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	89 a	88 a	75 bc	73 bc
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	43 c	40 d	69 c	68 c
P-Value (0.05)		**<0.0001**	**<0.0001**	**0.0383**	**0.0472**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAAC = Days after application C.

A repeat application of Ultra Blazer at 12 fl oz/A plus NIS gave waterhemp control similar to a single Ultra Blazer application at 16 fl oz/A plus NIS.

Roundup PowerMax3 provided excellent common lambsquarters control whereas Ultra Blazer provided little or no common lambsquarters control (Table 7). We did not observe any antagonism with common lambsquarters when Ultra Blazer and Warrant were tank mixed with glyphosate.

Table 7. Common lambsquarters control 7 and 14 days after herbicide treatments, Moorhead, MN, 2023.[a]

		Common Lambsquarters Control	
Herbicide Treatment	**Rate**	**7 DAAC[b]**	**14 DAAC**
	-----fl oz/A-----	------------------------%	----------------------
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	3 d	0 e
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	35 b	10 d
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	23 c	23 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	99 a	94 b
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	99 a	97 ab
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	98 a	98 a
P-Value (0.05)		**<0.0001**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAAC = Days after application C.

Conclusion

The 2023 (and 2022) Ultra Blazer experiments were designed to determine if sugarbeet injury in response to Ultra Blazer could be reduced, while maintaining or improving waterhemp control through improved water volume, spray nozzle selection, adjuvants or herbicide mixtures. Unfortunately, there is no ‘silver bullet’ with Ultra Blazer. COC mixed with Ultra Blazer increased vegetative sugarbeet injury and reduced root yield while providing only a modest improvement in waterehemp control. Repeat Ultra Blazer applications extended the length of time with visual necrosis with only a modest improvement in waterhemp control. Mixing Warrant with Ultra Blazer, Roundup PowerMax3, and AMS reduced sugarbeet injury but waterhemp control was inconsistent across locations. We have not investigated glyphosate formulations with adjuvants different from Roundup PowerMax3. Once again, improving sugarbeet safety likely results in less waterhemp control. At this time, I am hesitant to recommend Warrant mixtures with Ultra Blazer and Roundup PowerMax3. Warrant, a chloroacetamide herbicide, is a very important component to our waterhemp control strategy. Suggesting Warrant can be used to safen sugarbeet injury from Ultra Blazer and Roundup PowerMax3 seems to send a confusing message. Likewise, the weed control results from Warrant mixtures with Ultra Blazer and Roundup PowerMax3 were inconsistent.

We recommend applying single Ultra Blazer applications at 16 fl oz/A plus NIS for waterhemp control with XR TeeJet, Turbo TeeJet, or Turbo TwinJet nozzles in 20 gpa water carrier (Table 8). Waterhemp should be less than 4-inches tall to optimize control. Ultra Blazer mixtures with Roundup PowerMax3 may be used in situations with significant waterhemp control challenges. We recommend ammonium sulfate with Roundup PowerMax3 and Ultra Blazer but no additional surfactant. As with Ultra Blazer alone, optimize spray quality to deliver good spray coverage.

Table 8. Sugarbeet necrosis, growth reduction, and waterhemp control in response to spray nozzle and water carrier volume, Moorhead, MN, 2022.

Spray Nozzle[a]	Necrosis[b]		Growth Reduction[b]		Waterhemp Control[c]	
	15 GPA	20 GPA	15 GPA	20 GPA	15 GPA	20 GPA
XR TeeJet	33 abc	38 ab	19 a	20 a	60 c	80 a
AIXR	23 c	23 c	8 c	8 c	64 c	68 c
Turbo TeeJet	28 bc	30 bc	15 ab	13 bc	69 bc	78 ab
Turbo TwinJet	26 c	43 a	10 bc	19 a	83 a	81 a
P-Value (0.20)	0.1781		0.0324		0.0357	

[a]TeeJet.
[b]Necrosis and growth reduction, 13 DAT.
[c]Waterhemp control, 41 DAT.

ULTRA BLAZER SECTION 18 EMERGENCY EXEMPTION IN MINNESOTA AND NORTH DAKOTA AND RELATED EXPERIMENTS IN 2023

Thomas Peters[1], Emma Burt[2], Alexa Lystad[3], and David Mettler[4]

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Summary

1. Glyphosate (Roundup PowerMax/Roundup PowerMax3) mixed with Ultra Blazer consistently improves waterhemp control from Ultra Blazer.
2. Roundup PowerMax3 mixed with Ultra Blazer increased necrosis and sugarbeet growth reduction injury and reduced root yield and recoverable sucrose as compared with Ultra Blazer alone.
3. Control escaped waterhemp less than 4-inches tall with Ultra Blazer at 16 fl oz/A with NIS; control ‘train-wreck’ situations with Roundup PowerMax3 mixed with Ultra Blazer and AMS.
4. Ninety-four percent of respondents indicated the emergency exemption was beneficial for sugarbeet producers in Minnesota and North Dakota and contributed to overall weed management in 2023.
5. Ninety-one percent of respondents indicated they would willingly support application for a 2024 emergency exemption in sugarbeet.

Introduction

The Environmental Protection Agency (EPA) approved our request for a Section 18 emergency exemption for Ultra Blazer (acifluorfen) which provided Minnesota and eastern North Dakota sugarbeet growers a postemergence herbicide to control glyphosate-resistant waterhemp in sugarbeet in 2023. Delayed melt of snow pack, especially in fields adjacent to shelter belts, pushed back sugarbeet plant. Further, rainfall to activate preemergence herbicides was variable. Finally, above normal maximum daily air temperatures combined with dry conditions caused inconsistent sugarbeet stands in both Minnesota and eastern North Dakota. The average plant date was May 13, May 6, and May 8 for American Crystal Sugar Cooperative (ACS), Minn-Dak Farmers’ Cooperative (MDFC), and Southern Minnesota Beet Sugar Cooperative (SMBSC) growers, respectively. With the discontinuance of Betamix, there are currently no registered POST herbicides for effective waterhemp control that escapes soil-residual herbicide treatments.

The exemption allowed a single Ultra Blazer application at 16 fluid ounces (fl oz) per acre per year. A Section 18 exemption under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) authorizes EPA to allow an unregistered use of a pesticide for a limited time if EPA determines that an emergency condition exists. This paper summarizes the Ultra Blazer Section 18 emergency exemption including application parameters and results of a survey completed by agriculturalists and/or sugarbeet growers who applied Ultra Blazer. This report contains three 2022 program objectives: a) summarize results and user experiences from the 2023 Section 18 emergency exemption for use of Ultra Blazer in sugarbeet; b) summarize the crop tolerance yield experiment conducted at multiple locations; and c) summarize waterhemp control at multiple locations.

Materials and Methods

Section 18 Emergency Exemption

Ultra Blazer was applied at 16 fl oz/A with non-ionic surfactant (NIS) or mixed with glyphosate and ammonium sulfate (AMS). One Ultra Blazer application was made per season using ground application equipment at 20 to 30 gpa water carrier targeting waterhemp less than 4-inches tall and sugarbeet greater than the 6-lf stage. Pre-harvest interval (PHI) was 45 days and Ultra Blazer was applied from May 22 through July 28, 2022.

Application of Ultra Blazer was targeted to air temperatures less than 85F to reduce injury in sugarbeet. Likewise, producers were informed that sugarbeet injury may be greater following sudden changes from a cool, cloudy environment to a hot, sunny environment. On days when air temperature was greater than 85F, we recommended delaying application until late afternoon or early evening or when air temperatures began to decrease.

Producers and agriculturalists at Southern Minnesota Beet Sugar Coop, Minn-Dak Farmers Coop, and American Crystal Sugar Coop were surveyed by electronic mail to learn about producer experiences with Ultra Blazer (Appendix).

Ultra Blazer Tolerance Yield and Waterhemp Control Experiments.
Sugarbeet tolerance experiments were conducted near Crookston, Hendrum, Kent, Lake Lillian, and Murdock, MN in 2023. Waterhemp efficacy experiments were conducted near Moorhead and Blomkest, MN. 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. We had started the Moorhead experiment in a sugarbeet area; however, due to challenges with waterhemp emergence and sugarbeet size, we moved the Moorhead experiment into a bulk fill soybean area to be consistent with waterhemp size at application.

Treatments shown in Table 1 were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 35 psi to the center four rows of six row plots 40 feet in length. Environmental conditions at application are in Table 2 and 3.

Table 1. Herbicide treatment, herbicide rate, and application timing across locations in 2023.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	6-8 lf
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	6-8 lf / A + 3-days
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	2 lf / 6 lf

Table 2. Application information for tolerance experiments.

	Crookston	Hendrum	Kent	Murdock	Lake Lillian
Plant Date	May 5	May 16	May 17	May 9	May 4
Application Date	June 8	June 15	June 21	June 9	June 6
Time of Day	10:30 AM	10:00 AM	6:00 PM	12:30 PM	8:00 AM
Air Temperature (F)	72	73	86	73	61
Relative Humidity (%)	56	62	43	57	83
Wind Velocity (mph)	8	3	8	7	6
Wind Direction	SSE	NE	NW	SW	E
Soil Temp. (F at 6”)	70	66	-	-	-
Soil Moisture	Good	Fair	-	-	-
Cloud Cover (%)	50	100	-	-	-

Table 3. Application information for efficacy experiments.

	Moorhead	Blomkest
Plant Date	May 24	May 22
Application Date	July 5	June 23
Time of Day	7:00 AM	7:00 AM
Air Temperature (F)	67	66
Relative Humidity (%)	43	94
Wind Velocity (mph)	2	2
Wind Direction	-	-
Soil Temp. (F at 6”)	70	70
Soil Moisture	Good	-
Cloud Cover (%)	90	20

Visible sugarbeet necrosis, malformation, and growth reduction were evaluated approximately 7 and 14 days after treatment (DAT) as sugarbeet injury using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. Visible weed control was evaluated 7, 14, and 21 days after the 2-lf stage application using a 0 to 100 scale (0 is no control and 100 is complete control). All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared with the adjacent untreated strip.

At harvest for tolerance experiments, sugarbeet was defoliated, harvested mechanically from the center two rows of each plot, and weighed. A root sample (about 20 lbs) was collected from each plot and analyzed for sucrose content and sugar loss to molasses by American Crystal Sugar Company (East Grand Forks, MN). Experimental design was randomized complete block with six replications. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2023.3 software package.

Results

Section 18 Emergency Exemption

According to a survey of sugarbeet growers and agriculturalists, Ultra Blazer at 16 fl oz/A was applied to 19,458 sugarbeet acres in 2023 (totaling 2,432.3 gallons of Ultra Blazer). Seventy-nine percent or 16,212 acres were applied in Minnesota and 21% or 4,246 acres were applied in North Dakota (Tables 4 and 5).

Table 4. Sugarbeet acres sprayed with Ultra Blazer and Ultra Blazer product usage by state.

State	Acres treated	Ultra Blazer	Acifluorfen
		---gallon---	---pound---
Minnesota	16,212	2,026.5	4,053
North Dakota	4,246	530.8	1,061.6
Total	20,458	2,557.3	5,114.6

Table 5. Sugarbeet acres sprayed with Ultra Blazer and Ultra Blazer product usage by cooperative.

Cooperative	Acres treated	Ultra Blazer	Acifluorfen
		---gallon---	---pound---
ACSC	4,732	591.5	1183
MDFC	9,750	1,18.8	2437.5
SMBSC	5,976	747	1494
Total	20,458	2557.3	5,114.5

Three observations standout from overseeing the emergency exemption and summarizing observations and agriculturist/producer critiques. First, our producers understand Ultra Blazer is a tool we would prefer not to use. Many agriculturists stated Ultra Blazer does not fix our problem; however, it is a necessary tool in emergency situations. Second, Ultra Blazer consistently causes sugarbeet injury and only provides 65% to 80% control (Figure 2). Waterhemp control is strongly influenced by environmental conditions at application and by spray quality or the selection of spray nozzles and carrier volume. Finally, Roundup PowerMax3 mixed with Ultra Blazer caused more sugarbeet injury than with Roundup PowerMax. The restriction of applying Ultra Blazer with Roundup PowerMax3 likely limited the number of growers who utilized this escaped weed control method.

Injury Scale:	
1	None (0-15%)
2	Slight (15-30%)
3	Moderate (30-50%)
4	Severe (50-70%)

Control Scale:	
1	Excellent (90-99%)
2	Good (80-90%)
3	Fair (65-80%)
4	Poor (40-65%)

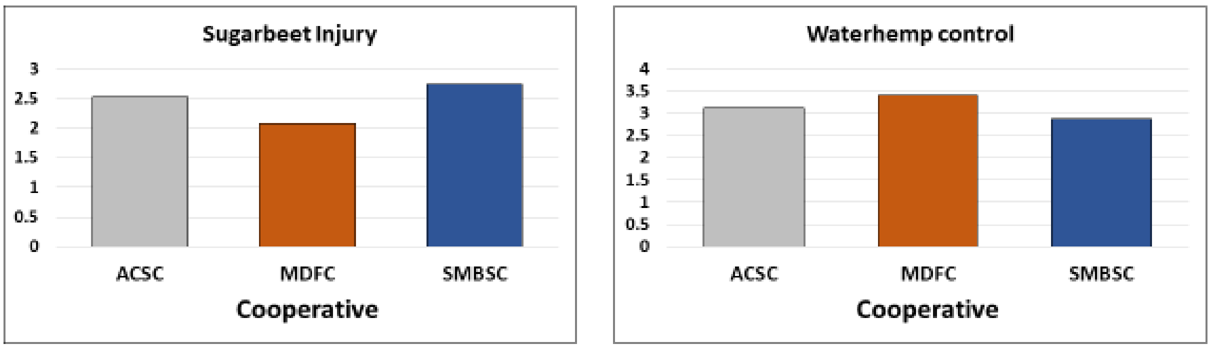

Figure 2. Producer and Agriculturalist survey of sugarbeet injury and waterhemp control from Ultra Blazer Section 18 EE, Minnesota and North Dakota, 2023.

Producers and agriculturalists surveyed reported the Section 18 EE was beneficial for sugarbeet growers and have encouraged Extension Sugarbeet to file for a Section 18 EE in 2024 and to urge UPL NA Inc. to continue towards Section 3 approval for Ultra Blazer in sugarbeet.

Ultra Blazer Tolerance Yield and Waterhemp Control Experiments
<u>Tolerance Yield Experiment.</u> Sugarbeet necrosis injury was evaluated as the percent of sugarbeet leaf area that was bronzed from Ultra Blazer application. All Ultra Blazer treatments caused necrosis injury; however, necrosis injury was greatest from Ultra Blazer at 16 fl oz/A plus crop oil concentrate (COC) at 1.25% v/v and was consistent across locations (Table 6). Similarly, an application of Roundup PowerMax3 mixed with Ultra Blazer plus AMS increased necrosis injury as compared with Ultra Blazer alone. Repeat Ultra Blazer applications of 12 fl oz/A followed by (fb) 12 fl oz/A gave slightly less necrosis injury than Ultra Blazer at 16 fl oz/A; however, the repeat Ultra Blazer application extended the duration of necrosis injury as compared with a single application.

Necrosis injury from Warrant mixed with Ultra Blazer, Roundup PowerMax3, and liquid AMS was less than injury from Ultra Blazer plus Roundup PowerMax3 and liquid AMS (Table 4). Sugarbeet necrosis and growth reduction injury from adding Warrant to Ultra Blazer and Roundup PowerMax3 was similar to the Ultra Blazer at 16 fl oz/A plus NIS standard treatment, across locations.

Sugarbeet growth reduction injury across treatments averaged 28%, 29%, and 21%, 3, 10, and 20 DAAC, respectively (Table 6). As with necrosis, growth reduction injury was greatest when COC or Roundup PowerMax3 with liquid AMS was mixed with Ultra Blazer. Sugarbeet growth reduction injury from Ultra Blazer at 16 fl oz/A with NIS was similar to sugarbeet injury from 2-times Roundup PowerMax3 applications with NIS and liquid AMS. Two-times Ultra Blazer application at 12 fl oz/A with NIS gave growth reduction injury similar to Ultra Blazer at 16 fl oz/A with NIS; however, injury was greater than injury from the Roundup PowerMax3 control.

Table 6. Sugarbeet visible injury from herbicide treatments, across locations, 2023.[a]

Herbicide Treatment	Rate	Necrosis[b] 3 DAAC[c]	Sugarbeet Growth Reduction 3 DAAC	10 DAAC	20 DAAC
	-----fl oz/A-----	----------------------------------	%-------------------------------		
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	26 bc	25 b	22 b	13 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	21 b	22 b	33 bc	23 bc
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	49 d	43 c	46 d	34 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	48 d	44 c	43 cd	32 c
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	35 c	29 b	28 b	18 b
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	1 a	4 a	2 a	3 a
P-Value (0.05)		<0.0001	<0.0001	<0.0001	<0.0001

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b] Nec. = Visual necrosis.
[c]DAAC = Days after application C.

Root yield, % sucrose, and recoverable sucrose from Ultra Blazer at 16 fl oz/A plus NIS were the same as two applications of glyphosate alone (Table 7). Root yield and % sucrose from two applications of Ultra Blazer at 12 floz/A with NIS were the same as Ultra Blazer at 16 fl oz/A. However, recoverable sucrose from two applications of Ultra Blazer applications at 12 fl oz/A was less than a single application of Ultra Blazer at 16 fl oz/A.

Warrant mixed with Ultra Blazer, Roundup PowerMax3, and liquid AMS appeared to reduce sugarbeet vegetative injury and yield components as compared with Ultra Blazer mixed with Roundup PowerMax3 and liquid AMS. This is consistent from results in Michigan (personal communication with Dr. Christy Sprague).

Table 7. Sugarbeet root yield, % sucrose, and recoverable sucrose in response to herbicide treatment across locations, 2023.[a]

Herbicide Treatment	Rate	Root Yield	Sucrose	Recoverable Sucrose
	-----fl oz/A-----	-Ton/A-	--%--	---lb/A---
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	35.5 ab	17.7	11,180 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	34.2 bc	17.7	10,611 c
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	33.3 c	17.7	10,417 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	33.3 c	17.8	10,430 c
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	34.9 bc	17.5	10,737 bc
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	37 a	17.8	11,639 a
P-Value (0.05)		0.001	NS	0.001

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.

Waterhemp Control. The waterhemp control experiment at Moorhead was terminated and reestablished in soybean. The efficacy experiment was in sugarbeet at Blomkest. Thus, we elected to consider each experiment singly due to the difference in crop species between the two experiments.

Waterhemp control ranged from 40 to 88% at Moorhead, MN and 68 to 93% at Blomkest, MN, 14 DAAC (Table 8). Waterhemp control was or tended to be best when Ultra Blazer was tank mixed with Roundup PowerMax3 plus AMS across locations and evaluations. These results are consistent with results from Ms. Emma Burt's Master of Science research and other results previously communicated. Ultra Blazer plus COC provided or tended to provide waterhemp control similar to Ultra Blazer mixed with Roundup PowerMax3 across locations and evaluations.

Table 8. Waterhemp control 7 and 14 days after herbicide treatments, two locations, 2023.[a]

		Waterhemp Control			
		Moorhead		Blomkest	
Herbicide Treatment	Rate	7 DAAC[b]	14 DAAC	7 DAAC	14 DAAC
	-----fl oz/A-----	-----------------------------------%--------------------------------			
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	71 b	61 c	79 abc	81 abc
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	74 b	71 c	84 ab	89 ab
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	83 ab	73 bc	88 ab	81 abc
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	91 a	85 ab	93 a	93 a
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	89 a	88 a	75 bc	73 bc
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	43 c	40 d	69 c	68 c
P-Value (0.05)		<0.0001	<0.0001	0.0383	0.0472

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAAC = Days after application C.

Two applications of Ultra Blazer at 12 fl oz/A gave better waterhemp control at Blomkest than Moorhead. Conversely, Ultra Blazer plus Roundup PowerMax3 and Warrant plus AMS gave better control at Moorhead than Blomkest. A repeat application of Ultra Blazer at 12 fl oz/A plus NIS gave waterhemp control similar to a single Ultra Blazer application at 16 fl oz/A plus NIS.

Roundup PowerMax3 provided excellent common lambsquarters control whereas Ultra Blazer provided little or no common lambsquarters control (Table 9). We did not observe any antagonism with common lambsquarters when Ultra Blazer and Warrant were tank mixed with glyphosate.

Table 9. Common lambsquarters control 7 and 14 days after herbicide treatments, Moorhead, MN, 2023.[a]

Herbicide Treatment	Rate	Common Lambsquarters Control	
		7 DAAC[b]	14 DAAC
	-----fl oz/A-----	-------------------------%-----------------------	
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	3 d	0 e
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	35 b	10 d
Ultra Blazer + Crop Oil Concentrate	16 + 1.25%	23 c	23 c
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	99 a	94 b
Roundup PowerMax3 + Ultra Blazer + Warrant + Amsol Liquid AMS	25 + 16 + 40 + 2.5% v/v	99 a	97 ab
Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS / Roundup PowerMax3 + Prefer 90 NIS + Amsol Liquid AMS	25 + 0.25% + 2.5% v/v / 25 + 0.25% + 2.5% v/v	98 a	98 a
P-Value (0.05)		<0.0001	<0.0001

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAAC = Days after application C.

Conclusion

Controlling weeds in sugarbeet with pesticides continues to be a compromise between sugarbeet injury and weed control. For many years, producers had the luxury of broad-spectrum and uniform weed control with glyphosate and no sugarbeet injury. Glyphosate applied over RR sugarbeet continues to be the safest active ingredient I have evaluated in sugarbeet in my 36-year career, both as a graduate student working with sugarbeet, a representative of industry, and an academic, developing weed control strategies in sugarbeet. Sugarbeet are not affected by glyphosate rate, adjuvant, growth stage, or environmental conditions.

Glyphosate resistant (GR) weeds forces producers to pursue products that cause greater sugarbeet injury in pursuit of control of escaped weeds. The Section 18 emergency exemption exemplifies the need for Ultra Blazer in sugarbeet but also reveals the crop injury potential and the possibilities for waterhemp regrowth. I support the use of Ultra Blazer for control of weed escapes in sugarbeet. However, it is clear that we need to find ways to improve sugarbeet safety and optimize waterhemp control. Finally, we need to continue to pursue other options for control of GR weeds. The 2023 (and 2022) Ultra Blazer tolerance yield experiments were designed to determine if sugarbeet injury in response to Ultra Blazer could be reduced, while maintaining or improving waterhemp control through improved water volume, spray nozzle selection, adjuvants, or herbicide mixtures. Unfortunately, there is no ‘silver bullet’ with Ultra Blazer.

Appendix. Survey

2023 Ultra Blazer Section 18 Emergency Exemption
Field Observations

Please answer the following questions.

1. What county was Ultra Blazer used for weed control in sugarbeet?____________________

2. How many acres were sugarbeet treated with Ultra Blazer for weed control? ________________

3. Record sugarbeet injury (necrosis or growth reduction) from Ultra Blazer?

    None (0-15%) Slight (15-30%) Moderate (30-50%) Severe (50-70%)

4. Record weed control from Ultra Blazer in sugarbeet?

    Excellent (90-99%) Good (80-90%) Fair (65-80%) Poor (40-65%)

5. Did you observe any unexpected / adverse effects from using Ultra Blazer in sugarbeet?

    YES NO

6. Did you find the Section 18 to be valuable/useful?

    YES NO

7. Would you like to use Ultra Blazer again in 2024?

    YES NO.

Write comments to provide additional details regarding your experiences.

____

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KOCHIA CONTROL WITH ROUNDUP POWERMAX3 AND SURFACTANTS

Thomas J. Peters[1] and Adam Aberle[2]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist and [2]Graduate Student and Research Technician, North Dakota State University & University of Minnesota, Fargo, ND and North Dakota State University

Summary

1. Apply Roundup PowerMax at full rates for control of kochia. Growers may consider mixing Roundup PowerMax3 with ethofumesate at 4 fl oz per acre and Spin-Aid (rate dependent on sugarbeet stage and environmental conditions) on dime-size kochia glyphosate sensitive or resistant kochia or Roundup PowerMax3 and ethofumesate at 12 fl oz per acre on glyphosate sensitive kochia greater than 1-inch in size.
2. Tallow amine adjuvant mixed with Roundup PowerMax3 controlled or tended to control kochia better than nonionic surfactant with PowerMax3.
3. We observed greater kochia control when Level Best Pro tallow amine surfactant was applied at 0.5% v/v with Roundup PowerMax3 as compared to Level Best Pro at 0.25 % v/v

Introduction

Glyphosate tolerant kochia was widespread in sugarbeet production in 2023. Conversation with Agriculturalists suggest kochia might have been too large for control with Roundup PowerMax3 by the time it was identified in fields. Some growers using maximum labeled glyphosate rates and a tallow amine surfactant reported improved kochia control as compared to glyphosate alone or glyphosate with non-ionic surfactant (NIS).

Surfactants are molecules with hydrophilic (water-attracting) and hydrophobic (water-repellent) regions. This dual nature enables surfactants to reduce the interfacial tension between immiscible liquids or between liquids and solids. This is especially important with hydrophilic herbicides such as Roundup PowerMax3.

Ethoxylated tallow amine (ETA) surfactant was a component in the original glyphosate (Roundup) formulation. It was viewed by most old time weed scientists as the best glyphosate formulation ever produced. Dr. Kirk Howatt, NDSU Weed Control specialist, reported weed control with tallow amine surfactants is best with glyphosate and that they are not as efficacious with other herbicides. The objectives of this experiment was to consider kochia control from Roundup PowerMax3 alone with surfactants or Roundup PowerMax3 mixed with Spin-Aid and surfactants.

Materials and Methods

Two greenhouse experiments were conducted in 2024. A tray was filled with PROMIX general purpose greenhouse media (Premier Horticulture, Inc., Quakertown, PA) and seeded with kochia collected from a field near Kragnes, MN in 2023. Two kochia seedlings were transplanted into 4 × 4-inch pots filled with the same general purpose greenhouse media. Kochia was grown at 75 to 85F under natural light supplemented with a 16 h photoperiod of artificial light until they were approximately 3-inch in height. Roundup PowerMax3 at 25 fl oz per acre alone with surfactants or Roundup PowerMax3 mixed with Spin-Aid plus surfactants gave over 90% kochia control and did not differentiate between treatments. In the second experiment, Roundup PowerMax3 was applied at 15 fl oz per acre across treatments, allowing a better understanding of the virtues of surfactants.

Herbicide treatments (Table 1) were applied using a spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet® 8002E nozzle calibrated to deliver 15 gpa spray solution at 25 psi and 3 mph. Visible kochia control (0% to 100%, 100% indicating complete control) was evaluated approximately 3, 7, and 14 days after treatment (DAT). Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2024.0 software package.

Table 1. Herbicide treatment, rate, and kochia size, NDSU greenhouse, 2024.

Num	Treatment	Rate	Kochia size
		(fl oz + % v/v)	(inch)
1	Control		3
2	Roundup PowerMax3	25 or 15	3
3	Roundup PowerMax3 + nonionic surfactant[a]	25 or 15 + 0.25%	3
4	Roundup PowerMax3 + tallow amine surfactant[b]	25 or 15 + 0.25%	3
5	Roundup PowerMax3 + tallow amine surfactant	25 or 15 + 0.5%	3
6	Roundup PowerMax3 + Spin-Aid	25 or 15 + 32	3
7	Roundup PowerMax3 + Spin-Aid + tallow amine surfactant	25 or 15 + 32 + 0.25%	3

[a]Prefer 90 nonionic surfactant, CHS Inc., Inver Grove Heights, MN
[b]Level Best Pro, CHS Inc., Inver Grove Heights, MN

Results
Roundup PowerMax3 treatments at 25 fl oz/a provided kochia control greater than 90% 11 DAT (Table 2). Thus, we conducted the second experiment using Roundup PowerMax3 at 15 fl oz/A. We want our producers to use full glyphosate rates on small kochia. A sublethal rate applied over large kochia is a researchers way of differentiating between treatments, in this case surfactants.

Surfactants with Roundup PowerMax3 or Roundup PowerMax3 and Spin-Aid improved or tended to improve kochia control compared to Roundup PowerMax3 or Roundup PowerMax3 and Spin-Aid alone, 11 and 17 DAT (Table 3, Figure 2). Kochia control, across evaluation timing, numerically was best when tallow amine surfactant was mixed with Roundup PowerMax3 (Figure 1, Figure 2). PowerMax3 plus Level Best Pro at 0.5% v/v (2 quart per 100 gallon of water) controlled kochia better than PowerMax3 plus Level Best Pro at 0.25% v/v (1 quart per 100 gallon of water).

Table 2. Kochia control in response to Roundup PowerMax3 with adjuvants, greenhouse, 2024

Num	Treatment	Rate	4 DAT	7 DAT	11 DAT
		(fl oz + % v/v)	%	%	%
1	Control		0 d	0 d	0 d
2	Roundup PowerMax3	15	59 c	81 bc	96 abc
3	Roundup PowerMax3 + nonionic surfactant[a]	25 + 0.25%	68 ab	93 a	97 ab
4	Roundup PowerMax3 + tallow amine surfactant[b]	25 + 0.25%	65 abc	84 abc	98 ab
5	Roundup PowerMax3 + tallow amine surfactant	25 + 0.5%	60 bc	90 ab	99 a
6	Roundup PowerMax3 + Spin-Aid	25 + 32	73 a	84 abc	93 c
7	Roundup PowerMax3 + Spin-Aid + tallow amine surfactant	25 + 32 + 0.25%	65 abc	80 c	95 bc
	LSD (0.10)		8	9	4

[a]Prefer 90 nonionic surfactant, CHS Inc., Inver Grove Heights, MN
[b]Level Best Pro, CHS Inc., Inver Grove Heights, MN

Spin-Aid mixed with Roundup PowerMax3 did not improve control compared to Roundup PowerMax3 alone. We have been evaluating Spin-Aid for kochia control in the field in 2023 and in the greenhouse in 2023-24. We have observed kochia control with Spin-Aid is best when timed to small glyphosate sensitive or glyphosate resistant kochia; Spin-Aid application on 5-lf, dime-size kochia and following with one or two repeat applications on 5 to 7 day intervals. These data indicate there is no benefit from mixing Spin-Aid with Roundup PowerMax3 for control of escape glyphosate sensitive kochia, up to 3-inch tall. Further, we observed improvement of kochia control following the addition of Level Best Pro with Spin-Aid and Roundup PowerMax3, however, improvement in kochia control was not as dramatic as with Roundup PowerMax3 alone.

Table 3. Kochia control in response to Roundup PowerMax3 with adjuvants, greenhouse, 2024

Num	Treatment	Rate	4 DAT	7 DAT	11 DAT	17 DAT
		(fl oz + % v/v)	%	%	%	%
1	Control		0 e	0 c	0 d	0 e
2	Roundup PowerMax3	15	25 d	40 b	55 c	51 c
3	Roundup PowerMax3 + nonionic surfactant[a]	15 + 0.25%	38 c	44 b	63 bc	58 bc
4	Roundup PowerMax3 + tallow amine surfactant[b]	15 + 0.25%	50 b	53 b	69 b	70 b
5	Roundup PowerMax3 + tallow amine surfactant	15 + 0.5%	68 a	73 a	89 a	90 a
6	Roundup PowerMax3 + Spin-Aid	15 + 32	28 cd	45 b	64 bc	65 bc
7	Roundup PowerMax3 + Spin-Aid + tallow amine surfactant	15 + 32 + 0.25%	29 cd	46 b	68 b	70 b
	LSD (0.10)		12	13	10	13

[a]Prefer 90 nonionic surfactant, CHS Inc., Inver Grove Heights, MN
[b]Level Best Pro, CHS Inc., Inver Grove Heights, MN

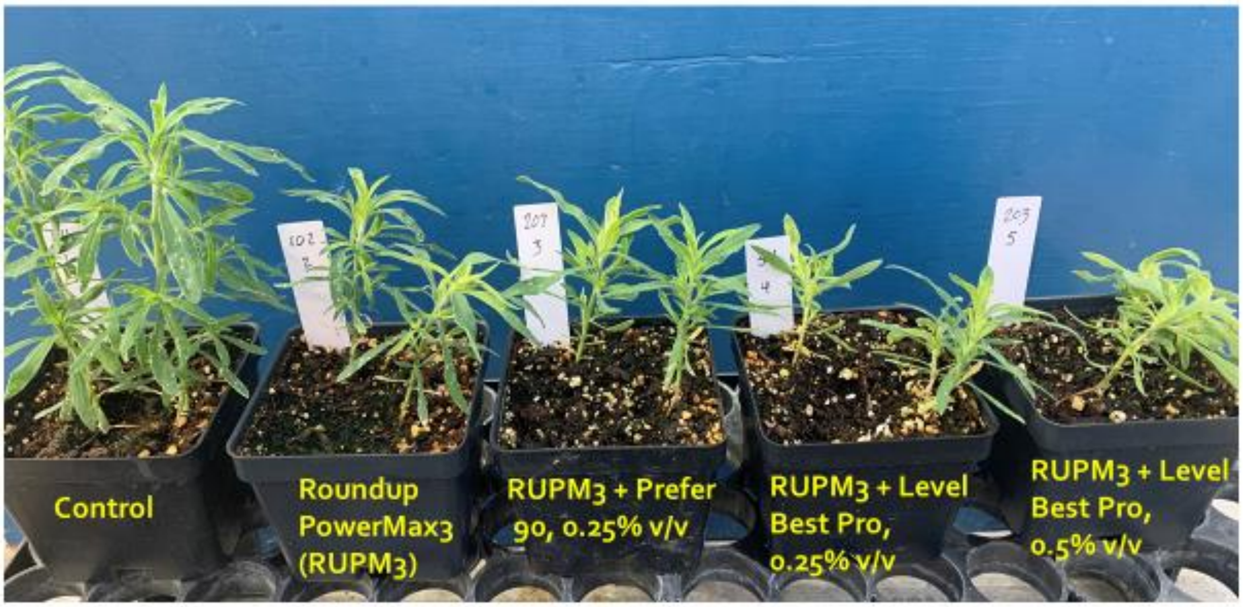

Figure 1. Kochia control from Roundup PowerMax3 alone or with surfactants, 4 DAT, greenhouse, 2024.

Summary
Glyphosate resistant and susceptible populations in the countryside challenge kochia control. In general, we observe more glyphosate resistant kochia in proximity to rail road tracks and glyphosate sensitive kochia along fence lines. We recommend growers identifying kochia as their most important weed control challenge use ethofumesate PRE or spray Gramoxone when kochia has emerged but before sugarbeet have emerged. Gramoxone is durable, inexpensive, and efficacious even with cool weather conditions.

Two- or three-times Spin-Aid at rate commensurate with sugarbeet size and environmental conditions and mixed with ethofumesate is an effective kochia control strategy. However, kochia must be small; application targeting 5-leaf or dime-size kochia.

We recommend full rates if growers choose to use glyphosate. Glyphosate should always be applied with ammonium sulfate water conditioner (liquid or solid) and extra surfactant. These research indicate a tallow amine surfactant at 0.5% v/v is more effective with Roundup PowerMax3 than Prefer 90 nonionic surfactant with Roundup PowerMax3.

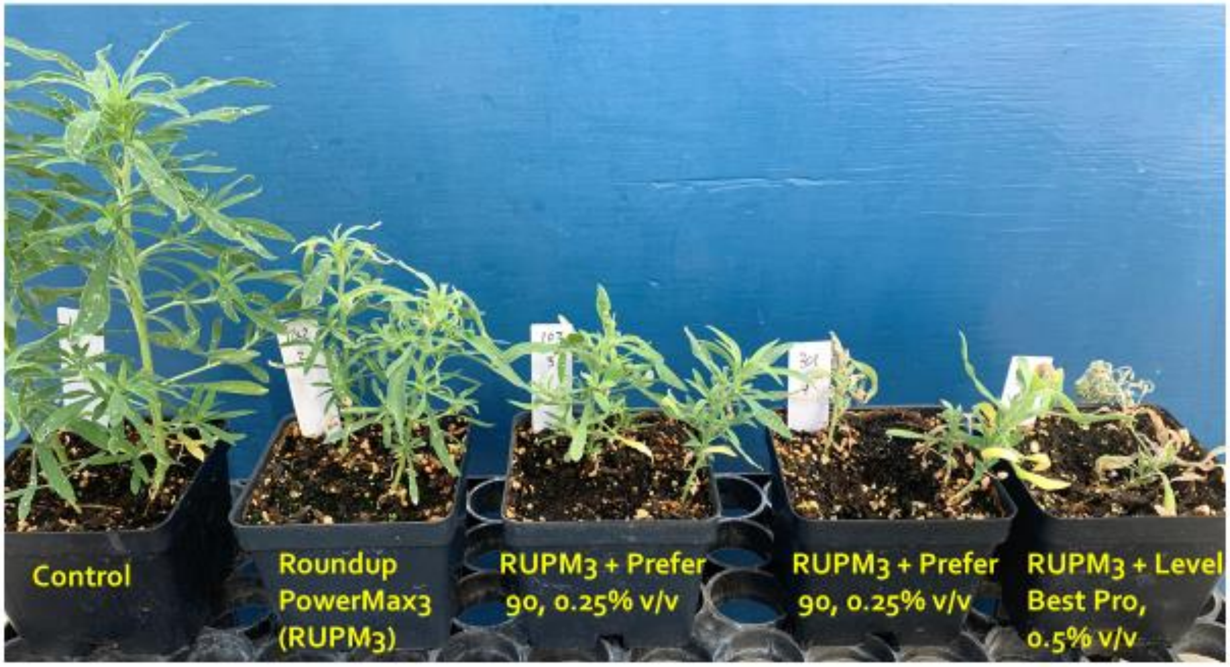

Figure 2. Kochia control from Roundup PowerMax3 alone or with surfactants, 11 DAT, greenhouse, 2024.

SOIL MANAGEMENT PRACTICES

NOTES

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

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Justification: Nitrogen is the single most researched nutrient for sugar beet as nitrogen is the nutrient most likely to limit production. Numerous trials in Minnesota and North Dakota have been conducted studying nitrogen rate and the impact of residual nitrate on sugar beet yield and quality. Most of these studies have included spring nitrogen rates usually applied as urea. Nitrogen suggestions assume the same amount of N is required for fall versus spring application on N if best management practices are followed. As nitrogen is applied in the fall in some cases, more research needs to be conducted to determine if fall application of nitrogen can continue to be an acceptable practice.

While spring application of nitrogen is generally suggested for most crops to limit the potential for spring N losses, wet springs present challenges to plant crops at optimal times amid getting fertilizer applied and fields prepared for planting. Fall application of all fertilizer is advantageous to limit the number of field operations which must be completed prior to planting. Current nitrogen best management practices for much of the sugar beet growing regions in Minnesota maintain fall nitrogen application as an acceptable practice. Anhydrous ammonia is the source of nitrogen encouraged for use in the fall due to the impacts anhydrous ammonia has on soil nitrifying bacteria. Fall application of urea has been considered acceptable in Western and Northwestern Minnesota but the practice is being increasingly questioned due to increased rainfall in areas presenting a greater risk for nitrogen loss.

Urea and anhydrous ammonia when applied to the soil both result in the accumulation of ammonia and ammonium in the soil. Urea differs in that it must be hydrolyzed by the enzyme urease before ammonium is forms. The urease enzyme is ubiquitous in soils and hydrolysis of urea can be rapid if the appropriate conditions exist in the soil. Since urea does not impact soil microorganisms the same as anhydrous ammonia the conversion of urea can be quicker presenting greater risks for nitrate loss while shallow application can present volatility issues also representing a potential loss for the product. More recent data collected from multiple locations in Western Minnesota has shown a significant yield penalty for identical rates of nitrogen applied to corn in the fall versus in the spring. The corn yield penalty is greater when corn follows corn which could be partially due to immobilization of nitrogen by the corn residue. With typical rotations of sugar beet following corn a comparison of fall versus spring nitrogen applied as urea is needed to determine the efficiency of fall versus spring application or urea to determine if changes to nitrogen best management practices are warranted, or if sugar beet differs enough where fall urea can still be an acceptable practice even if it is not suggested for corn.

Nitrification inhibitors are currently available to be used for urea which could limit the potential for nitrate accumulation in the soil profile. Research with N-serve applied with anhydrous ammonia has demonstrated that nitrapyrin is an effective nitrification inhibitor. The primary nitrification inhibitor for urea historically was dicyandiamide (DCD). Mobility of the DCD molecule has led to inconsistent results with this product. More recently Dow has released Instinct which is an encapsulated nitropyrin product for use with urea. Research has shown no overall benefit for Instinct applied with broadcast urea for corn, but the product is still sold to growers with a promise of reducing nitrogen loss from fall urea applications. Inhibitor research is needed in sugar beet production to determine if the additional cost of the products justifies their use for fall application.

Polymer coated urea is available in Minnesota as the product ESN. Polymer coated urea differs from inhibitors as the polymer coating provides a barrier which slows the release of nitrogen to the soil. Water moves into the polymer coating dissolving urea which then diffuses through the coating into the soil. The rate of release of urea through the polymer coating is related to soil moisture and temperature. Cool or dry soils can limit release subsequently resulting in a deficiency of nitrogen for the plant even through there may be adequate nitrogen in the soil for the crop. The lack of predictability of release and higher cost of the product has resulted in polymer coated urea suggested for application as a blend rather than 100% of the nitrogen required applied as ESN. However, ESN has been demonstrated as being effective at limiting nitrogen loss in high loss environments and thus may be better suited for fall application than urea treated with an inhibitor. Data reporting fall application of polymer coated products on sugar beet is scare and is needed to determine if this practice is better and what the optimal blend rate may be.

Objectives:

1. Evaluate nitrogen fertilizer requirement for sugar beet.
2. Compare the efficiency of fall versus spring application of urea for the southern and northern growing region through impacts on root yield and sugar content.
3. Determine if polymer coated urea (ESN) blends with urea results in greater root yield and recoverable sugar per acre when applied in the fall.
4. Determine if root yield and recoverable sugar are greater when commercially available nitrification and/or urease inhibitors marketed for use with urea when applied in the fall.

Materials and Methods: Two field locations were established in at new locations in Fall 2020, 2021, and 2022 (Table 1). Each year, one of the field trials was located in the northern growing region at the Northwest Research and Outreach Center at Crookston following wheat in 2021 and 2022 and soybean in 2023. The second second located on an on-farm trial location in the southern growing region following corn near Hector in 2021 and near Renville in 2022 and 2023. There are two separate studies at each location.

Study 1 consists of six N rates at Crookston (0 to 200 lbs) and eight in the southern region (0 to 210 lbs). All N is applied as urea in the fall and in the spring. Trials consist of a split plot design where main plots consist of N rate and sub-plots within each main plot will be N timing such that the same rate can be applied side by side for comparison. Fall application are targeted to the end of October or when the soil has stabilized below 50°F and incorporated as soon as possible after application. Spring fertilizer application was made just prior to- and incorporated before planting (Table 2).

Study 2 consists of multiple fertilizer sources applied at a sub-optimal N rate applied in fall and spring. The target rate was 45 lbs of N only which, including the four-foot nitrate test, the total N should account for roughly two-thirds to three quarters of the suggested N needed for sugar beet production. The 45 lb rate was not meant to represent an optimal rate of N applied to sugarbeet. Rather, the 45 lb N rate should be on the more responsive part of the N response curve allowing for easier detection of smaller differences related to N availability from the sources used. A split plot design is used for the source trial where main plots will consist of N source and sub-plots will be time of application.

N sources consist of:

1. 0 N control
2. Urea only
3. 33% ESN/66% urea
4. 66% ESN/33%urea
5. 100% ESN
6. Super U [NBPT (urease inhibitor) +DCD (nitrification inhibitor)]
7. Agrotain (urease inhibitor) – 0.45 qt/ton (low rate similar to the NBPT rate in Super U)
8. Anvol (urease inhibitor) – 1.5 qt/ton
9. Instinct (nitrification inhibitor) – 24 oz/ac
10. Ammonium sulfate

Initial site-composite soil samples were collected from each study at each location to a depth of four feet. A summary of soil test information is given in Table 2. Stand counts were taken early in the growing season to assess phytotoxicity of the urea rates and sources. In season plant tissue samples are collected towards the end of June to early July depending on planting date. Leaf blade and petiole samples are collected, and extractable nitrate-N is determined in Dr. Kaiser’s lab following extraction with water or 2% acetic acid. Petiole and leaf blade samples are additionally sent out to a private lab for total N analysis by dry combustion. The uppermost fully developed leaf blade and petiole were sampled which is consistent with what is suggested for petiole nitrate analysis. Plots were harvested at the end of the growing season and root samples will be analyzed for quality parameters.

A single variety is planted at each location and differed by location. All practices, weed and disease control, planting, and tillage will be consistent with common practices for the growing regions. Additional P, K, and S is applied as needed based on current fertilizer guidelines.

Results

A summary of the main effect significance is given in Table 3a, 3b, and 3c for the urea rate trial and Table 4a and 4b for the urea source trial for the 2021 and 2022 growing seasons, respectively. Figures 1 through 5 summarize sugar beet response to N for the rate trials only. Data are summarized across all rate or treatments when the statistical analysis indicated no N rate or source by time interaction for a given locations. The summary of the main effect of time for the rate and source trials is given in Table 5a, 5b, and 5c for 2021, 2022, and 2023, respectively.

An application error resulted in the loss of all fall treatments for the urea source trial at Crookston 2021. The spring treatments were applied as planned and the source main effect at Crookston only summarizes the spring treatments. There was also a misapplication of treatments at the Renville 2022 site. I am still sorting through the treatments to know what can be used so none of the Renville 2022 data are reported other than the petiole nitrate data will be summarized in the graph comparing petiole nitrate-N to relative root yield. All 2023 data were collected as planned.

Sugar beet emergence was significantly impacted by N rate at nearly all locations (Tables 3a to 3c and Figure 1a to 1c). Sugar beet emergence was less as the rate of N applied as spring urea increased. Fall urea had a slight impact on sugarbeet emergence in some cases but the impact was mostly seen in the fall with the highest rates of urea application. When decreased, sugarbeet emergence decreased linearly as fertilizer rate increased. Emergence was poor at Crookston in 2022 (Tables 3b and Figure 1b) but nitrogen rate and timing did not impact emergence at this location.

Urea source impacted emergence at both locations (Table 6a) in 2021, but seldom affected emergence in future years. In 2021, all sources reduced emergence at Crookston while emergence was greater for most urea sources compared to the control at Hector. Due to the differences in response between the two locations, the ranking of sources generally differed except for urea treated with instinct which resulted in the lowest emergence of all treatments. Urea sources did not impact emergence at Crookston in 2022 (Table 6b). The lack of impact of sources on sugar beet emergence is not unexpected as only 45 lbs of N were applied which may have not been enough N to impact emergence.

Sugar beet root yield as impacted by N application rate at Hector but not at Crookston and time was not significant at either site (Table 4a). Root yield responded to 130 lbs of total N (applied N plus nitrate-N in a four-foot soil sample) at Hector (Figure 2a). Dry soils at Crookston resulted in less and more variable root yield. If root yield did vary by N rate the likely would not have been any additional yield produced passed around 120 lbs of total N at Crookston. The fact that timing of application did not impact root yield likely resulted from the dry soils and a lack of potential for leaching of nitrate.

Root yield was not impacted by nitrogen rate and timing at Crookston in 2022 (Table 4b). Residual nitrate in the soil in Fall of 2021 was extremely high (Table 2). No- or very little nitrogen would be suggested based on the fall four-foot soil nitrate test at Crookston.

Root yield was highly affected by N rate in 2023 at both locations (Table 4c and Figure (2c). Residual nitrate in the soil profile was relatively low at both locations (Table 2). Time of application was significant at Crookston. However, the fall urea application tended to outyield the spring application. It is not clear why fall application of urea produced greater root yield but it could be due to shallow incorporation of urea in dry soils. It also took less N to maximize root yield when urea was applied in the fall at Crookston, but the total N required was still within current suggestions for sugar beet in the Northern growing region. Root yield exceeded expectations at Renville and the response to N was slightly greater than suggested.

Root yield varied by urea source only at Hector (Table 6a) in 2021. Almost all urea sources increased root yield over the non-fertilized control. The greatest yield was produced with the 33% ESN, urea plus Anvol, and urea plus Agrotain treatments. Anvol and Agrotain are urease inhibitors which slow volatility of ammonia by reducing the rate of hydrolysis of the urea. Super-U also contains NBPT, the active ingredient in Agrotain, but at a lower rate that what is applied with the suggested application rate of Agrotain. Issues with coating of the fertilizer resulted in a NBPT rate applied that was roughly 2x that of the amount of NBPT in Super-U (Agrotain rate was targeted to supply the same NBPT rate as in Super-U). It should be noted that this dataset is limited in that it is one site-year total. The addition of more site-years of data is needed to make a conclusion of the optimal urea source. Urea sources did not impact root yield in 2022 at Crookston (Table 6b). In 2023, sources impacted sugar beet root yield at both locations (Table 6c). Similar to the rate trial, fall application outyielded spring at Crookston.

The decrease in plant population did not impact sugar beet root yield. The loss of population was compensated for 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. A reduction in emergence without a resulting decrease in yield was also seen in 2020.

Recoverable sucrose per ton was affected by urea rate and timing at both 2021 locations, but the time by rate interaction was not significant. Fall urea application resulted in 3% more recoverable sucrose at both locations. Urea rate resulted in a general decrease in recoverable sucrose at both locations (Figure 3a). In both cases increasing urea rate decreased recoverable sucrose per ton. The decrease was relatively minor at the rate where root yield was maximized at Hector. There was no impact of urea rate and timing on recoverable sucrose at Crookston in 2022 (Figure 3b) or both locations in 2023 (Figure 3c).

Urea sources had a relatively minor impact on recoverable sucrose (Table 6a to 6c). Most sources did not differ from the non-fertilized control except for Super-U which resulted in the lowest recoverable sucrose per ton at both locations.

Recoverable sucrose per acre is summarized for the rate study in Figure 4a, 4b, and 4c. Recoverable sucrose was not impacted by urea rate at Crookston in 2021 while recoverable sucrose was maximized by 80 lbs of total N at Hector and did not increase or decrease beyond that point. Time of urea application did not impact recoverable sucrose per acre at most locations (Table 5a to 5c). For the source trial there was no impact of urea source on recoverable sucrose per acre at Crookston 2021, but recoverable sucrose was increased by urea sources at Hector (Table 6). Most sources were similar, but 100% ESN produced slightly less recoverable sucrose than the other urea sources.

Petiole and leaf blade nitrate concentrations were determined following sampling in early to late-July. The targeted sampling time was 40-50 days after planting at each site. Nitrogen rate and timing affected petiole and leaf blade nitrate-N concentration in 2021 (Table 3a) while only rate impacted blade and petiole nitrate-n concentration in 2022 (Table 3b). Both petiole (Tables 5a and 5b) and leaf blade (Table 6a and 6b) nitrate-N concentration increased with increasing N application rate. In general, petiole and leaf blade nitrate-N concentrations did not plateau and increased beyond the highest rate of N applied even at Crookston in 2022 where the residual nitrate-N content in the soil was high and the relative amounts of nitrate-N in the leaf blade and petiole samples were extremely high compared to samples collected from the 2021 locations. While the main effect of timing was significant in 2021, there was no timing x rate interaction indicating that in general fall application of urea resulted in less nitrate-N in the plant tissue, but the effect of N and the shape of the N response curves were similar even though the maximum values achieved were different based on timing.

Nitrogen rate impacted both petiole and leaf blade nitrate-N concentration at both locations in 2023 (Figures 5c and 6c). Time of application impacted only petiole nitrate N concentration at Crookston where petiole nitrate-N concentration was greater with fall urea application. In all cases the concentration of nitrate-N increased with increasing rate of applied N and was not maximized with the greatest rate of urea applied. There was an interaction between rate and timing for petiole nitrate-N concentration at Crookston, However, the interaction was generally due to no difference in nitrate-N concentration based on time of application with the lowest rates of urea applied.

Source effects on petiole and leaf blade nitrate-N concentration are summarized in Tables 6a through 6c. The timing main effects on leaf blade nitrate-N concentration differed for all three locations in 2021 and 2022 (Tables 5a and 5b) but did not differ in 2023 (Table 5c). Petiole nitrate-N only varied based on time of application for the two 2021 locations (Table 5a) and not at any of the other locations. The relative rankings among the sources varied by site and individual site effects will not be discussed but are given in Tables 6a through 6c. A source x time interaction only occurred at Hector in 2021 for petiole nitrate-N concentration and at Crookston in 2021 for leaf blade nitrate-N concentration. Again, these individual effects will not be discussed on a site-by-site basis in lieu of an analysis across locations.

The urea source data was analyzed across the five field locations. It should be noted that only the spring application from Crookston in 2021 was utilized while both fall and spring data from the remaining locations. There was no significant impact of time or source on sugarbeet emergence (Figures 7). Root yield was impacted by source but not time (Figure 8). The root yield data are somewhat messy, but root yield tended to be greater with the urea sources where Anvol or Agrotain were applied or with AMS. This would indicate that the loss pathway of N from urea was more related to volatilization of ammonia rather than nitrate leaching. Recoverable sucrose per ton was not impacted by urea source (Figure 9).

Leaf blade and petiole nitrate-N concentration were analyzed but only petiole nitrate-N concentration is summarized in this report (Figure 10). Both main effects of time and source significantly differed but the interaction between time and source was not significant. For the time main effect, petiole nitrate-N concentration was significantly greater following spring application. For sources, the greatest increase in petiole nitrate-N concentration was produced with Anvol and Instinct. The next greatest increase was due to 33% of N as ESN and Super-U which did not differ from each other. Agrotain, AMS, 100 and 66% ESN did not differ from straight urea and were only slightly better than the 0N control. In general, there was no class of inhibitor that was better than another (urease versus nitrification inhibitors). The 33% ESN blend was slightly better than 66 or 100% but was still slightly worse than Anvol or Instinct. More data will be added as additional sites are added.

Petiole nitrate concentration was regressed with relative yield from previous studies and the data are given in Figure 11. 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 like 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 like 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.

The petiole nitrate-N data was also compared to the difference in the amount of nitrogen applied relative to the rate that maximized root yield at each location (Figure 12). The petiole nitrate-N concentration at the optimal N rate was 750 to 800 ppm slightly lower than the optimal value shown in Figure 11. Nitrate-N concentration continued to increase beyond the optimal N rate indicating luxury uptake of nitrogen by the beet plant. Below the 750 ppm, the relationship between petiole nitrate-N concentration and root yield was relatively linear but also relatively vertical making it difficult to determine potential suggested application rates of N when the petiole nitrate-N concentration was below 750 ppm. Optimal application rate could be as much as 100 lbs N or as little as 50. It should be noted that petiole nitrate concentration can be highly affected by plant stress, including moisture stress, around the time of sampling. In addition, concentrations are diurnal meaning they can fluctuate from daytime to nighttime. Sampling should be collected at oar near the same time of the day. Most samples in this study were collected between 10 am and 2 pm the day of sampling.

Petiole nitrate-N concentration was also related to recoverable sucrose per ton (Figure 13). There was no clear relationship between the two variables but that may be due to differences in recoverable sucrose based on site or variety. Recoverable sucrose per ton tended to be lower at the southern locations and appeared to decrease with increasing petiole nitrate-N concentration. However, the decrease in petiole nitrate-N seemed to occur at concentrations near concentrations that resulted in maximum root yield.

Acknowledgments

The authors would like to thank the research crews at the Southern Minnesota Beet Sugar Cooperative, the Department of Soil, Water, and Climate Field Crew, and the research staff at the Northwest Research and Outreach Center for their work with this study. I would also like to thank both Southern Minnesota Beet Sugar Cooperative and American Crystal Sugar Co. for providing the quality analysis for this research, and the Sugar beet Research and Education Board of Minnesota and North Dakota for providing funding for this project.

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

Year	Location	Date of					Soil		
		Urea Application		Planting	Tissue Sampling	Harvest	Series	Texture†	Classification‡
2021	Crookston	29-Oct	4-May	4-May	8-Jul	14-Sept	Wheatville	FSL	Ae. Calciaquoll
	Hector	6-Nov	30-Apr	30-Apr	12-Jul	29-Sept	Canisteo-Glencoe	CL	T. Endoaquoll
2022	Crookston	1-Nov	27-May	27-May	22-Jul	20-Sept	Wheatville	FSL	Ae. Calciaquoll
	Renville	3-Nov	21-May	24-May	19-Jul	19-Sept	Normania	L	Aq. Hapludoll
2023	Crookston	4-Nov	10-May	10-May		14-Sept	Wheatville	FSL	Ae. Calciaquoll
	Renville	1-Nov	3-May	3-May	12-Jul	9-Oct	Leen-Okaboji	SiCL	T. Calciaquoll

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

‡Ae, aeric; Aq, aquic; T, typic

Table 2. Summary of soil test results for 2021 locations.

Year	Location	0-6” Soil Test: Olsen P	Ammonium Acetate K	pH	SOM	Soil Test Nitrate-N: 0-2’	2-4’
		----------ppm----------			----%----	--------------------lb/ac--------------------	
					Urea Rate Trials		
2021	Crookston	9	159	8.2	3.0	25	43
	Hector	8	168	7.3	5.4	21	39
2022	Crookston	9	140	8.2	2.7	135	9
	Renville	11	155	7.1	3.9	22	8
2023	Crookston	6	113	8.3	2.8	15	24
	Renville	11	181	8.1	7.1	31	--
					Urea Source Trials		
2021	Crookston	12	140	8.2	2.3	39	70
	Hector	7	151	7.6	4.0	25	68
2022	Crookston	9	140	8.2	2.7	135	9
	Renville	13	222	7.3	4.0	30	14
2023	Crookston	6	113	8.3	2.8	15	24
	Renville	11	181	8.1	7.1	31	--

Table 3a. Summary of analysis of variance for main effects of nitrogen application rate (N rate) and time of application (Time) and their interaction at Crookston

(CRX) and Hector (H), MN in 2021.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Recoverable Sugar (ton)	
Effect	CRX	H	CRX	H	CRX	H	CRX	H	CRX	H
	---------------------	-------------------	-------------------	-------------------	-------------------P>F	-------------------	-------------------	-------------------	-------------------	
N rate	***	0.10	***	***	***	***	0.50	**	0.10	*
Time	***	***	**	***	*	*	0.66	0.88	**	**
N ratexTime.	***	***	0.13	0.16	0.88	0.45	0.13	0.90	0.25	0.46

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

Table 3b. Summary of analysis of variance for main effects of nitrogen application rate (N rate) and time of application (Time) and their interaction at Crookston (CRX) and Renville (R), MN in 2022.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Recoverable Sugar (ton)	
Effect	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R
	---------------------	-------------------	-------------------	-------------------	-------------------P>F	-------------------	-------------------	-------------------	-------------------	
N rate	0.50	na	0.07	na	*	na	0.69	na	0.25	na
Time	*	na	0.20	na	0.07	na	**	na	0.38	na
N ratexTime.	0.34	na	0.87	na	0.80	na	0.42	na	0.88	na

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

Table 3c. Summary of analysis of variance for main effects of nitrogen application rate (N rate) and time of application (Time) and their interaction at Crookston (CRX) and Renville (R), MN in 2023.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Recoverable Sugar (ton)	
Effect	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R
	---------------------	-------------------	-------------------	-------------------	-------------------P>F	-------------------	-------------------	-------------------	-------------------	
N rate	***	*	***	***	0.13	***	***	**	0.44	0.68
Time	***	***	0.08	0.25	0.92	0.70	***	0.20	0.66	0.92
N ratexTime.	***	***	*	0.61	0.08	0.17	0.08	0.38	0.60	0.83

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

Table 4a. Summary of analysis of variance for main effects of urea source (Source) and time of application (Time) and their interaction at Crookston (CRX) and Hector (H), MN in 2021.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Recoverable Sugar (ton)	
Effect	CRX	H	CRX	H	CRX	H	CRX	H	CRX	H
	-----------	-----------	-----------	-----------	----------- *P*>F -----------	-----------	-----------	-----------	-----------	
Source	***	**	0.10	0.07	0.06	0.12	0.18	**	*	*
Time	na	0.58	na	***	na	**	na	0.26	na	0.63
SourcexTime.	na	0.55	na	*	na	0.40	na	0.62	na	0.95

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

Table 4b. Summary of analysis of variance for main effects of urea source (Source) and time of application (Time) and their interaction at Crookston (CRX) and Renville (R), MN in 2022.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Recoverable Sugar (ton)	
Effect	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R
	-----------	-----------	-----------	-----------	----------- *P*>F -----------	-----------	-----------	-----------	-----------	
Source	0.99	na	0.81	na	*	na	0.99	na	0.23	na
Time	0.08	na	0.43	na	0.35	na	*	na	*	na
SourcexTime.	0.08	na	0.44	na	*	na	0.08	na	0.42	na

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

Table 4c. Summary of analysis of variance for main effects of urea source (Source) and time of application (Time) and their interaction at Crookston (CRX) and Renville (R), MN in 2023.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Recoverable Sugar (ton)	
Effect	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R
	-----------	-----------	-----------	-----------	----------- *P*>F -----------	-----------	-----------	-----------	-----------	
Source	0.14	0.96	0.16	0.18	0.56	0.12	0.10	*	0.17	0.31
Time	0.18	0.86	0.56	0.41	0.71	0.08	***	0.88	0.43	0.28
SourcexTime.	0.57	0.13	0.35	0.22	0.40	0.27	0.19	0.19	0.64	0.34

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

Table 5a. Summary of the main effect of in-urea timing or source for selected variables at Crookston (CRX) and Hector (H), MN in 2021. Letters indicating least significant difference are only listed in the table when the main effect of timing was significant. Data are given separately for the urea rate and source trials at each location. Fall treatments for the Crookston source trial were not included in this dataset.

	Emergence	Petiole NO_3-N	Blade NO_3-N	Yield	Rec. Sugar (ton)	Rec Sugar (acre)

Time	CRX	H	CRX	H	CRX	H	CRX	H	CRX	H	CRX	H
	------%------		----ppm----				--tons/ac--		---lb/ton---		----lb/ac----	
						Urea Rate Trial						
Fall	79a	86a	1702b	764b	478b	89b	19.4	39.5	326a	246a	6340	9690
Spring	72b	74b	2147a	1307a	622a	125a	19.1	39.6	316b	240b	6027	9479
						Urea Source Trial						
Fall	--	84	--	647b	--	47b	--	33.9	--	261	--	8587b
Spring	--	83	--	1005a	--	90a	--	34.6	--	260	--	8859a

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

Table 5b. Summary of the main effect of in-urea timing or source for selected variables at Crookston (CRX) and Renville (R), MN in 2022. Letters indicating least significant difference are only listed in the table when the main effect of timing was significant. Data are given separately for the urea rate and source trials at each location. Fall treatments for the Crookston source trial were not included in this dataset.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Rec. Sugar (ton)		Rec Sugar (acre)	
Time	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R
	------%------		----ppm----				--tons/ac--		---lb/ton---		----lb/ac----	
						Urea Rate Trial						
Fall	72a	na	5299	na	1372b	Na	23.5a	na	316	na	7409a	na
Spring	56b	na	5740	na	1593a	Na	20.5b	na	312	na	6400b	na
						Urea Source Trial						
Fall	60.3b	na	567	na	3447	Na	21.7b	na	306b	na	6664	na
Spring	68.5a	na	599	na	3322	Na	23.3a	na	312a	na	7263	na

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

Table 5c. Summary of the main effect of in-urea timing or source for selected variables at Crookston (CRX) and Renville (R), MN in 2023. Letters indicating least significant difference are only listed in the table when the main effect of timing was significant. Data are given separately for the urea rate and source trials at each location. Fall treatments for the Crookston source trial were not included in this dataset.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Rec. Sugar (ton)		Rec Sugar (acre)	
Time	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R
	------%------		----ppm----				--tons/ac--		---lb/ton---		----lb/ac----	

						Urea Rate Trial						
Fall	78a	87a	908a	1017	119	390	18.1a	43.1	344	276	6217a	11885
Spring	69b	79b	779b	1154	122	372	15.0b	44.2	342	276	5087b	12196
						Urea Source Trial						
Fall	81.8	84.8	501	81	77	43b	18.8a	23.5	341	279	6337a	6570
Spring	80.1	84.6	554	109	71	55a	16.5b	23.4	339	278	5506b	6512

†Numbers followed by the same letter are not significantly different at the $P \leq 0.10$ probability level.

Table 6a. Summary of the main effect of urea source for selected variables at Crookston (CRX) and Hector (H), MN in 2021. Letters indicating least significant difference are only listed in the table when the main effect of timing was significant.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Rec. Sugar (ton)		Rec Sugar (acre)	
Source	CRX	H	CRX	H	CRX	H	CRX	H	CRX	H	CRX	H
	------%------			----ppm----			--tons/ac--		---lb/ton---		----lb/ac----	
None	86.4a	78.6cd	100c	471d	317c	33	18.1	29.9f	345.6a	261.5ab	6259	7092d
Urea	69.7ef	88.1a	227bc	625bcd	725bc	35	16.7	31.6def	336.2ab	261.9ab	5612	8639abcd
AMS	78.9bc	86.6a	154bc	888abc	674c	53	19.5	36.7abc	325.1bc	270.1a	6339	9768ab
33% ESN	73.7de	85.6ab	214bc	950ab	589c	79	15.7	39.0a	329.0b	263.5ab	5163	9839a
66% ESN	77.1bcd	80.1bcd	174bc	524cd	681c	53	18.5	30.7ef	329.9b	260.1b	6104	8094bcd
100% ESN	80.8b	88.5a	214bc	1064a	545c	92	19.6	34.2bcde	332.1b	262.0ab	6510	7596cd
Instinct	68.4f	75.2d	196bc	1162a	466c	104	17.9	34.0bcde	329.2b	257.1b	5909	8412abcd
Super-U	74.1cde	84.8ab	310ab	924abc	1332a	82	19.0	33.1cdef	314.8c	246.0c	5965	8922abc
Agrotain	77.3bcd	84.6abc	262bc	786abcd	744bc	48	18.7	37.6ab	327.7b	259.8b	6145	8909abc
Anvol	72.5def	80.4bcd	463a	867abcd	1214ab	109	18.9	35.5abcd	333.4b	259.4b	6282	9955a

†Numbers followed by the same letter are not significantly different at the P<0.10 probability level.
Na, data are not available

Table 6b. Summary of the main effect of urea source for selected variables at Crookston (CRX) and Renville (R), MN in 2022. Letters indicating least significant difference are only listed in the table when the main effect of timing was significant.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Rec. Sugar (ton)		Rec Sugar (acre)	
Source	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R
	------%------			----ppm----			--tons/ac--		---lb/ton---		----lb/ac----	
None	67	na	467	na	2502c	na	22.4	na	323	na	7252	na
Urea	68	na	608	na	3715ab	na	22.7	na	309	na	7017	na

AMS	64	na	536	na	2845c	na	23.0	na	304	na	6992	na
33% ESN	64	na	614	na	3700ab	na	22.9	na	308	na	7050	na
66% ESN	66	na	578	na	3652ab	na	22.4	na	310	na	6953	na
100% ESN	64	na	537	na	3086bc	na	23.3	na	301	na	7022	na
Instinct	65	na	586	na	3212abc	na	22.2	na	313	na	6951	na
Super-U	69	na	641	na	3829a	na	22.5	na	305	na	6893	na
Agrotain	61	na	626	na	3635ab	na	21.5	na	307	na	6664	na
Anvol	61	na	636	na	3670ab	na	22.1	na	310	na	6845	na

†Numbers followed by the same letter are not significantly different at the P<0.10 probability level.
Na, data are not available

Table 6c. Summary of the main effect of urea source for selected variables at Crookston (CRX) and Renville (R), MN in 2023. Letters indicating least significant difference are only listed in the table when the main effect of timing was significant.

	Emergence		Petiole NO_3-N		Blade NO_3-N		Yield		Rec. Sugar (ton)		Rec Sugar (acre)	
Source	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R	CRX	R
	------%------		----ppm----				--tons/ac--		---lb/ton---		----lb/ac----	
None	84	85	224	12	34	18b	13.8c	19.7c	328	275	4448	5411
Urea	81	87	452	307	65	121a	16.0bc	22.8bc	351	276	5563	6302
AMS	83	86	495	28	80	27b	17.8ab	25.2ab	329	281	5732	7105
33% ESN	84	85	798	53	102	33b	18.0ab	23.2abc	342	280	6035	6503
66% ESN	77	85	555	129	86	36b	18.3ab	20.6c	334	275	6036	5683
100% ESN	80	83	325	71	75	36b	17.4ab	25.9ab	351	279	6032	7235
Instinct	81	82	555	124	59	81ab	19.0ab	21.7c	343	276	6432	6037
Super-U	81	85	824	119	115	72ab	16.8bc	23.1abc	348	279	5757	6458
Agrotain	83	84	593	87	89	26b	20.3a	26.5a	334	279	6687	7405
Anvol	75	85	453	19	35	20b	19.2ab	25.7ab	344	283	6493	7272

†Numbers followed by the same letter are not significantly different at the P<0.10 probability level.
Na, data are not available

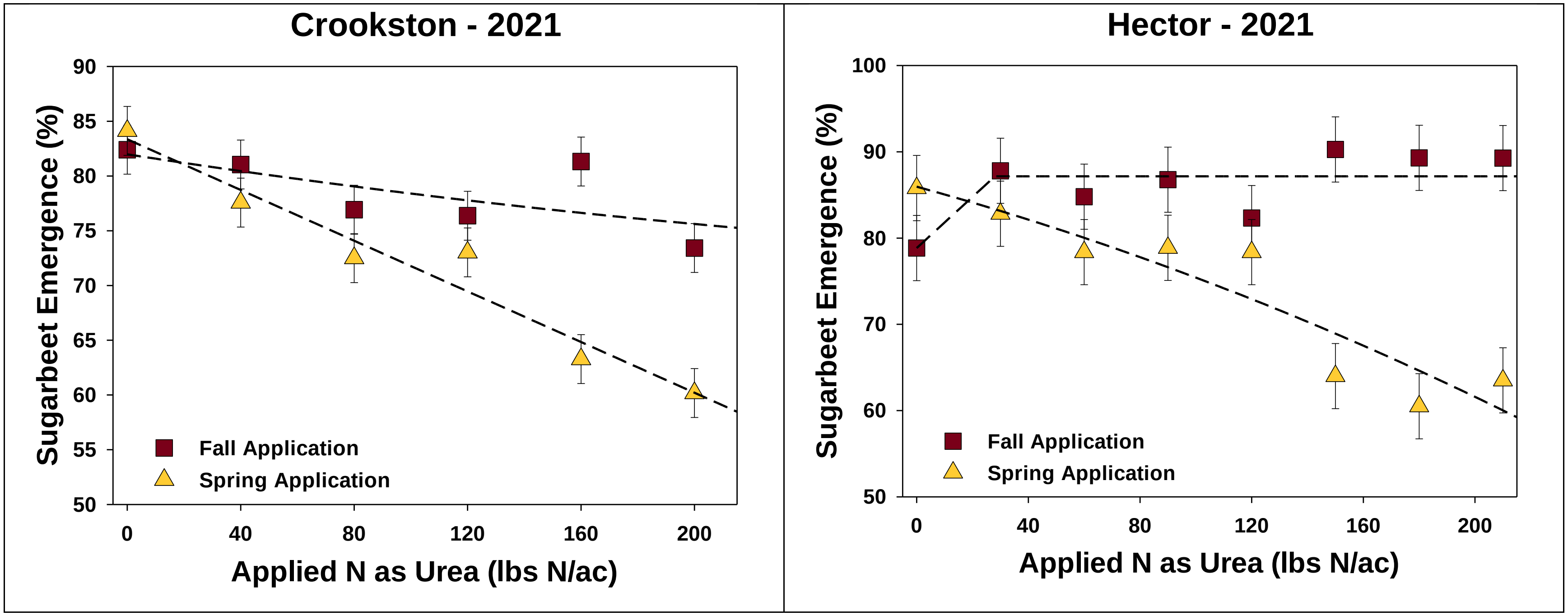


Figure 1a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet emergence at two Minnesota locations during the 2021 growing season.

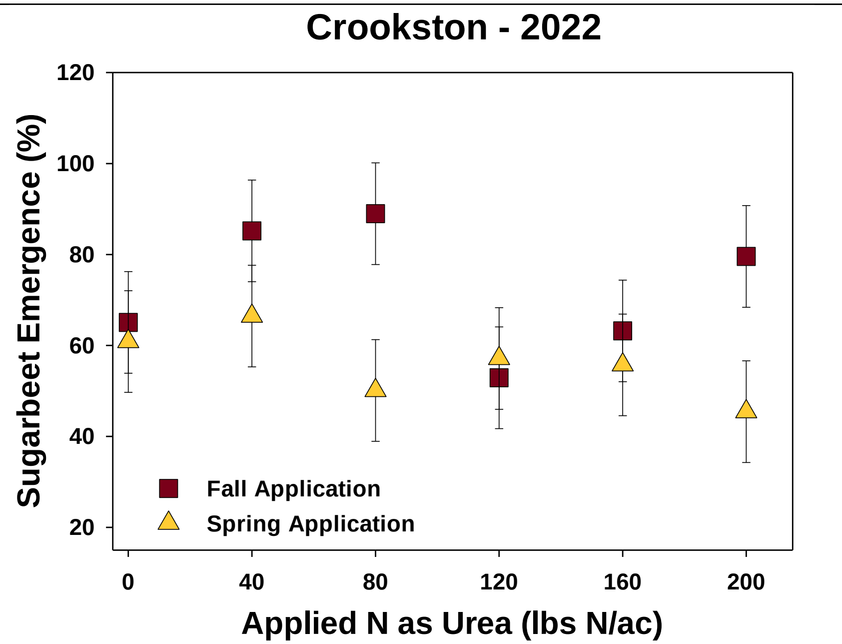


Figure 1b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet emergence at two Minnesota locations during the 2022 growing season.

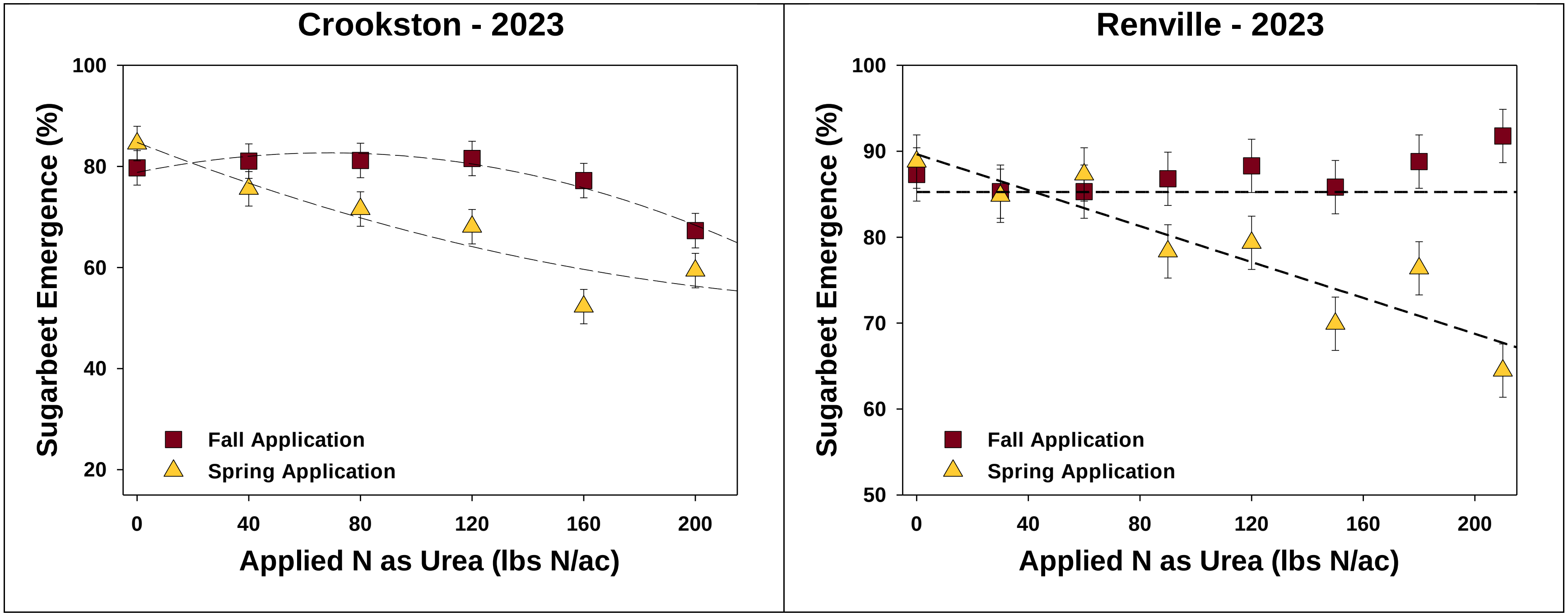


Figure 1c. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet emergence at two Minnesota locations during the 2023 growing season.

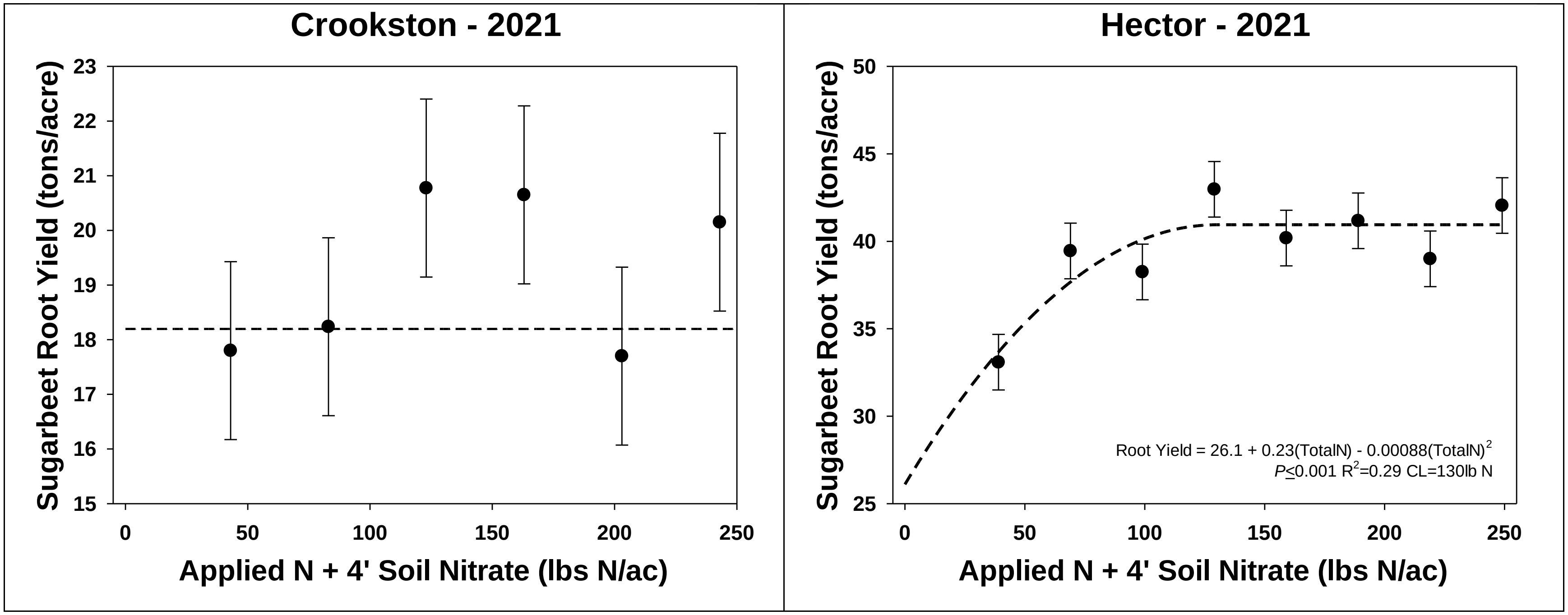


Figure 2a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet root yield at two Minnesota locations during the 2021 growing season.

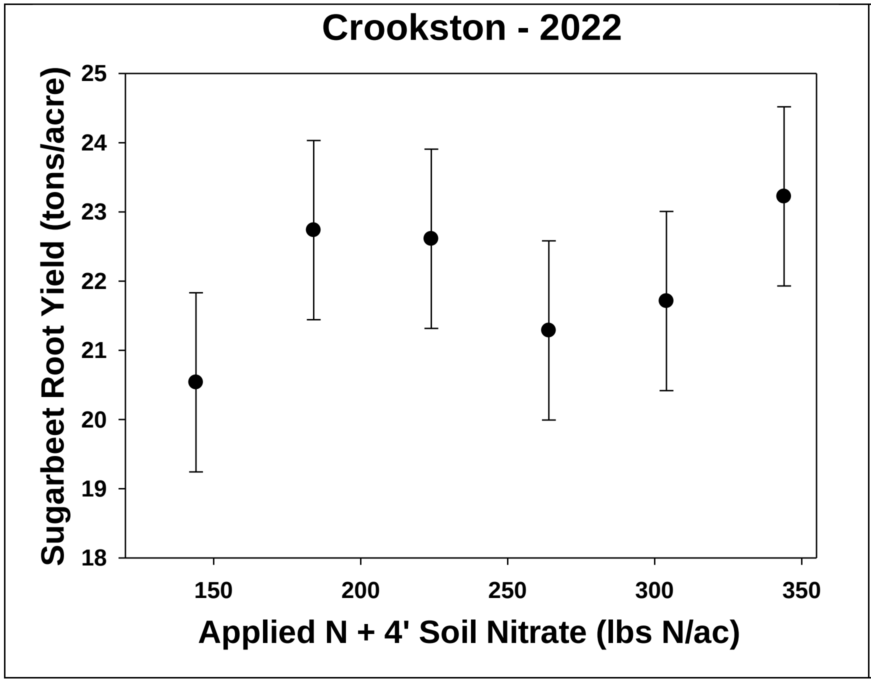
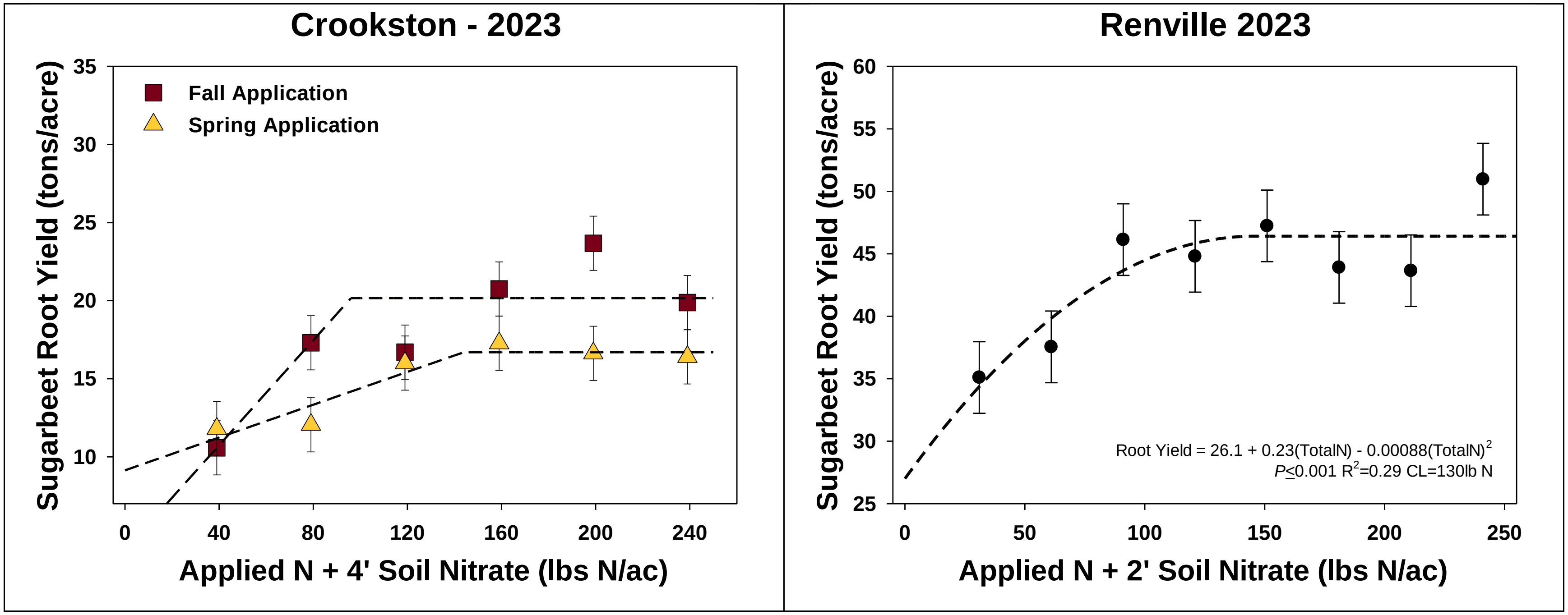


Figure 2b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet root yield at two Minnesota locations during the 2022 growing season.



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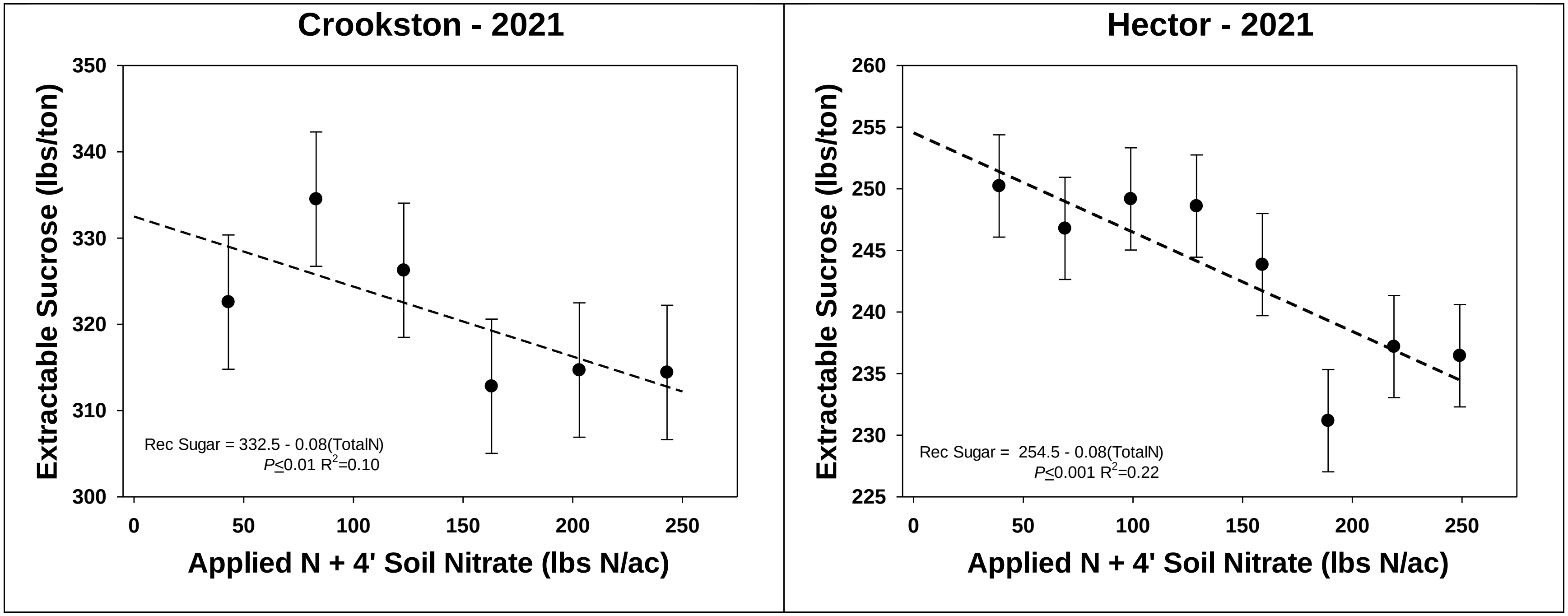

Figure 3a. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet extractable sucrose per ton at two Minnesota locations during the 2021 growing season.

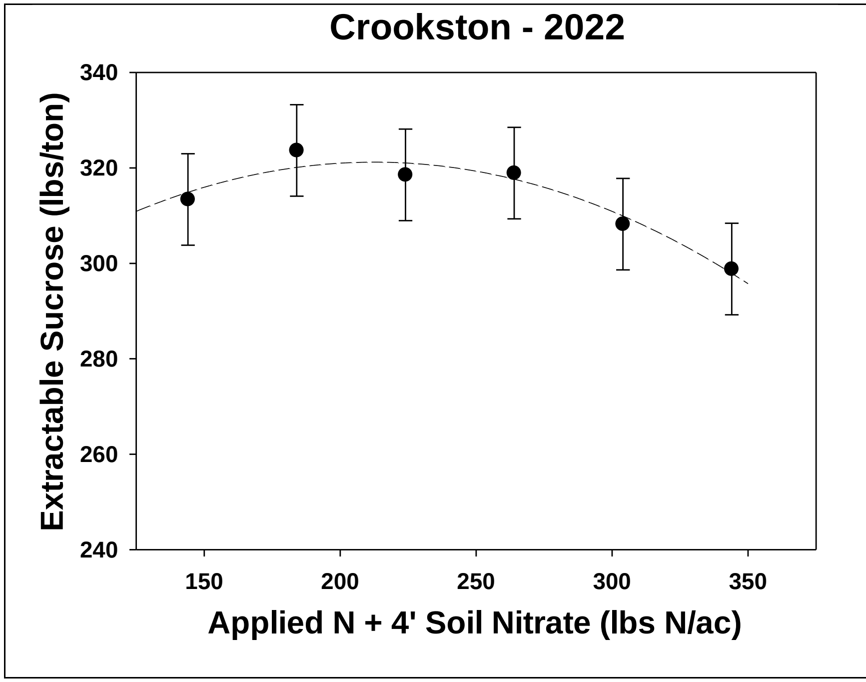

Figure 3b. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet extractable sucrose per ton at two Minnesota locations during the 2022 growing season.

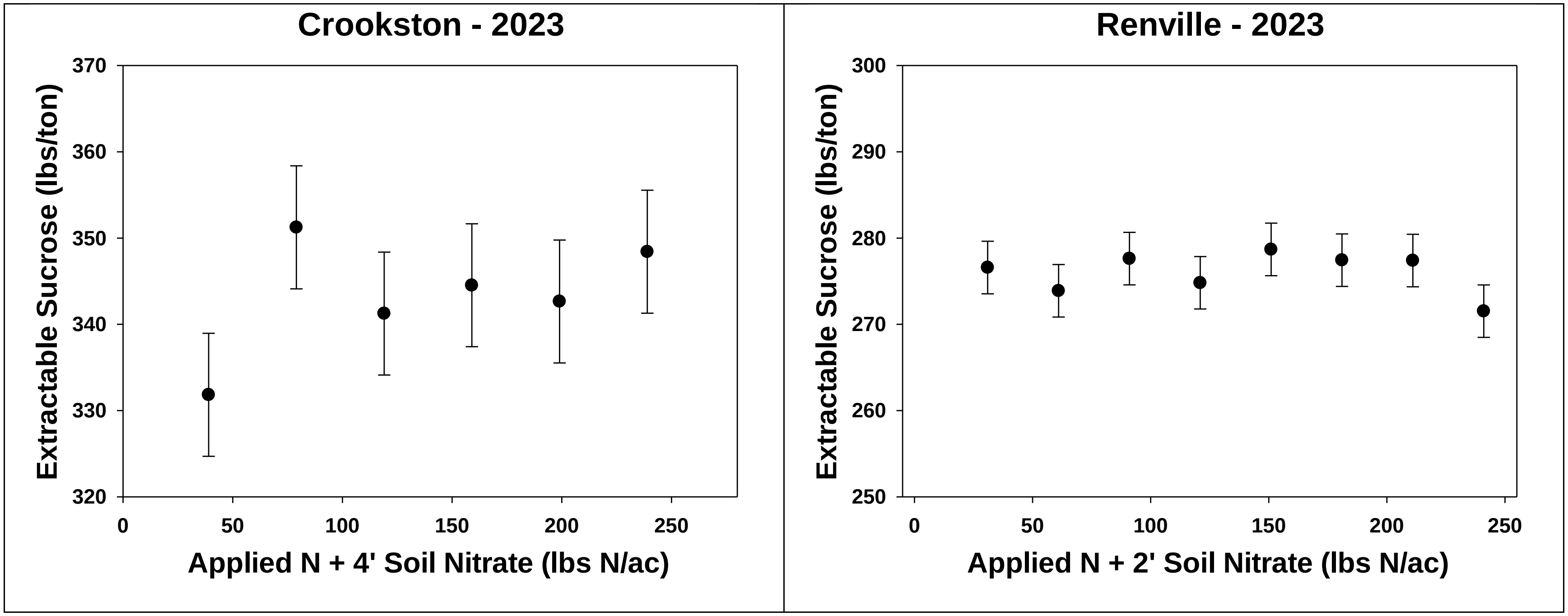

Figure 3c. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet extractable sucrose per ton at two Minnesota locations during the 2023 growing season.

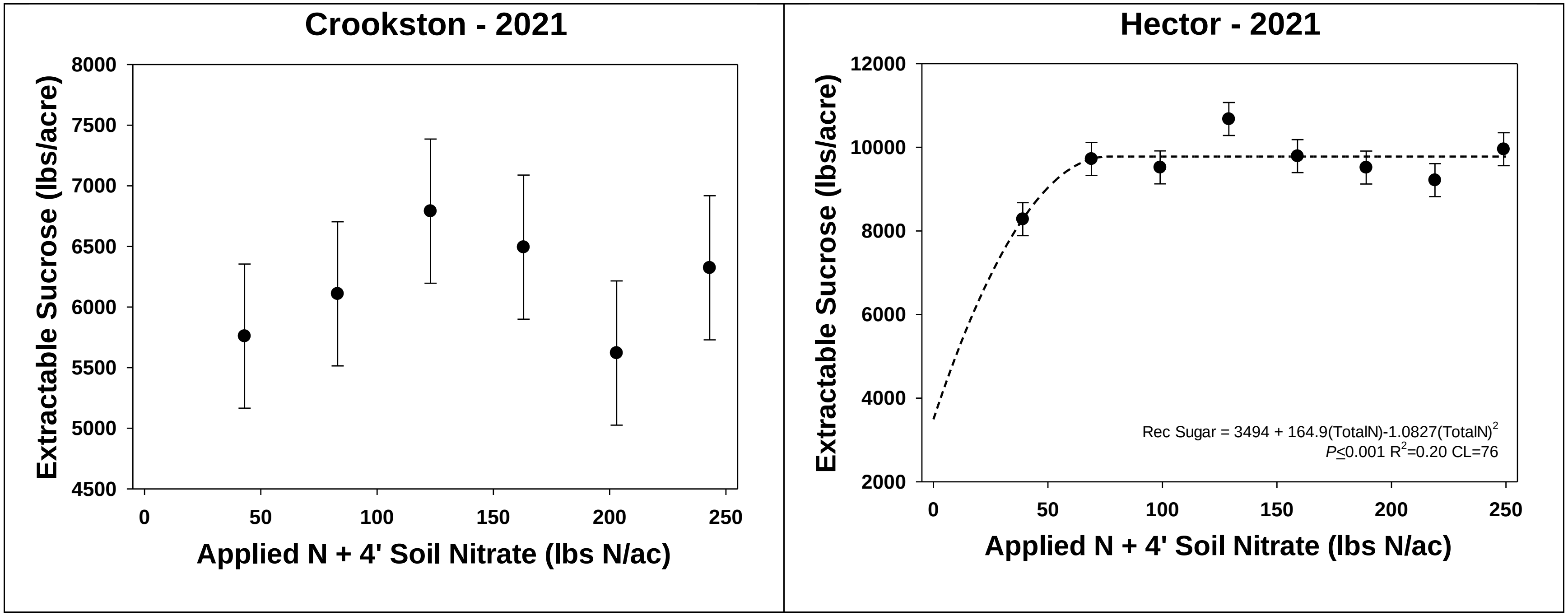

Figure 4a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet total extractable sucrose per acre at two Minnesota locations during the 2021 growing season.

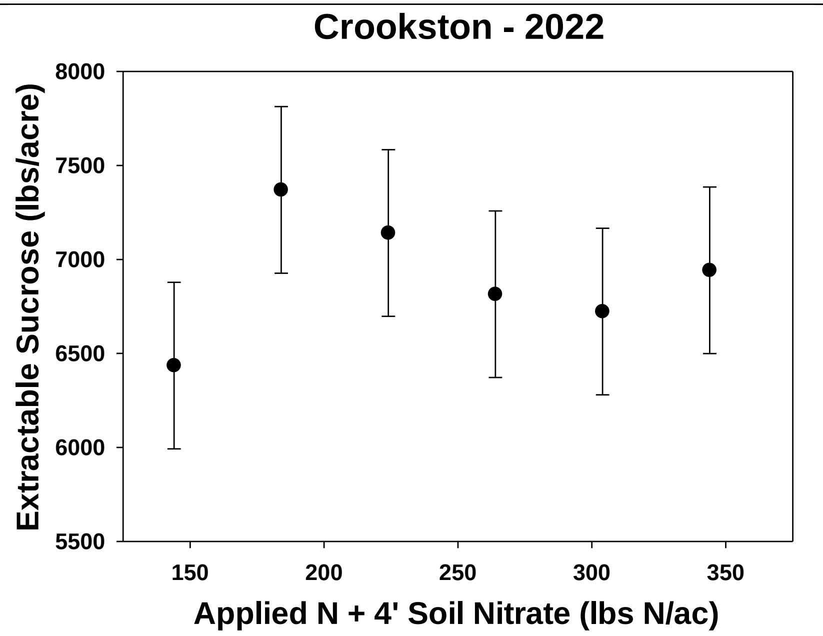

Figure 4b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet total extractable sucrose per acre at two Minnesota locations during the 2022 growing season.

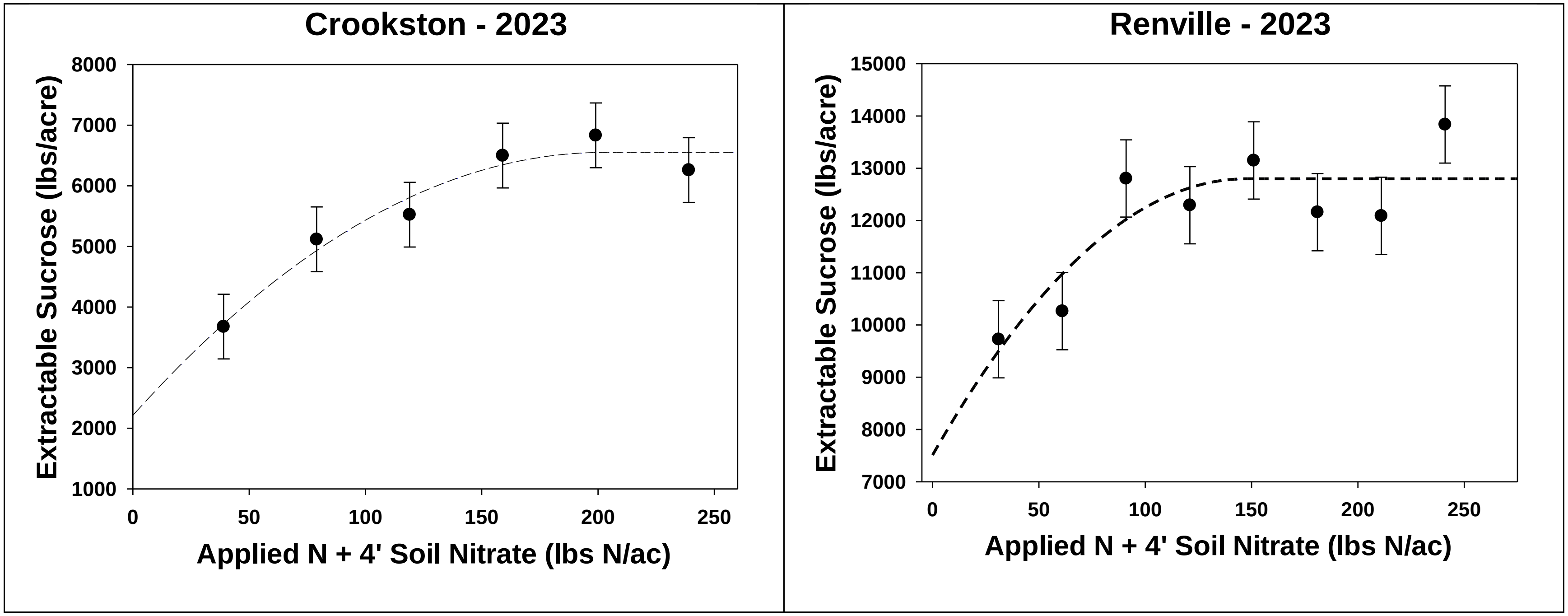

Figure 4c. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet total extractable sucrose per acre at two Minnesota locations during the 2023 growing season.

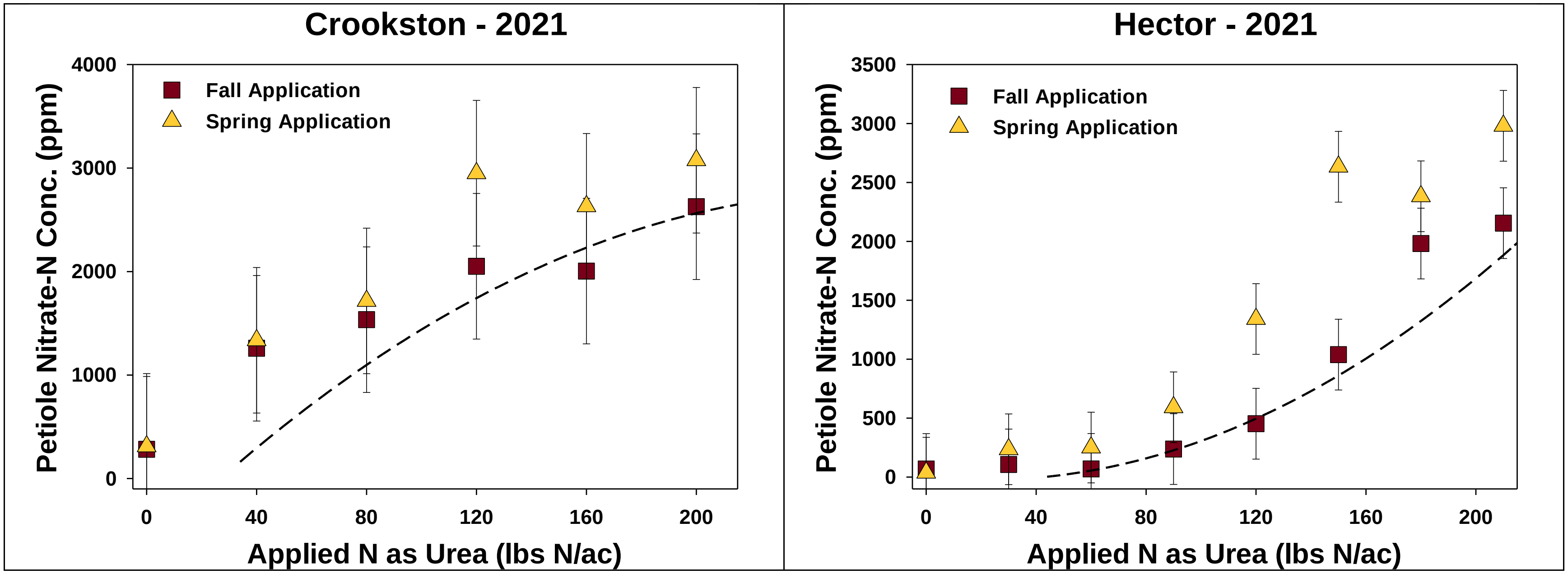

Figure 5a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July petiole nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2021 growing season. Samples were collected but had not been analyzed at the time of this report.

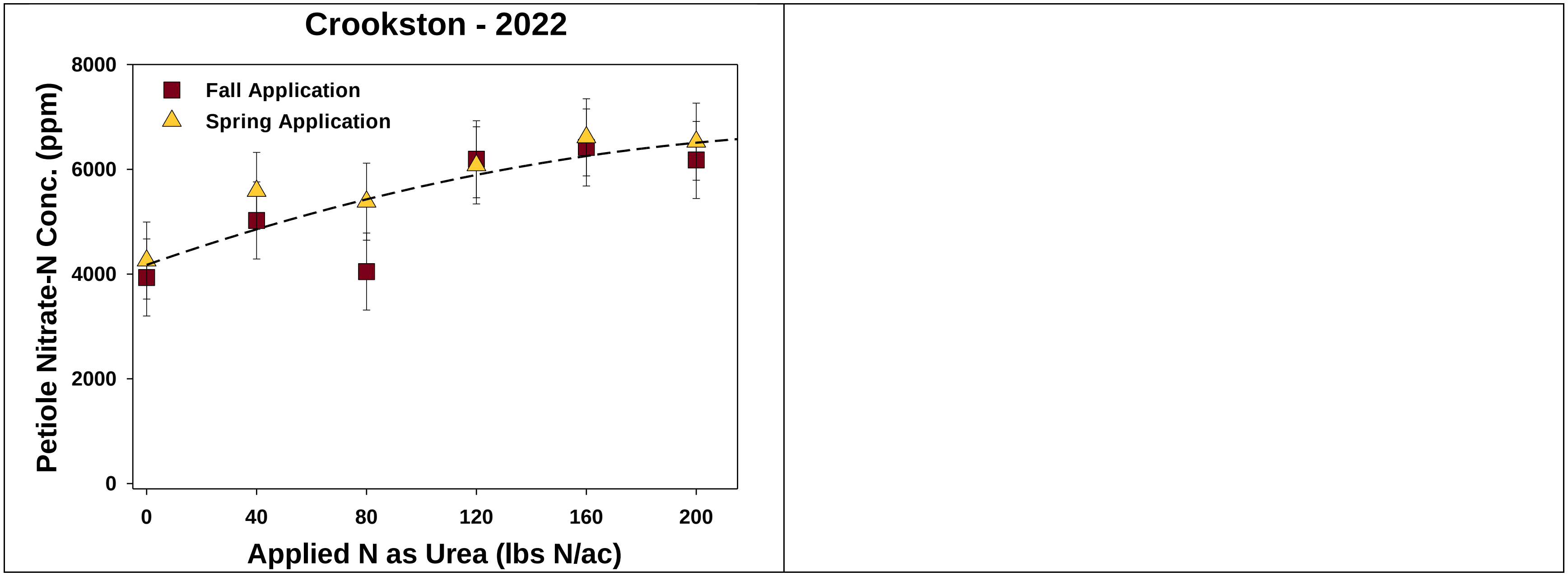

Figure 5b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July petiole nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2022 growing season. Samples were collected but had not been analyzed at the time of this report.

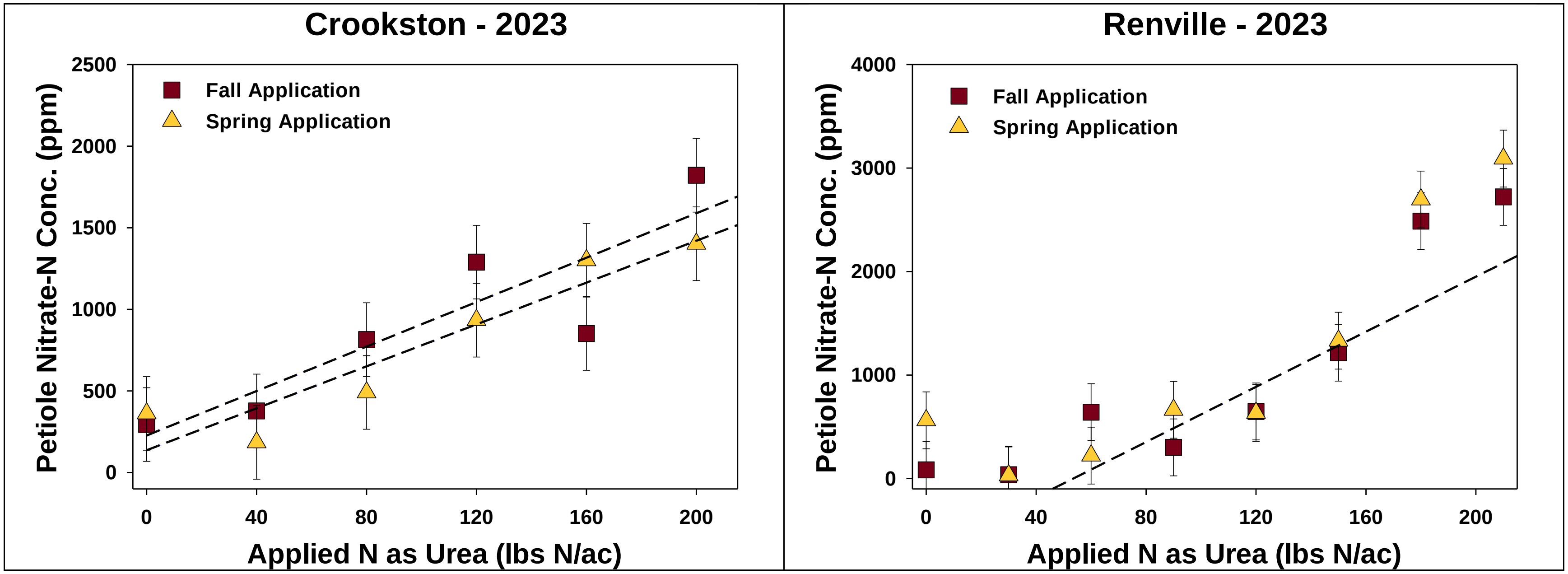

Figure 5c. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July petiole nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2023 growing season. Samples were collected but had not been analyzed at the time of this report.

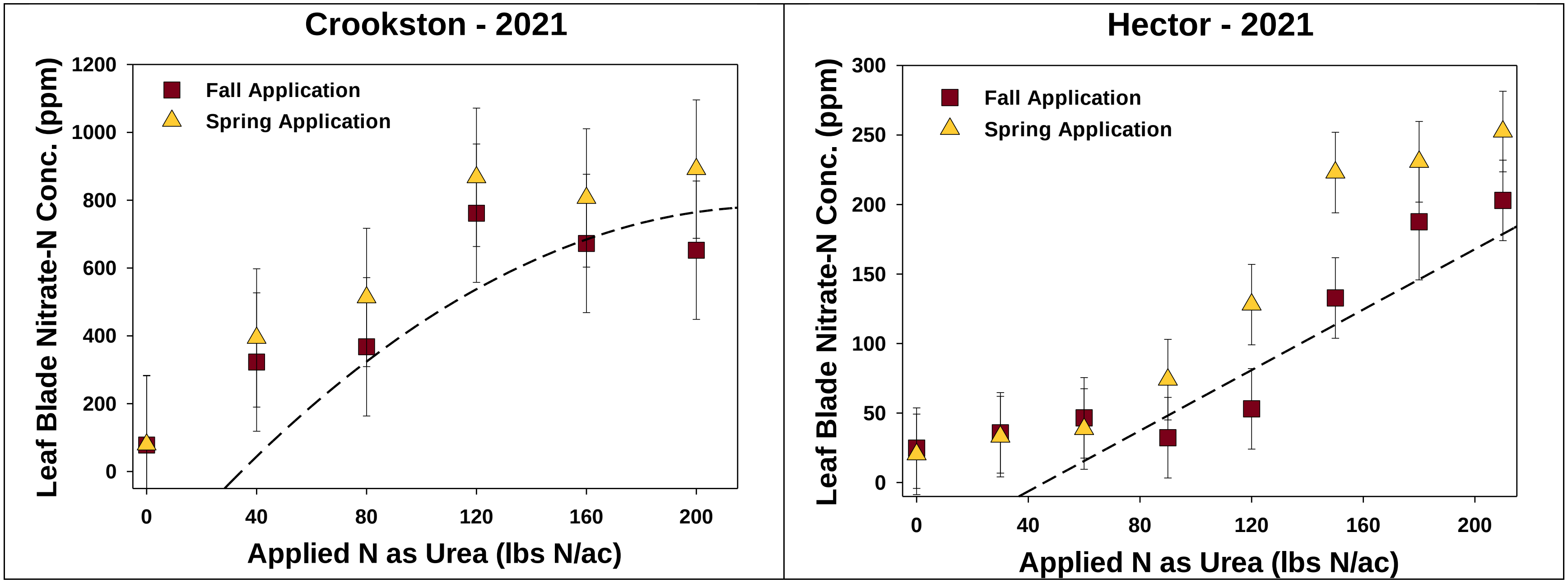

Figure 6a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July leaf blade nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2021 growing season. Samples were collected but had not been analyzed at the time of this report.

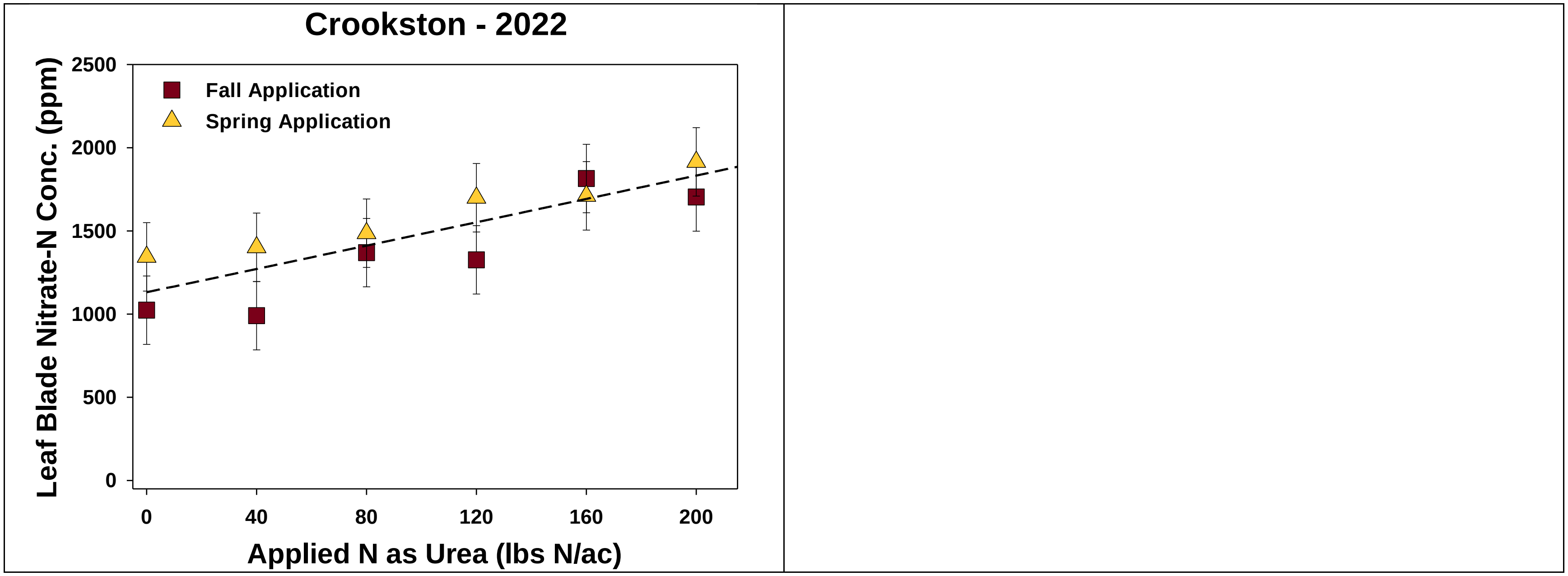

Figure 6b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July leaf blade nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2022 growing season. Samples were collected but had not been analyzed at the time of this report.

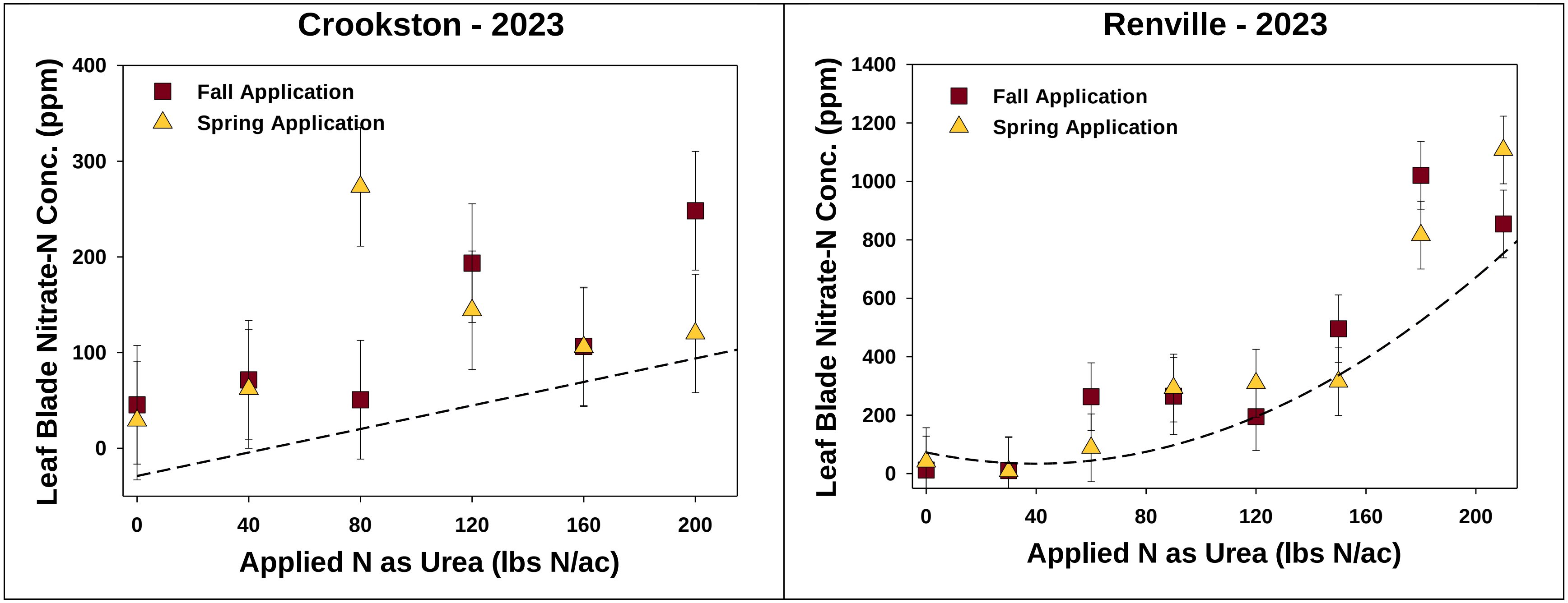

Figure 6c. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July leaf blade nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2023 growing season. Samples were collected but had not been analyzed at the time of this report.

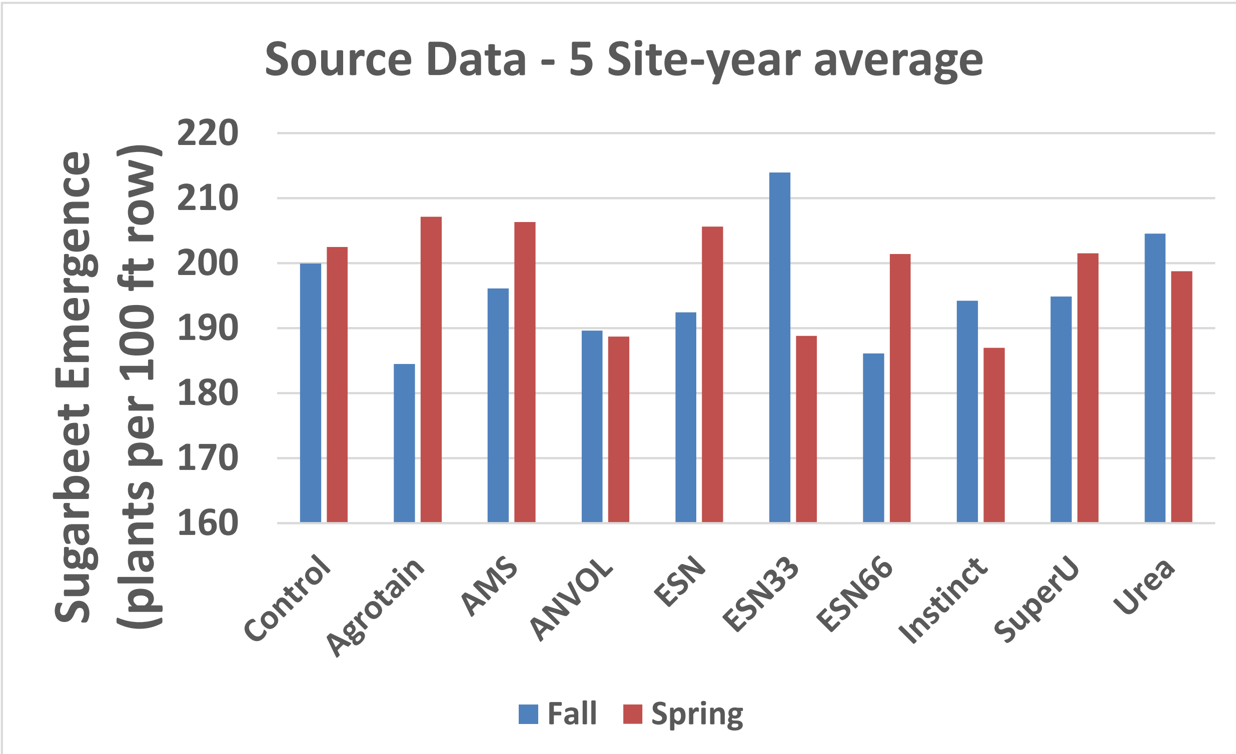

Figure 7. Summary of the impact of urea timing and source impacts on sugarbeet emergence following application of multiple urea sources and ammonium sulfate applied at 45 lbs. of N per acre summarized across 5 site-years for northern and southern Minnesota locations.

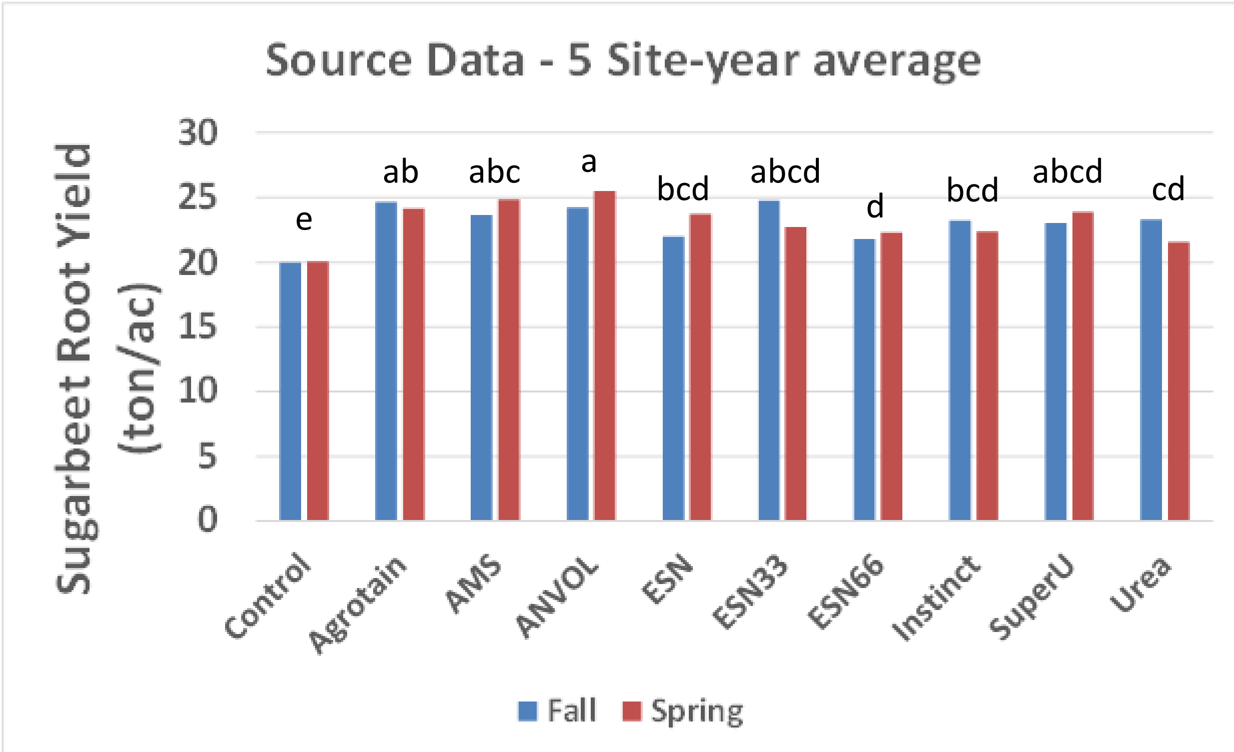

Figure 8. Summary of the impact of urea timing and source impacts on sugarbeet root yield following application of multiple urea sources and ammonium sulfate applied at 45 lbs. of N per acre summarized across 5 site-years for northern and southern Minnesota locations.

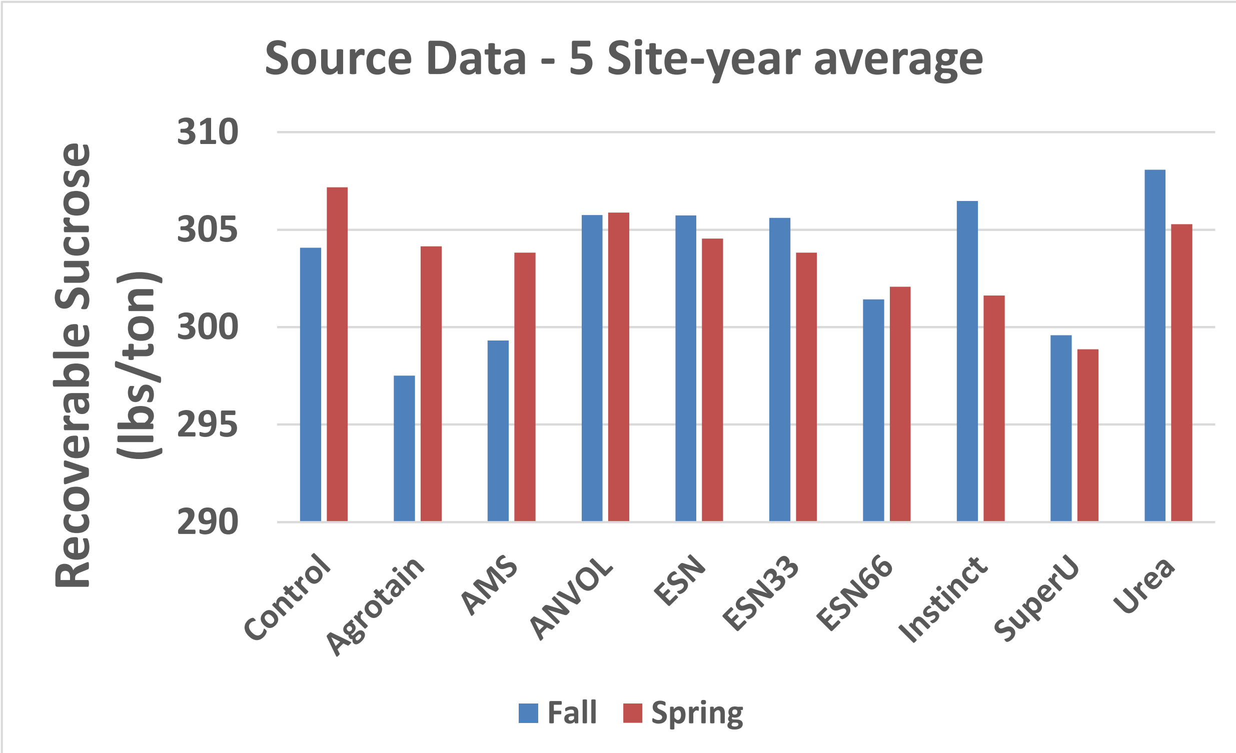

Figure 9. Summary of the impact of urea timing and source impacts on sugarbeet extractable sucrose per ton following application of multiple urea sources and ammonium sulfate applied at 45 lbs. of N per acre summarized across 5 site-years for northern and southern Minnesota locations.

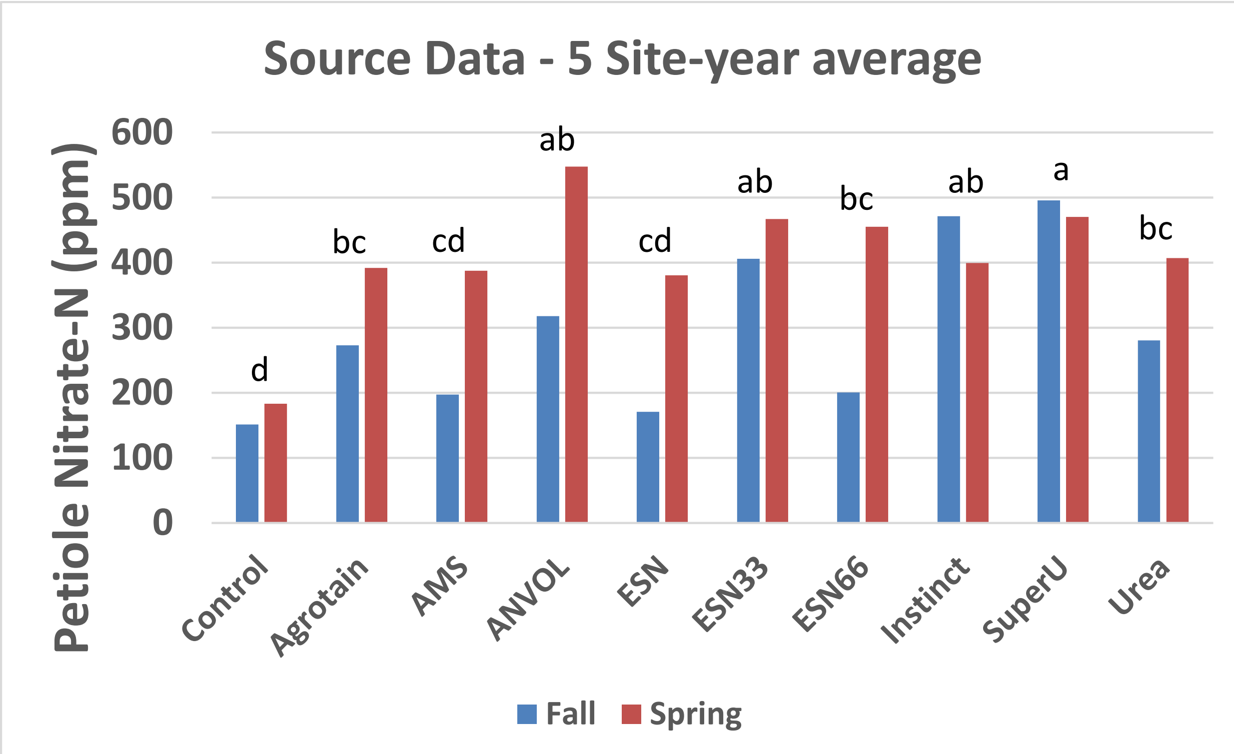

Figure 10. Summary of the impact of urea timing and source impacts on sugarbeet petiole nitrate-N concentration from the uppermost fully developed leaf 40-50 days after planting following application of multiple urea sources and ammonium sulfate applied at 45 lbs. of N per acre summarized across 5 site-years for northern and southern Minnesota locations.

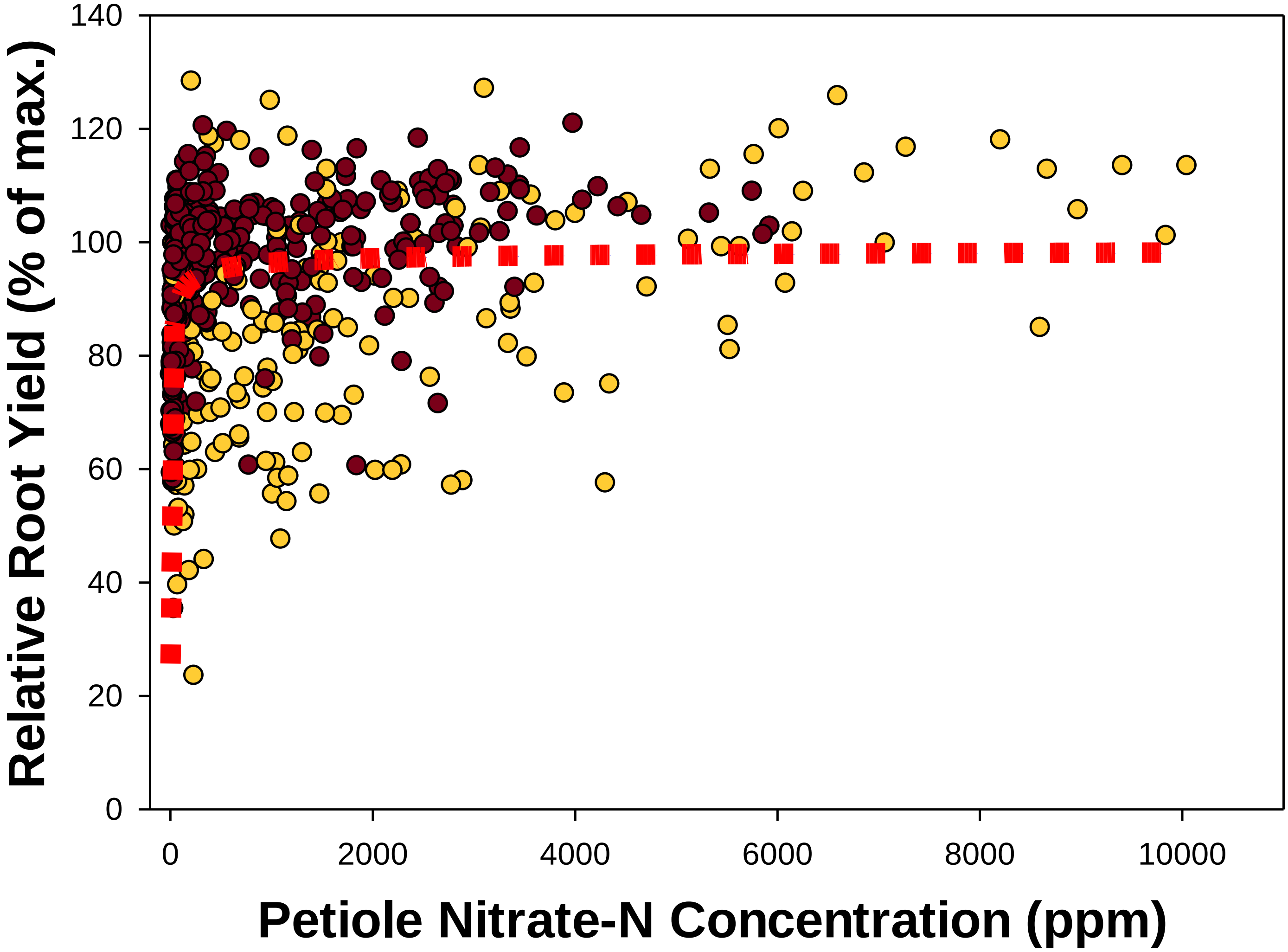

Figure 11. Relationship between relative sugar beet root yield (% of site maximum yield) and nitrate concentration in the uppermost fully developed petiole sampled in early- to mid-July roughly 40 to 50 days after planting. Maroon dots represent southern MN locations. Gold dots represent data from Crookston.

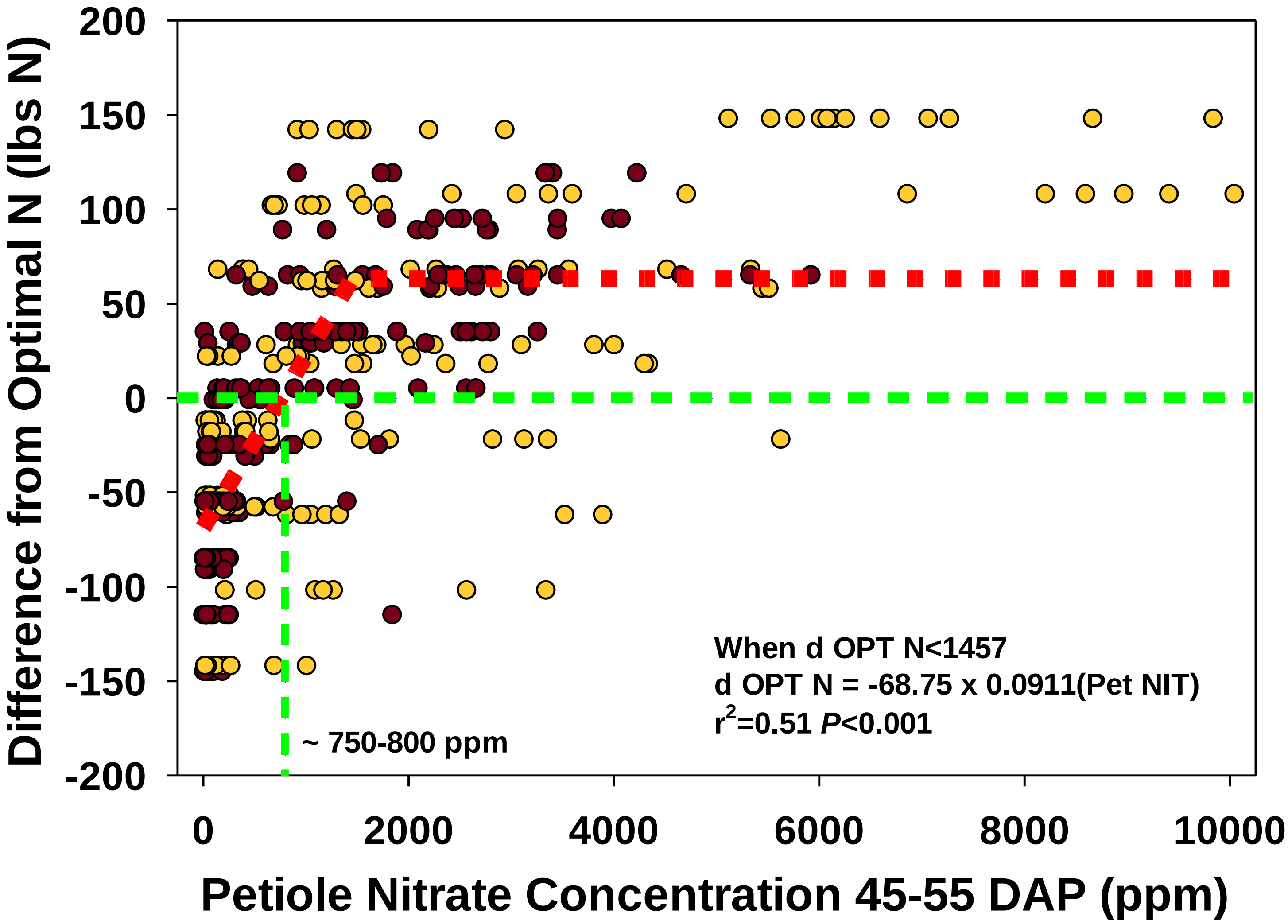

Figure 12. Relationship between the difference in the amount of N applied per plot and the amount of N required for optimum root yield and nitrate concentration in the uppermost fully developed petiole sampled in early- to mid-July roughly 40 to 50 days after planting. Maroon dots represent southern MN locations. Gold dots represent data from Crookston.

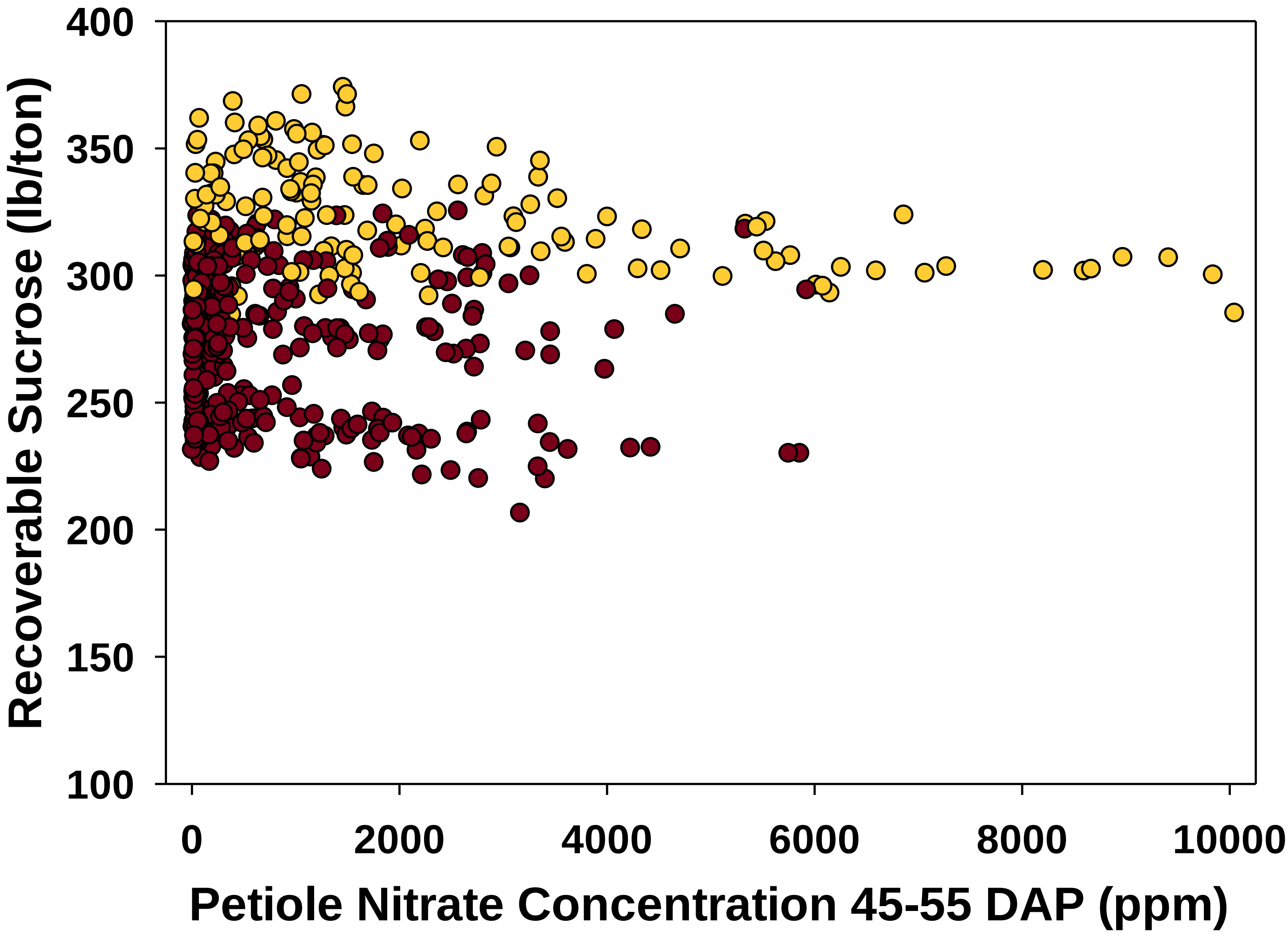

Figure 13. Relationship between recoverable sucrose per ton and nitrate concentration in the uppermost fully developed petiole sampled in early- to mid-July roughly 40 to 50 days after planting. Maroon dots represent southern MN locations. Gold dots represent data from Crookston.

IMPACT OF CROP SEQUENCE AND TILLAGE ON CROP YIELD AND QUALITY, SOIL NUTRIENTS, PH, TEXTURE AND MICROBIAL POPULATION – YEAR 3 REPORT.

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The increasing demand for agriculture productivity which aligns with sustainable and conservational goals has been a significant challenge for both growers and researchers (Cohen, 2002). Crop rotation and tillage practices which are considered a part of a "conservation agriculture" system (Giller et al. 2015) could significantly improve crop yield and quality (Pittelkow et al. 2015) in an environmentally friendly manner which resonates with the United Nations Sustainable Development Goals (SDGs) focuses on ensuring zero hunger, responsible production, and consumption, with positive impact on global climate. Conservation tillage (where ≥ 30% crop residue remains) and crop rotation (systematic inter-cropping over the years) can provide benefits such as reduced labor and energy use contributing to low CO2 emissions, soil conservation (Busari et al. 2015), improved soil organic matter content (Somasundaram et al. 2019) and infiltration which helps to reduced erosion losses (Govaerts et al., 2009). To tackle the earlier mentioned challenge of increasing food demand and sustainable agricultural productivity, there is a need to adopt conservational over conventional agricultural practices (Saikia et al. 2020).

To provide information that would help growers make that positive decision for the switch, an interdisciplinary study was carried out to assess the impact of crop sequence and tillage on crop yield quality, soil nutrients, pH, texture, and microbial population.

MATERIALS AND METHODS

A field trial was conducted at Prosper, ND in 2023 (Figure 1). The experimental design was a strip block with four replicates. Strip tillage and conventional tillage were conducted in both the fall of 2022 and prior to planting on 31 May 2023. Field plots comprised of six 30-feet long rows spaced 22 inches apart. Plots were planted on 1st of June with corn (Peterson Farms Seed 22T83), soybean (AG09XF0) and hard red spring wheat (Faller). Corn seeds were planted at a population of 35,000 seeds per acre, soybean seed was planted at a rate of 175,000 seeds per acre while wheat was drilled at a rate of 124 pounds per acre. Weeds in the corn and soybean plots were controlled with herbicide applications (Zidua @ 3 fl oz per acre; Roundup Powermax 3 @ 25 fl oz per acre) on June 6, (Outlook @ 12 fl oz per acre; Amsol @ 2.5%v/v; Interlock @ 4 fl oz per acre; Cornerstone 5 Plus @ 35 fl oz per acre) on June 18 and (Roundup Powermax 3 @ 30 fl oz per acre; Outlook @ 12 fl oz per acre; Amsol @ 1% v/v; Interlock @ 4 fl oz per acre) on June 30 as well as hand weeding throughout the summer.

Wheat was sprayed with Huskie Complete on June 6 to control weeds and hand weeding was done throughout the summer as needed. Urea fertilizer (46-0-0) was spread on the conventional tillage plots to be planted to corn and wheat prior to conventional tillage. Urea fertilizer (46-0-0) was spread on the strip tillage and no-tillage plots planted with corn and wheat on June 21 prior to rainfall. Wheat was harvested by plot combine on September 11, soybeans were harvested with a plot combine on October 17 and corn was harvested by a plot combine on November 2. Soybean and wheat analysis was conducted by the Plant Pathology Department at North Dakota State University. Corn analysis was conducted with Dickey John moisture and protein reader by the Plant Science Department at North Dakota State University. 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.

Soil samples were collected from different treatments just before planting. Representative soil samples were sent to the soil microbiology department, specifically Dr. Samiran Banerjee's lab, as well as the University of Minnesota for soil microbiome analysis. The remaining soil samples were sent to AGVISE for analysis of various soil parameters, including nutrients, organic matter, and carbon. The respective data will be analyzed after the testing is completed. In addition to the initial objectives, 27 soil temperature probes were installed to collect soil temperature data corresponding to the crop sequence and tillage type. Furthermore, soil erosion pads were installed within the planting rows to measure the impact of crop sequence and tillage type on soil erosivity. Early disease symptoms were not observed during the seedling stage in any of the treatments, and the plants are growing well, although the emergence rate differs among the different crop and tillage types. Towards the end of the season, there was no significant disease impact due to proper agronomic practices incorporated throughout the study, so there was no evaluation for disease severity.

RESULTS AND DISCUSSION

The effects of tillage methods and crop sequences respectively, were not significant on yield for soybean ($p>0.14$), corn ($p>0.20$), and wheat ($p>0.21$). This was the same for moisture content and test weight respectively in soybean ($p>0.78$, $p>0.70$), corn ($p>0.29$, $p>0.45$) and wheat ($p>0.16$, $p>0.21$). All values of LSD at $p=0.05$ were calculated and given in Table 1 a, b, and c. As can it be seen, none of the differences between any treatments was larger than the respective LSD value.

The microbiome study revealed no significant differences in observed taxa across crops or tillage methods ($p > 0.05$). However, the number of observed taxa tended to decrease with increasing depth ($p = 0.001$). Numerically, corn exhibited a higher abundance of observed microbial taxa than soybeans (Fig 2). Additionally, there was no significant interaction between tillage types and soil nutrients, pH, and carbonate. Nevertheless, a significant difference in pH across various soil depths was observed (Fig 3).

Remarkably, soil erosivity data indicated that wheat experienced significantly less soil erosion compared to corn and soybeans ($p < 0.05$). Soil erosivity across tillage types was significantly lower in the wheat crop sequence and the no-tillage type which is an indication that the type of tillage employed can significantly increase soil erosion which is a significant limitation faced in many research and commercial fields. This difference was attributed to the previous year's crop sequence, where no-till corn was planted, and existing corn residues helped prevent erosion. Across tillage types, no-till practices demonstrated significantly less soil erosion than conventional and strip tillage (Fig 4).

Analysis of beneficial and other insects' collection revealed that the highest number of insects was observed in weeks 1 and 3, with corn and wheat hosting the most insects. Insect populations decreased in weeks 4 and 5, followed by a gradual increase until week 8 (Fig 5). Similarly, earthworm collections, indicative of healthy soil, showed a uniform distribution of their numbers across both crop types and tillage methods, although the counts were generally lower (Fig 6).

Recent data from the year 2023 field experiment further supports previous research results which indicated that corn, soybean, sugar beet including wheat can be successfully grown under different tillage types in the Red River Valley. Where possible, care should be taken to reduce corn residue especially in strip tillage and moving residue with coulters in to till to facilitate planting to get a good plant population. With continuous flooding of some plots which seems to be the recurring challenges faced every year regarding this research, there are ongoing consultations as to how to prevent these limitations in future experiments.

With additional objectives added to the focus of these project, there is a more diverse insights to how crop sequences and tillage type can impact not only crop yield, quality, soil physio-chemical properties, microbial populations but also earthworm and beneficial insects' distribution as well as soil temperature and erosivity. The overall results from these objectives would significantly contribute to more environmentally friendly agronomic practices that can be adopted by growers in the Red River.

Considering the continuous progressive results obtained from this project, we aim to proceed with another field year in 2024. This will complete the initial 4-year crop rotation plan initially budgeted for this project. The 2024 plots will be planted in May with the crops being corn, soybean, and sugar beet in the 4th year of the sequence (Sugar beet/Soybean/Soybean/Corn).

Table 1a. Soybean, Table of Means, Tillage

Tillage	Yield	Moisture (%)	Test weight
Conventional Tillage	41.73a	11.25a	57.20a
Strip Tillage	44.63a	11.20a	57.28a
No Till	42.55a	11.13a	57.38a
LSD at p=0.05	3.16	0.43	0.50

Table 1b. Corn, Table of Means, Tillage Type

Tillage	Yield	Moisture (%)	Test weight
Conventional Tillage	208.93a	15.53a	58.34a
Strip Tillage	208.25a	17.43a	57.53a

No Till	184.73a	15.98a	58.93a
LSD at p=0.05	23.17	1.98	1.81

Table 1c. Wheat, Table of Means, Tillage Type

Tillage	Yield	Moisture (%)	Test weight
Conventional Tillage	64.43a	12.80a	58.40a
Strip Tillage	52.15a	14.03a	57.15a
No Till	61.00a	19.80a	53.30a
LSD (p=0.05)	15.6	8.25	6.46

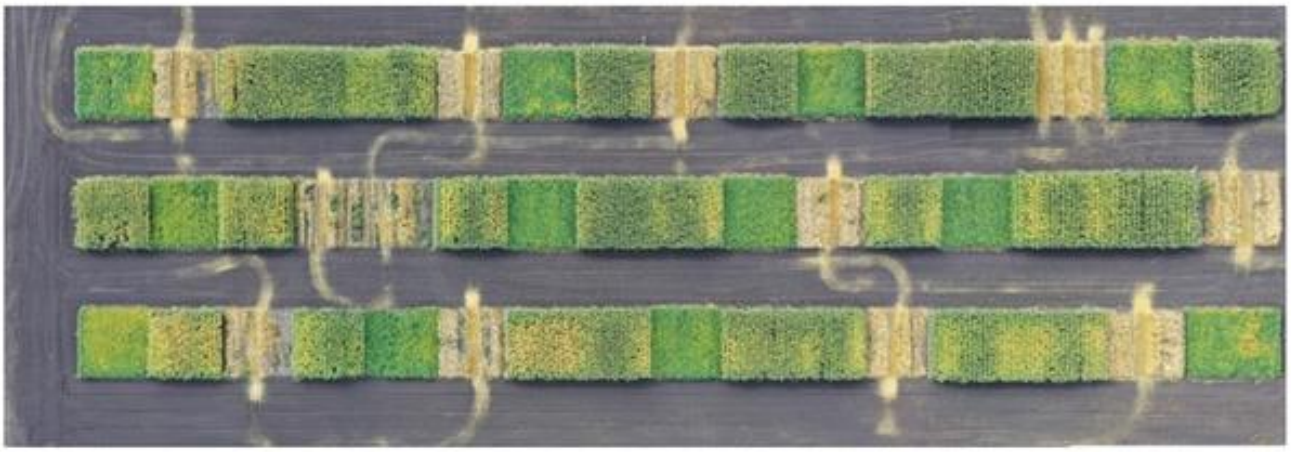

Fig 1: Crop sequence and tillage trial (wheat/corn/corn/soybean) located at Prosper, ND

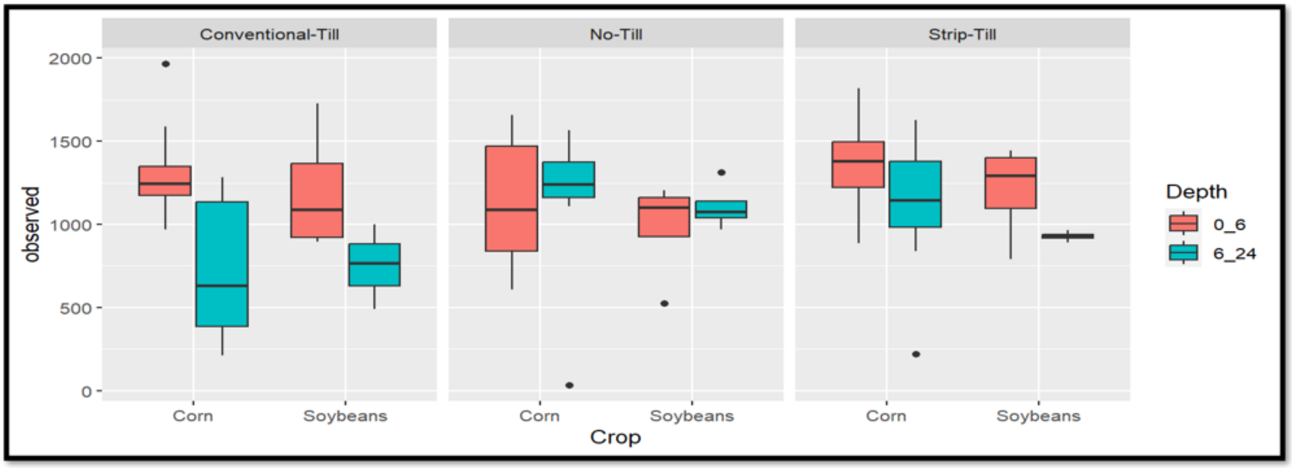

Fig 2: 2023 Data for Corn and Soybean (Beta Diversity) showing the relative abundance of the 16S gene from soil samples (0-6'' and 6-24'') under different tillage regimes

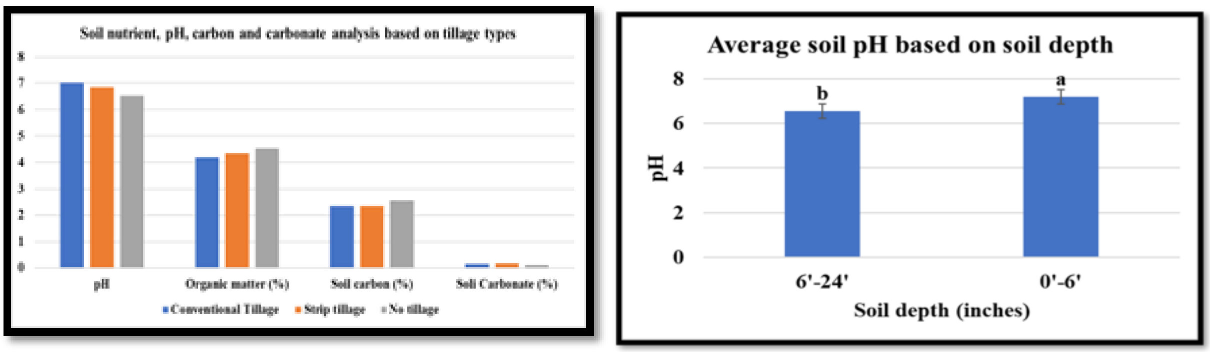

Fig 3: Soil nutrient, pH, carbon, and carbonate analysis (left) and soil pH based on soil depth (right)

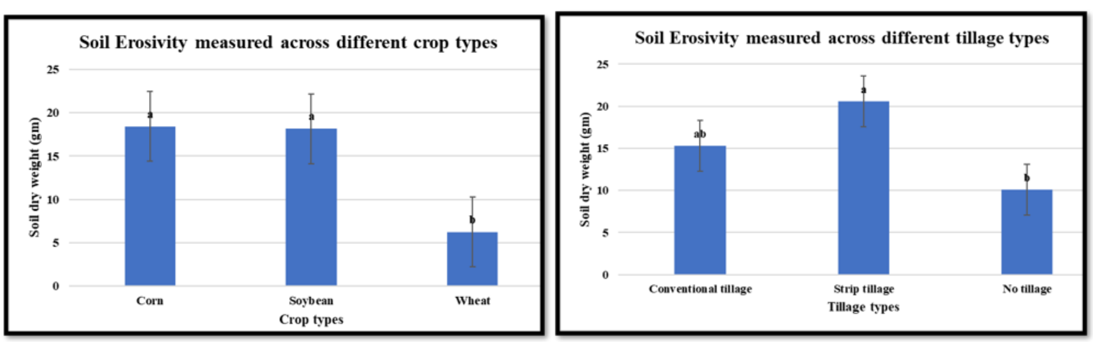

Fig 4: Soil erosivity across crop types (left) and tillage types (right)

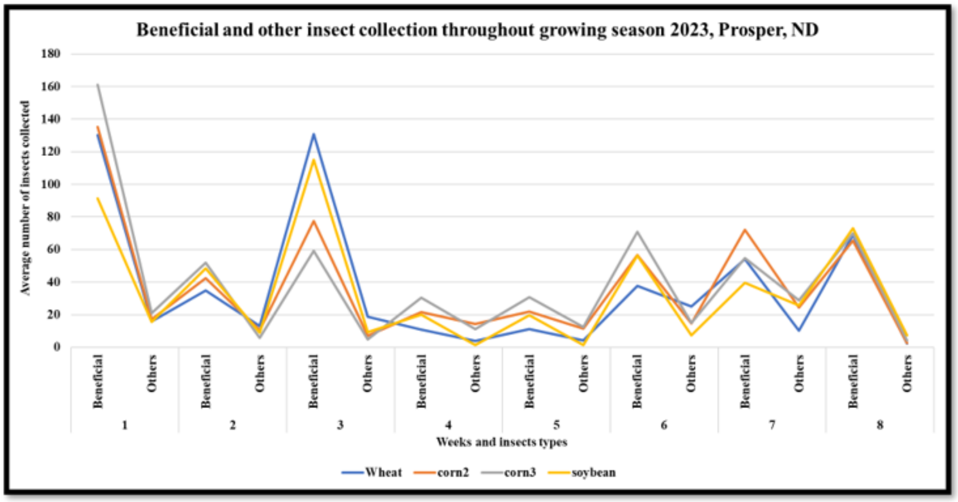

Fig 5: Survey of beneficial and other insects collected throughout growing season 2023

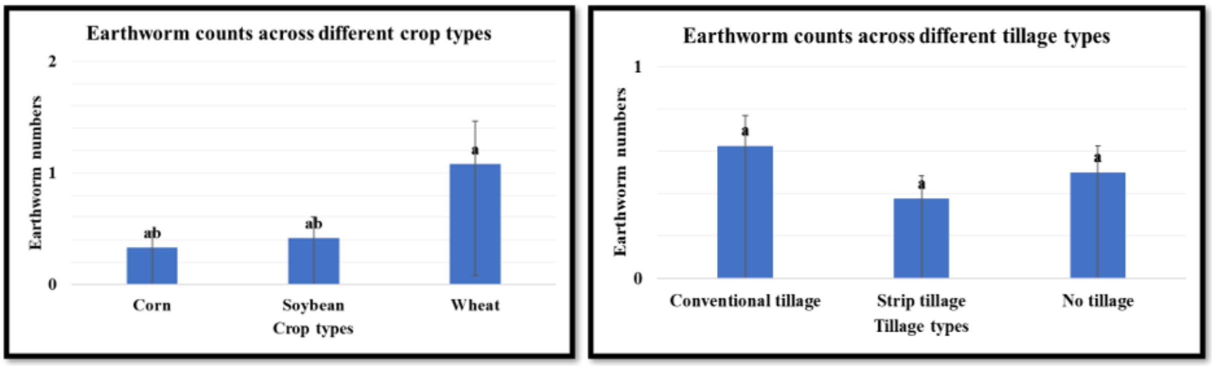

Fig 6: Earthworm distribution across different crop types (left) and tillage types (right)

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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 application 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 sugarbeets at Nashua and Murdock, respectively. Soil samples (1-ft depth) were collected two times throughout each growing season to monitor potential changes in the levels of both nitrate and ammonium.

Preliminary Results:

Year 1 following manure application - This experiment began in the fall of 2019 at a farm site near Murdock, MN and in fall 2020 at a farm site near Nashua, MN. Both sites followed a corn crop. 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). At the Murdock site, corn (Enesvedt E-696RR), soybean (Stine Liberty Link GT27), and sugarbeet (SESVDH 863) were planted on April 30 to May 1, 2020 and maintained according to typical practices in the region. At the Nashua site, corn (Dekalb DKC49-44RIB), soybean (Dekalb AG10XF1), and sugarbeet (ACH 973) were planted on May 3, 2021.

Table 3. Soil and manure test results for Murdock site in fall 2019 and Nashua site in fall 2020.

Initial soil test results		Manure characteristics		Manure as-applied (lb/acre)†		
		Nutrient	(lb/1000 gal)	Nutrient	High rate	Low rate
Murdock site – Fall 2019						
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
Nashua site – Fall 2020						
pH	7.3	Total N	25	Total N	380	260
Nitrate – 0-24" (lb/ac)	16.5	Ammonium-N	13.1	First year N‡	209	143
Bray P (ppm)	53	Total P_2O_5	14	Total P_2O_5	219	145
K (ppm)	194	Total K_2O	21	Total K_2O	321	212

†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 source. We collected soil samples (0-1 ft) twice during the growing season for nitrate analysis. Early in the growing season at the Murdock site we noted some issues with the soybean in the manured plots; growth was stunted and the plants were yellow, indicative of iron chlorosis deficiency. We collected trifoliate tissue samples to see if nitrate and/or chloride levels were elevated in the plants. This problem did not occur at Nashua. When corn reached maturity (around the R6 growth stage) we collected plant samples (stalk, cob, and grain) to evaluate nitrogen uptake. Post-harvest soil samples were also collected from each plot. These samples have not been fully analyzed yet and the results will be discussed in a later report.

Sugarbeets were harvested on September 30, 2020 at Murdock and on September 26, 2021 at Nashua. There were no significant differences between nutrient source treatments on yield or quality measurements when averaged over both sites (Table 4). There was a significant difference between sites for root yield (Nashua had higher root yield than Murdock) but not for quality measurements. Soybeans were harvested on October 2, 2020 at Murdock and November 4, 2021 in Nashua. There was a significant nutrient source treatment by site interaction. For the Murdock site, there were few plants that survived 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. At Nashua, however, manured plots tended to have higher yield than the fertilizer-only plots, though differences were not significant (Figure 1). Corn was harvested on November 4, 2020 at the Murdock site and October 18, 2021 at Nashua. Both treatments with manure tended to have higher yield than the fertilizer only plot (Figure 2), but differences were not significant. There were no differences between sites.

Table 4. Yield, extractable sucrose (per ton and per acre), and sucrose percent purity averaged over both sites the first year after manure application.

Main effect	Yield (tons/acre)	Extractable Sucrose (lb/ton)	Extractable Sucrose (lb/acre)	Sucrose Purity (%)
Nutrient Source				
Fertilizer only	36.1a†	290a	10,452a	91.2a
Low dairy manure rate	36.9a	285a	10,511a	91.3a
High dairy manure rate	38.5a	282a	10,831a	90.8a
Site				
Murdock	34.7b	292a	10,118a	90.9a
Nashua	39.7a	279a	11,078a	91.2a

†Similar letters within a row and research site indicate no significant differences between the values ($p > 0.05$).

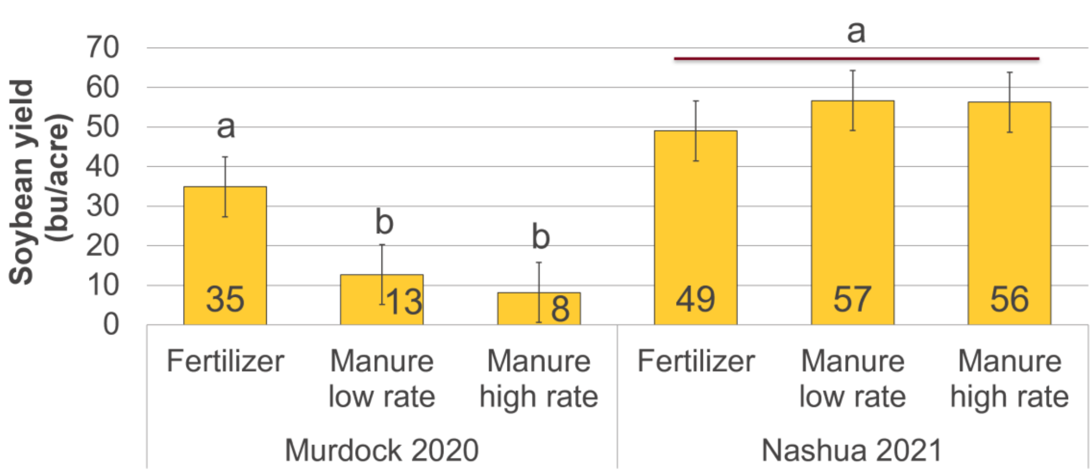

Figure 1. Soybean yield (adjusted to 13% moisture) at Murdock site in 2020 and Nashua site in 2021. There was a significant site by nutrient source interaction. Different letters above a bar indicates a significant difference ($p <0 .05$).

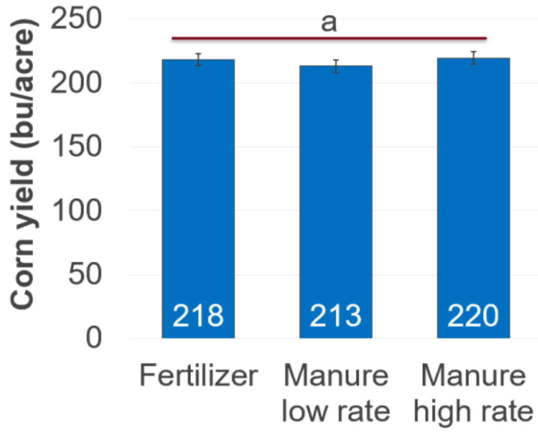

Figure 2. Corn yield (adjusted to 15.5% moisture) averaged over sites (Murdock in 2020 and Nashua in 2021). Different letters above a bar indicates a significant difference ($p < 0.05$).

Post-harvest soil samples from the top six and 24 inches of soil (Table 5) indicated that there were differences in residual nutrient content across treatments. Soil nitrate levels in the top 24 inches of soil tended to be lowest in plots that were previously in sugarbeet and were consistent across treatments. Soil nitrate increased with increasing manure application rate in the plots where soybean was the previous crop, while the opposite happened in the plots where corn was the previous crop. This was interesting since these trends were consistent across sites and in two different years. Soil test phosphorus levels varied and ranged from medium to high levels. They tended to be higher at Nashua than at Murdock. Soil test potassium levels were all high or very high and tended to increase with increased manure application rate. Fertilizer rates were adjusted accordingly for each crop and nutrient treatment.

Table 5. Soil test results for the Murdock site in fall 2020 and the Nashua site in fall 2021. All samples were taken in the top six inches of soil except the nitrate samples which were the top 24 inches of soil.

	Murdock site – Fall 2020			**Nashua site – Fall 2021**		
Initial soil test results	**Nitrate 0-24” (lb/ac)**	**Olsen P (ppm)**	**K (ppm)**	**Nitrate 0-24” (lb/ac)**	**Olsen P (ppm)**	**K (ppm)**
Previous crop sugarbeet (going into soybean)						
Fertilizer-only	37	10	157	15	16	216
Low-rate manure	33	9	178	14	26	233
High-rate manure	37	12	243	15	34	264
Previous crop soybean (going into corn)						
Fertilizer-only	29	10	155	31	17	206
Low-rate manure	143	12	201	44	29	240
High-rate manure	222	15	247	58	31	240
Previous crop corn (going into sugarbeet)						
Fertilizer-only	100	12	157	29	16	289
Low-rate manure	55	12	178	22	27	245
High-rate manure	38	10	229	19	29	280

Year 2 following manure application – The second growing season after manure was applied occurred in 2021 at the Murdock site and in 2022 at the Nashua site. We calculated the second-year nitrogen credit from the manure assuming 25% of the total nitrogen applied was available and then subtracted it from the fertilizer recommendations for each crop. At Murdock, there was a 39 and 80 pounds of nitrogen per acre credit for the low and high rate manure plots, respectively. At Nashua, the nitrogen credit was 65 and 95 pounds of nitrogen per acre from the low and high manure rates, respectively. Fertilizer rates were adjusted accordingly for each crop and nutrient treatment based on these credits as well as the soil tests taken the previous fall. At the Murdock site, corn (Enesvedt E-696RR), soybean (Stine Liberty Link GT27), and sugarbeet (Beta 9952) were planted on May 1, 2021. This year, Soygreen® was applied to the soybean plots to potentially reduce issues with iron-deficiency chlorosis. At the Nashua site, corn (Dekalb DKC49-44RIB), soybean (Dekalb AG10XF1), and sugarbeet (ACH 973) were planted on May 25, 2022. All crops were maintained according to typical practices in the region. Similar soil and plant samples were collected in the second year as in the first year, though samples are still currently being analyzed.

Sugarbeets were harvested on October 12, 2021 at Murdock and October 3, 2022 at Nashua. Averaged over sites, root yield and extractable sucrose (lb/acre) was significantly highest in plots where the high rate of manure was applied in the rotation (Table 6). The low dairy manure rate and fertilizer only-plots yielded similarly. There were no differences across nutrient source treatments for extractable sucrose (lb/ton) and sucrose purity. There were also differences in sites with Murdock having higher root yield and sucrose purity while Nashua had higher extractable sucrose. Soybeans were harvested on October 8, 2021 at Murdock and September 29, 2022 at Nashua (Figure 3). Yield was not affected by nutrient source treatments nor did it differ by site. Corn was harvested on October 25, 2021 by hand at the Murdock site because the corn had lodged during a windstorm near harvest. At Nashua, corn was harvested October 7, 2022. There was a significant yield difference between sites, with Murdock yielding 197 bushels per acre while Nashua yielded 101 bushels per acre. We experienced drought in both years, so it is not surprising that yields were lower than anticipated. Interestingly, nutrient source treatments also affected corn yield even though this was the second year after application. The plots that had the high manure rate history yielded 25 bushels per acre than the fertilizer-only treatment (Figure 3). Yield in the low-rate manure plots was not significantly different than either of the other treatments, however.

Post-harvest soil samples from the top six and 24 inches of soil (Table 7) indicated that there were differences in residual nutrient content across treatments at the Murdock site in fall 2021. Similar to the previous rotation year, soil nitrate levels in the top 24 inches of soil tended to be lowest in plots that were previously sugarbeet and were consistent across treatments. Opposite of the previous rotation year, however, soil nitrate decreased with increasing manure application rate in the plots where soybean was the previous crop, while the reverse happened in the plots where corn was the previous crop. Soil test phosphorus levels varied. In fertilizer-only plots, soil test P levels were low, while plots with a manure history had medium to high soil test P levels. Soil test potassium levels were all high or very high and tended to increase with increased manure application rate.

Table 6. Yield, extractable sucrose (per ton and per acre), and sucrose percent purity averaged over both sites the second year after manure application. Manure was not applied this year, but fertilizers were applied as needed considering second-year manure nitrogen credits and soil tests.

Main effect	Yield (tons/acre)	Extractable Sucrose (lb/ton)	Extractable Sucrose (lb/acre)	Sucrose Purity (%)
Nutrient Source				
Fertilizer only	31.5b†	307a	9,378b	91.5a
Low dairy manure rate	31.1b	303a	9,148b	90.8a
High dairy manure rate	33.6a	302a	9,914a	91.6a
Site				
Murdock	40.3a	271b	10,914b	91.8a
Nashua	23.9b	337a	8,046a	90.8b

†Similar letters within a row and research site indicate no significant differences between the values ($p > 0.05$).

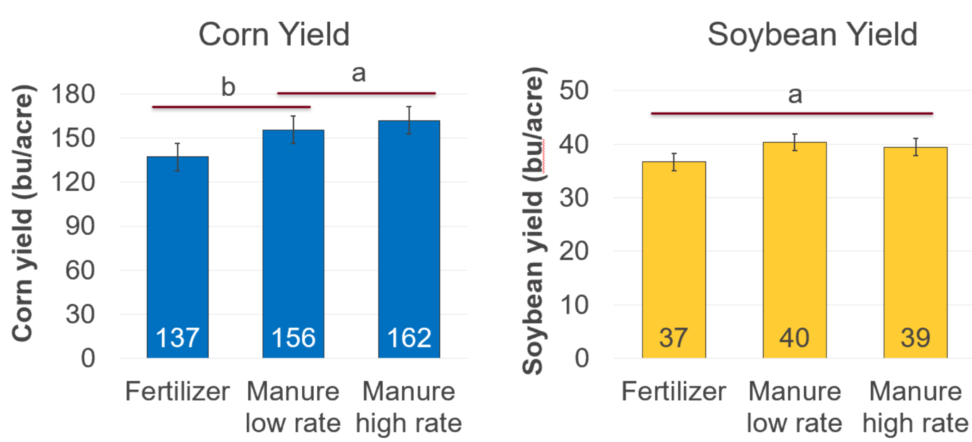

Figure 3. Corn (adjusted to 15.5% moisture) and soybean (adjusted to 13% moisture) yield averaged over sites (Murdock site in 2021 and Nashua site in 2022). In this second year, only fertilizer was applied but a nitrogen credit was taken for the manure. Soil tests for each treatment were used to adjust phosphorus and potassium application rates, as well. Different letters above a bar within a graph indicate a significant difference ($p < 0.05$).

Table 7. Soil test results for the Murdock site in fall 2021 and the Nashua site in fall 2022. All samples were taken in the top six inches of soil except the nitrate samples which were the top 24 inches of soil.

	Murdock site – Fall 2020			Nashua site – Fall 2021		
Initial soil test results	**Nitrate 0-24" (lb/ac)**	**Olsen P (ppm)**	**K (ppm)**	**Nitrate 0-24" (lb/ac)**	**Olsen P (ppm)**	**K (ppm)**
Previous crop sugarbeet (going into soybean)						
Fertilizer-only	14	7	172	14	9	247
Low-rate manure	12	8	186	13	15	229
High-rate manure	16	11	213	12	21	273
Previous crop soybean (going into corn)						
Fertilizer-only	76	8	209	18	14	176
Low-rate manure	85	10	241	27	16	185
High-rate manure	75	10	254	25	27	205
Previous crop corn (going into sugarbeet)						
Fertilizer-only	97	6	174	76	13	181
Low-rate manure	78	9	186	44	18	201
High-rate manure	86	12	222	43	16	202

<u>Year 3 following manure application</u> – The third growing season after manure was applied occurred in 2022 at the Murdock site and in 2023 at the Nashua site. Manure credits were not considered for the third growing season of the rotation. Fertilizer rates were based on N guidelines for each crop and the soil tests taken the previous fall. At the Murdock site, corn (Enesvedt E-696RR), soybean (Stine Liberty Link GT27), and sugarbeet (Beta 9952) were planted on May 26, 2022. Soygreen® was applied to the soybean plots to potentially reduce issues with iron-deficiency chlorosis. At the Nashua site, corn (Dekalb DKC49-44RIB), soybean (Dekalb AG10XF1), and sugarbeet (ACH 973) were planted on May 16, 2023. All crops were maintained according to typical practices in the region. Similar soil samples were collected in the third year as in the first and second year, though the 2023 samples from the Nashua site are still currently being analyzed.

Sugarbeets were harvested on October 5, 2022, soybeans on October 4, 2022, and corn on October 20, 2022 at Murdock. At Nashua, sugarbeets were harvested on October 3, 2023, soybeans on October 11, 2023, and corn on September 28, 2023. There were no differences across nutrient source treatments for sugarbeet root yield or quality measures, though there were differences across sites (Table 8). The Murdock site had higher yield and quality, though sucrose purity was not different between sites. Corn and soybean yields tended to be higher in the plots that had a manure history, though differences from the fertilizer-only plots were not significant (Figure 4). There were no differences between sites for corn yield (207 and 167 bu/ac for Murdock and Nashua, respectively) or soybean yield (47 and 34 bu/ac for Murdock and Nashua, respectively).

Post-harvest soil samples from the top six and 24 inches of soil (Table 9) indicated that there were differences in residual nutrient content across treatments at the Murdock site in fall 2022, though the differences were not as distinct as previous years. Soil nitrate levels in the top 24 inches of soil tended to be lowest in plots that were previously sugarbeet and were generally consistent across treatments. The exception being where the high rate of manure had been applied and corn was the previous crop, which had the highest residual nitrate levels. Soil test phosphorus levels ranged from 7 to 13 ppm (Olsen P test) which are mainly considered low to medium, with one set of fertilizer-only plots being rated high (in the plots where soybean was the previous crop). These levels were fairly consistent with the previous year. Soil test K levels remained high or very high, similar to the previous year. Soil test K levels tended to be lower in the manured plots where sugarbeet had just been harvested compared to the fertilizer only plot. Where corn and soybean had been harvested, soil test K levels tended to be higher in the manured plots and increased with increased manure application rate.

Table 8. Yield, extractable sucrose (per ton and per acre), and sucrose percent purity averaged over both sites the third year after manure application. Manure was not applied this year, but fertilizers were applied as needed considering nitrogen and soil test guidelines for each crop.

Main effect	Yield (tons/acre)	Extractable Sucrose (lb/ton)	Extractable Sucrose (lb/acre)	Sucrose Purity (%)
Nutrient Source				
Fertilizer only	40.3a†	277a	11,202a	90.0a
Low dairy manure rate	43.9a	274a	12,098a	89.8a
High dairy manure rate	43.3a	277a	12,021a	89.8a
Site				

Murdock	45.2a	284a	12,848a	89.9a
Nashua	39.8b	269b	10,700b	89.8a

†Similar letters within a row and research site indicate no significant differences between the values ($p > 0.05$).

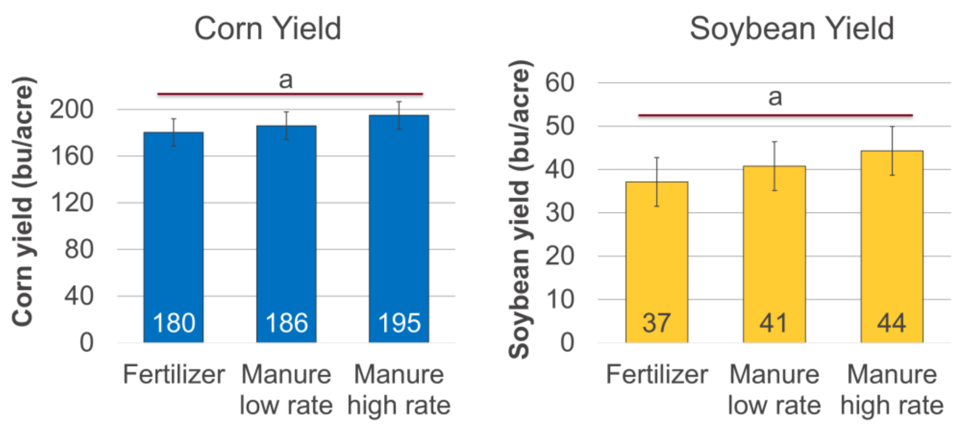

Figure 4. Corn (adjusted to 15.5% moisture) and soybean (adjusted to 13% moisture) yield at the Murdock site in 2022. In this third year, only fertilizer was applied based on N-needs of each crop. Soil tests for each treatment were used to adjust phosphorus and potassium application rates, as well. Different letters above a bar within a graph indicate a significant difference ($p < 0.05$).

Table 9. Soil test results for the Murdock site in fall 2022. All samples were taken in the top six inches of soil except the nitrate samples which were the top 24 inches of soil.

	Murdock site – Fall 2022		
Initial soil test results	**Nitrate 0-24" (lb/ac)**	**Olsen P (ppm)**	**K (ppm)**
Previous crop sugarbeet (going into soybean)			
Fertilizer-only	13	7	210
Low-rate manure	14	7	185
High-rate manure	13	9	184
Previous crop soybean (going into corn)			
Fertilizer-only	24	13	212
Low-rate manure	26	9	216
High-rate manure	27	7	238
Previous crop corn (going into sugarbeet)			
Fertilizer-only	55	7	177
Low-rate manure	55	8	191
High-rate manure	76	10	216

Overall, the liquid-separated dairy manure does not seem to have negatively affected sugarbeet yield, regardless of when it was applied in the rotation. In the second year after application, the high rate of manure application may have actually improved yield and quality. By the third year, however, there were no differences across treatments.

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SUGARBEET PHYSIOLOGY/STORAGE/PRODUCTION PRACTICES/ECONOMICS

NOTES

ASSESSING POSTHARVEST PATHOGENS IN SUGARBEET STORAGE PILES FROM NORTH DAKOTA AND MINNESOTA

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In the red river valley of Minnesota and North Dakota, postharvest sugarbeet roots require storage as the high tonnage of the crop exceeds immediate sugar factory processing capabilities. Sugarbeet roots are piled in factory yards, piling grounds, or ventilated sheds to allow the industry flexibility in sugar processing. Maintaining healthy sugarbeet roots in storage is essential to limit storage loss. Root pathogens in the production field, environmental conditions during harvest, varietal differences, and mechanical injuries from harvest and downstream operations all contribute to postharvest losses (Bugbee 1979; Klotz and Finger 2004; Strausbaugh 2018). Postharvest pathogens predominately infect injured sites on the root and can rapidly deteriorate roots depending on environmental conditions in the piles causing elevations in respiration rate and temperature inside the pile (Campbell and Klotz 2006; Mumford and Wyse 1976). These postharvest pathogens not only decrease sugar yield but also increase costs, as severely decayed roots may need to be disposed of without processing. Also, the roots that are processed typically might have higher concentrations of contaminants that can increase sucrose loss to molasses. Genetic resistance to storage diseases may alleviate postharvest losses, however, such resistance in sugarbeet cultivars has not been explored. The lack of knowledge on the predominant pathogens causing postharvest sugarbeet disease in each factory district have slowed the development of host resistance to storage diseases. Multiple fungal and bacterial strains are reported as causal agents for storage-related rots in sugarbeet growing areas in the US. However, limited information is available on the spectrum of postharvest pathogens in sugarbeet piles throughout the storage duration or if the factory districts have unique storage pathogens. Scientific understanding of the identity and abundance of postharvest pathogens will be the first key step to implement management strategies to minimize postharvest losses in sugarbeet storage. This study was conducted to understand the incidence of plant pathogens infecting sugarbeet roots in storage.

Materials and Methods

Symptomatic sugarbeet roots with microbial infestation or suspected roots in the vicinity of symptomatic roots were collected from factory yard and outside non-ventilated piles during the 2022/23 survey. A total of 150 symptomatic roots were collected from five factory districts (Moorhead, Hillsboro, Crookston, East Grand Forks, and Drayton). From each factory district, root samples were collected from three different non-ventilated piles (factory yard, Minnesota outside and North Dakota piles) at three time points i.e., mid-November, mid-December, and mid-December. Two sample bags with five beet roots each were collected from individual non-ventilated pile at each time point. The collected samples were transported to the USDA-ARS facility, Fargo, ND, and stored at 4˚C until processing. Root tissues were thoroughly washed with sterile distilled water and incubated on the potato dextrose agar (PDA), de Man Rogosa Sharpe agar (MRS) and nutrient agar (NA) amended with antibiotics using the protocol of Woodhall et al. (2020). Microbial isolates were further grown on the respective media or water agar until a pure culture of single isolates were received. The pure cultures of individual microbes were transferred into either 30% (bacteria and yeast) or 15% (filamentous fungi) glycerol in 2-mL cryovials and stored at -80°C.

The representative pathogen isolates were used to amplify and sequence ITS or 16S rRNA gene for fungi (filamentous and non-filamentous, yeast species) and bacteria, respectively, using sanger sequencing platform (Psomagen Inc., Rockville, MD). The ITS or 16S rRNA gene sequences were submitted for BLASTN search into the National Center for Biotechnology Information nucleotide database to identify the pathogen isolates. To test for pathogenicity of the *Penicillium* spp., healthy sugarbeet root samples were plug-inoculated with 8-mm diameter PDA plug into each of the two 15-mm-deep holes created on the shoulder of the roots (Strausbaugh, 2018). The diameter (measured by a ruler) as well as the weight of the rot was recorded to assess the pathogenicity of the isolates.

Results and discussions

The pure cultures of fungal and bacterial isolates were recovered from sugarbeet root tissues displaying the microbial invasion. Fungal and bacterial species were identified by sequencing of internal transcribed spacer regions and 16S rRNA genes in fungi and bacteria, respectively. In total 282 isolates were obtained from 150 root samples received from factory yard and outside during the 2022/23 surveys. Of the seven fungal (non-filamentous) species obtained, *Penicillim* sp. (31%) and *Mucor circinelloides* (23%) were the most isolated species (Fig. 1A, 2). *Pichia membranifaciens* (16%), *Hansespora valbyensis* (16%), and *Kurtzmaniella quercitrusa* (13%) remained the most isolated yeast species out of the 17 obtained during the 2022 survey (Fig. 1B). Three bacterial species (n = 164) were obtained from rotten roots samples including *Leuconostoc mensenteroides* (88%) and *Gluconobacter cerinus* (11%) (Fig. 3, 4). From the *Penicillium* population from the 2021/22 survey, *Penicillium expansum*, *P. italicum* and *P. firmorum* caused significantly ($P < 0.05$) more rots compared to other *Penicillium* species assessed (Fig. 5).

The study is ongoing to characterize additional isolates and assess pathogenicity tests in sugarbeet cultivars. Furthermore, analysis of more DNA barcoding genes such as beta-tubulin, translation elongation factor 1 alpha gene etc., for fungal isolate characterization will be completed later in 2024.

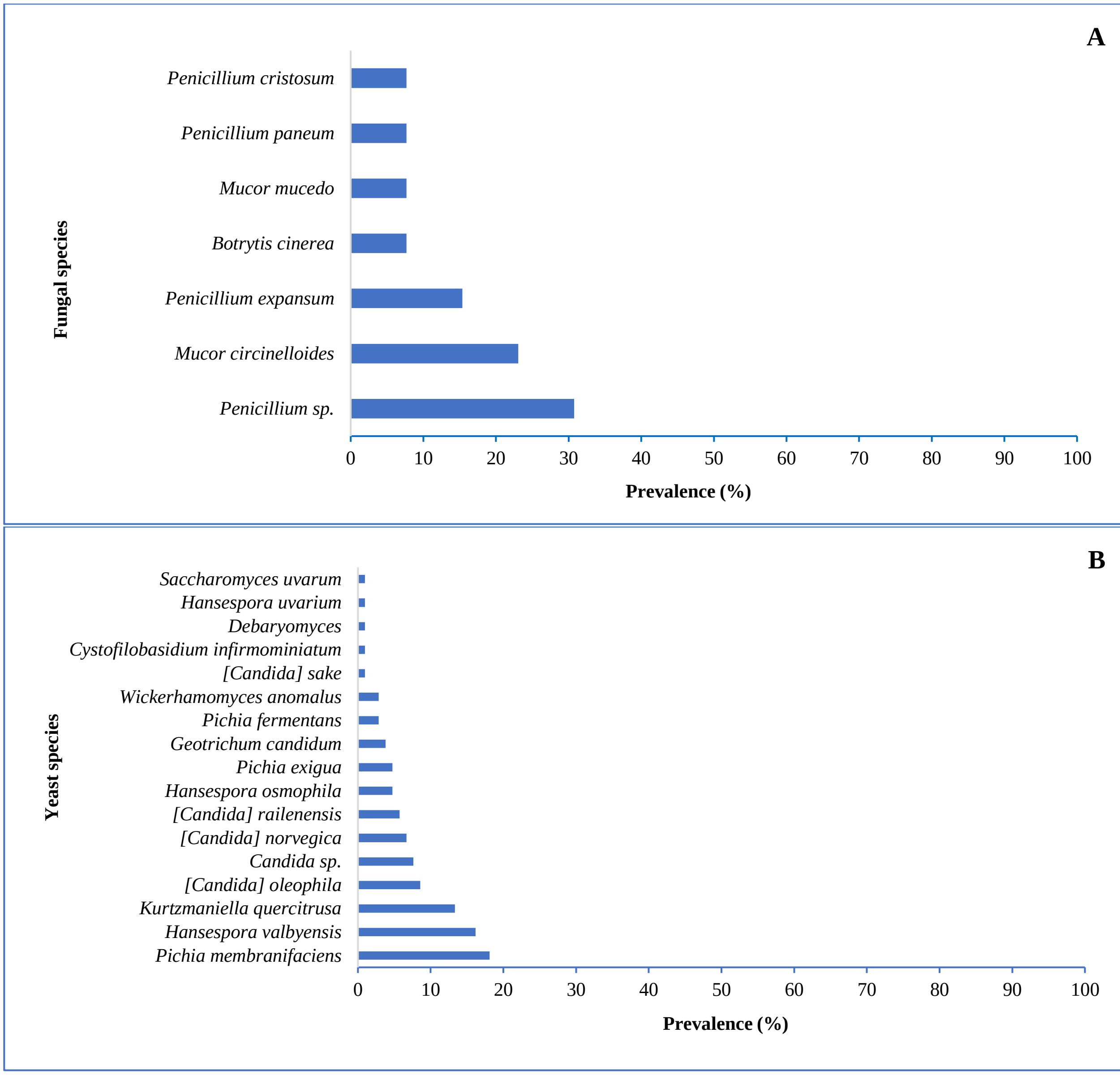

Fig. 1.
Prevalence of filamentous fungal (A) and yeast (B) isolates associated with the decaying tissues of sugarbeet roots from storage piles and factory yards during the 2022/23 processing campaign.

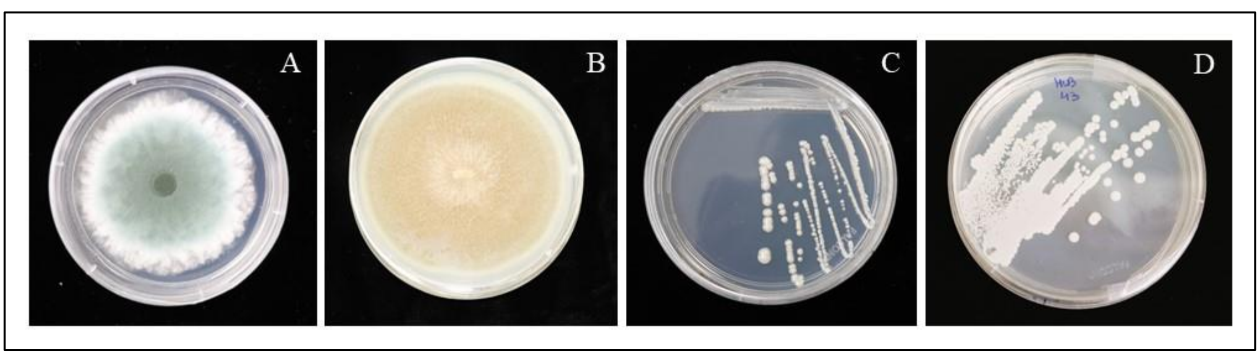

Fig. 2. Potato dextrose agar plates showing the growth of (A) *Penicillium* sp., (B*) Mucor circinelloides*, (C) *Hansespora valbyensis* and (D*) Kurtzmaniella quercitrusa* isolates from the rotten sugarbeet root samples.

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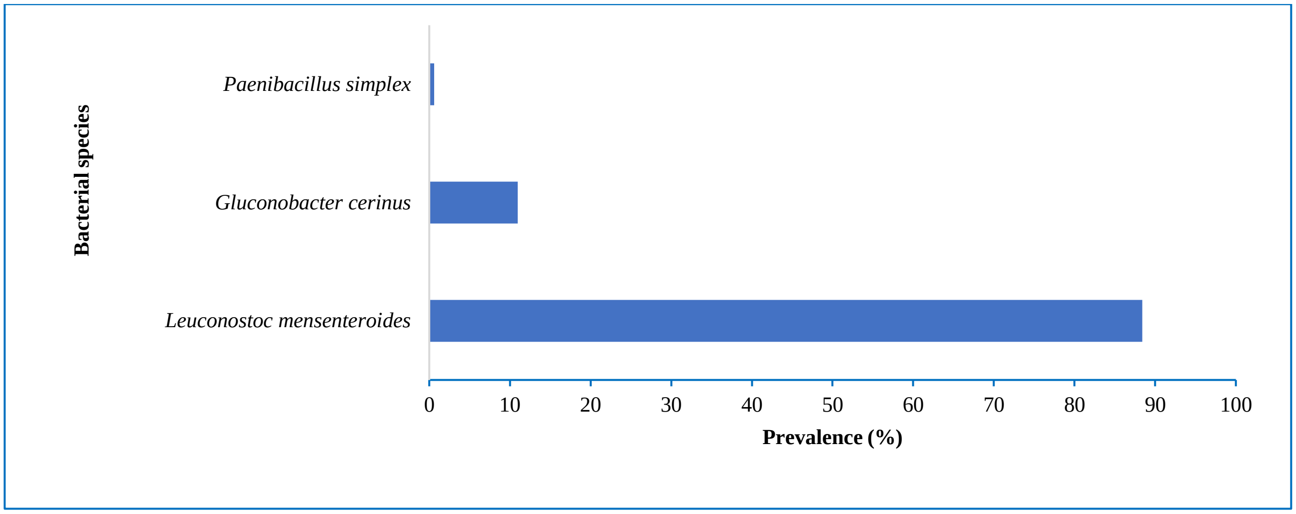

Fig. 3. Prevalence of bacterial isolates associated with the decaying tissues of sugarbeet roots from storage piles and factory yards during the 2022/23 processing campaign.

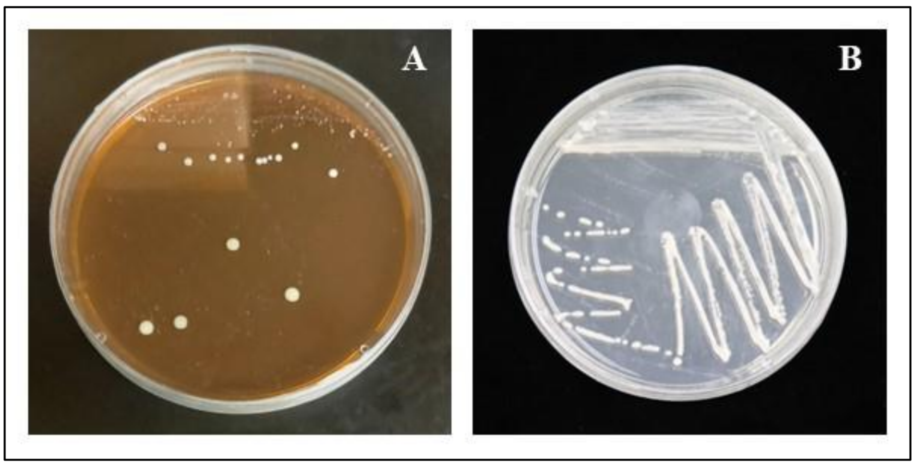

Fig. 4. Agar plates showing the growth of (A) *Leuconostoc mensenteroides* (MRS) and (B) *Gluconobacter cerinus* (PDA) isolated from the rotten sugarbeet root samples.

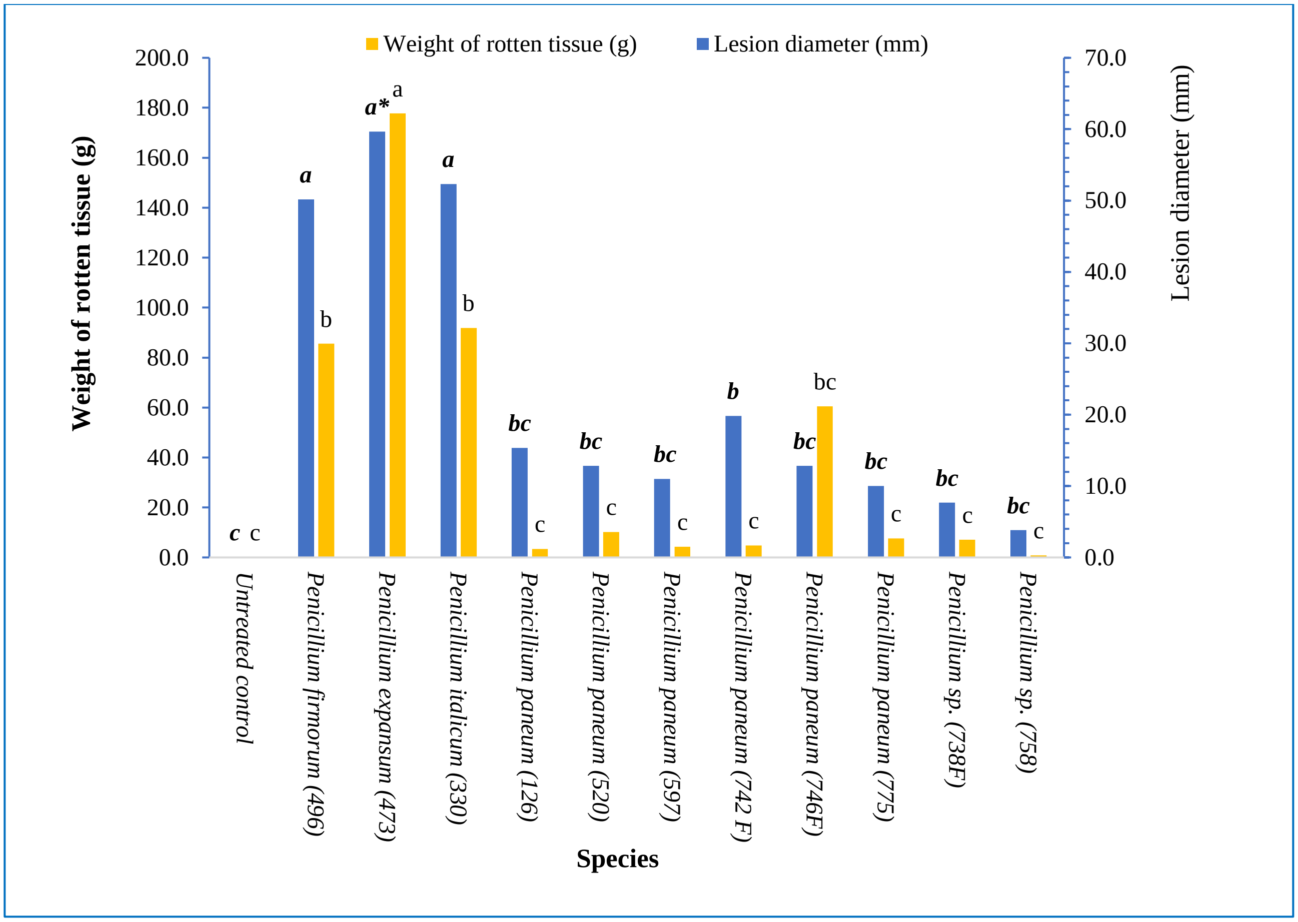

Fig 5. Pathogenicity of *Penicillium* isolates on sugarbeet roots. The asterisk, * indicates significant differences ($P < 0.05$) that are represented by different letters, which are also in order by highest to lowest.

ACKNOWLEDGEMENTS

We are thankful to the Sugarbeet Research and Education Board of Minnesota and North Dakota for the funding to perform this research. We appreciate help from American Crystal Sugar Company, Southern Minnesota Beet Sugar Cooperative, and Minn-Dak Farmers' Cooperative for collecting and getting sugarbeet root samples.

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ENTOMOLOGY

NOTES

TURNING POINT® SURVEY OF SUGARBEET INSECT PEST PROBLEMS AND MANAGEMENT PRACTICES IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2023

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Attendees of the 2024 Winter Sugarbeet Grower Seminars held at Fargo, Grafton, Grand Forks, and Wahpeton, ND were asked about their 2023 insect pest issues and associated management practices in a live polling session by using a Turning Point® interactive personal response system.

Initial questioning included identifying the county in which grower respondents produced the majority of their sugarbeet crop in 2023. Those results are presented in Tables 1-4. Most (64%) of Fargo seminar attendees indicated that the majority of their sugarbeet crop was grown in Clay, Norman, or Mahnomen counties of Minnesota, and an additional 24% reported having produced most of their crop in Cass County, ND (Table 1). The remaining producers responded that they produced the majority of their sugarbeet crop in either Barnes or Becker County, MN (6% each).

Table 1. 2024 Fargo Grower Seminar – county in which sugarbeet was grown in 2023

County	Number of responses	Percent of responses
Barnes	1	6
Becker	1	6
Cass	4	24
Clay	6	35
Norman/Mahnomen	5	29
Totals	17	100

The majority (78%) of attendees at the Grafton grower seminar reported that most of their sugarbeet production acreage was located in either Pembina or Walsh County, ND (Table 2). Kittson County, MN accounted for an additional 9% of the Grafton seminar attendees. Of the remainder, 6% produced most of their sugarbeet in Grand Forks County, ND, and an additional 3% each grew the majority of their sugarbeet crop in either Cavalier County, ND or Kittson County, MN.

Table 2. 2024 Grafton Grower Seminar – county in which sugarbeet was grown in 2023

County	Number of responses	Percent of responses
Cavalier	1	3
Grand Forks	2	6
Kittson	3	9
Marshall	1	3
Pembina	13	39
Walsh	13	39
Totals	33	100

The largest portion (44%) of Grand Forks grower seminar attendees indicated that the majority of their sugarbeet production occurred in Polk County, MN (Table 3). An additional 24% of grower attendees at Grand Forks responded that most of their sugarbeet was grown in Grand Forks County, ND. Other counties represented by grower attendees at Grand Forks included Marshall County, MN and Traill County, ND (6% of grower respondents each), and Walsh County, ND (3%).

Table 3. 2024 Grand Forks Grower Seminar – county in which sugarbeet was grown in 2023

County	Number of responses	Percent of responses
Grand Forks	15	25
Marshall	4	7
Nelson	2	3
Polk	29	47
Traill	3	5
Walsh	3	5
Other	5	8
Totals	61	100

Responses to this question at the Wahpeton winter sugarbeet grower seminar indicated that 47% of the attending producers grew the majority of their sugarbeet crop in Wilkin County, MN, with another 16% of the respondents reporting that most of their crop was produced in Richland County, ND (Table 4). An additional 11% of grower attendees at the Wahpeton seminar indicated that most of their sugarbeet production occurred in Clay County, MN, with the remainder of respondents responding that they produced the majority of their beet crop in Grant or Traverse County, MN, Cass County, ND, or Roberts County, SD in 2023.

Table 4. 2024 Wahpeton Grower Seminar – county in which sugarbeet was grown in 2023

County	Number of responses	Percent of responses
Cass	1	2
Clay	3	7
Grant	4	10
Richland	11	26
Traverse	3	7
Wilkin	20	48
Totals	42	100

This report is based on grower responses about their production activities on an estimated 134,750 acres of sugarbeet grown in 2023 by 181 grower respondents that attended the 2024 Fargo, Grafton, Grand Forks, and Wahpeton Winter Sugarbeet Grower seminars (Table 5). The majority (32%) of respondents reported growing sugarbeet on between 400 and 799 acres during the 2023 production season. That represents a shift upward in acres per grower from previous years, when the majority of growers produced sugarbeet on an average of between 300 and 599 acres. An additional 21% of producers grew sugarbeet on between 600 and 999 acres, and 25% produced beets on between 800 and 1,500 acres. A total of 11% of respondents reported growing sugarbeet on 1,500 acres or more in 2023, whereas, 21% of respondents produced sugarbeet on 299 or less acres.

Table 5. Ranges of sugarbeet acreage operated by respondents in 2023

		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	15	13	13	7	13	27	20	0	7	0	0
Grafton	30	0	10	0	7	13	10	7	37	10	7
Grand Forks	65	11	9	5	11	17	11	12	12	5	8
Wahpeton	71	3	8	10	13	21	15	6	15	8	0
Totals	181	6	9	6	11	19	13	8	17	7	4

From a combined total of 171 respondents at the Fargo, Grafton, Grand Forks, and Wahpeton seminars, 41% identified the sugarbeet root maggot (SBRM) as their worst insect pest problem in 2023 (Table 6). That was a 17% increase from the responses recorded during the 2023 grower seminars. Additionally, about 30% of all seminar location respondents viewed grasshoppers as their worst insect pest problem in during the 2023 growing season. Cutworms were rated as the worst pest by about 16% of all seminar respondents. Other insect groups identified as causing problems in 2023 included springtails, Lygus bugs, white grubs, and wireworms (5, 2, 1.8, and 1%, of the respondents, respectively, at across the four seminar locations.

Grasshoppers were reported as the worst insect problem for 42, 23, 21, and 39% of grower seminar respondents at Fargo, Grafton, Grand Forks, and Wahpeton, respectively. The majority of respondents at Grafton (74%) and Grand Forks (64%) identified the SBRM as their worst insect pest problem. Those responses equated to 42 and 31% increases in the numbers of Grafton and Grand Forks seminar attendees identifying root maggots as their key insect problem when compared to that reported for 2022, which suggests increasing grower awareness and concern regarding the severity of SBRM populations on their farms. Cutworms were viewed as the most significant insect pest problem by 39% of Wahpeton seminar attendees and 8% of Fargo attendees. There were no further responses on cutworms at the other seminar locations. Springtails were identified as the worst insect pest problem by 10% of Grand Forks seminar respondents and 5% of Wahpeton respondents, but there were no responses identifying springtails regarding this question at Fargo or Grafton. Overall, the frequency of responses identifying springtails as being the major insect pest problem was considerably lower than in previous years.

Table 6. Worst insect pest problem in sugarbeet in 2023

Location	No. of responses	Army-worms	Cut-worms	Grass-hoppers	Lygus Bugs	Root maggot	Spring-tails	White Grubs	Wire-worms	Other
		--------	--------	--------	--------	% of responses	--------	--------	--------	
Fargo	12	0	8	42	17	33	0	0	0	0
Grafton	35	0	0	23	3	74	0	0	0	0
Grand Forks	58	0	0	21	2	64	10	0	0	3
Wahpeton	66	2	39	39	0	6	5	5	3	2
Totals	171	1	16	30	2	42	5	2	1	2

A combined total of 84% of all grower respondents at across all winter grower seminars indicated that they used some form of insecticide to manage insect pests in 2023, which was down slightly from 89% as reported for 2022 (Table 7). The majority (36%) of respondents from all grower seminar locations reported that they planted seed treated with Poncho Beta insecticidal seed treatment. An average of 18% reported using Counter 20G for at-plant protection from insect pests, and the remaining producers indicated that they applied either Midac FC (13%) or Mustang Maxx (9%), or they used either Cruiser (4%) or NipsIt Inside (4%) seed treatment. The most substantial change in use for this purpose, when averaged for respondents at all seminar locations, was that Midac FC use increased by about 116% when compared to reported use from the 2022 growing season. The majority of planting-time insecticide use in 2023 was carried out by growers that attended the Fargo, Grafton, and Grand Forks seminars, at which 87, 96, and 96% of respondents, respectively, reported using insecticidal protection at planting. Although fewer (i.e., 61% overall) Wahpeton seminar respondents responded as having used an insecticide at planting than those at the other seminar locations, that figure represented a 49% increase in insecticide use by Wahpeton respondents from 2022 to 2023.

At the Fargo seminar, 33% of producers reported using Poncho Beta insecticidal seed treatment for at-plant protection from insect pests. No other seed treatment materials were reported as being used by Fargo attendees in 2023. An additional 20% of Fargo attendees applied Counter 20G for at-plant protection from insect pests. A considerable segment (27%) of Fargo attendees applied a liquid insecticide at planting in 2023, with the majority of those applications being Mustang Maxx (27% of respondents), but another 7% of respondents reported using Midac FC for insect control in their sugarbeet crop.

The majority (42%) of Grafton respondents reported planting Poncho Beta insecticide-treated seed as at least part of their insect control program in 2023. Cruiser- and NipsIt Inside-treated seed were each used by an additional 6% of Grafton attendees. A surprisingly low proportion (19%) of Grafton seminar attendees reported using Counter 20G for planting-time insect pest management, and that was identical to the reported use of Counter 20G during the 2022 growing season. An additional 25% of respondents at Grafton indicated that they used a sprayable liquid insecticide, which involved applications of Midac FC or Mustang Maxx (21 and 4% of respondents, respectively).

At the Grand Forks seminar location, 51% of respondents reported that they used Poncho Beta-treated seed for at-plant insect control, and NipsIt Inside- and Cruiser-treated seed each reported as used by 5% of respondents. Counter 20G was reported as being used at planting by 16% of grower respondents at Grand Forks, which was a decrease of about 45% when compared to 2022. Midac FC was reported as being used at planting by 17% of Grand Forks respondents in 2023, which represented an 89% increase in use of that product when compared to reported use during the 2022 growing season. Use of Mustang Maxx, as reported by Grand Forks respondents, was down to 1%, which was a significant decrease from 8% of attendees having reported using that insecticide in 2022.

At the Wahpeton seminar location, 18% of respondents indicated that they had applied Mustang Maxx for planting-time protection from insect pests in 2023, and 18% reported using a planting-time application of Counter 20G. An additional 16% reported that they used Poncho Beta-treated seed for insect pest management. Three percent of Wahpeton respondents reported using Midac FC for a planting-time insecticide. This was the first year of reported use of that product by Wahpeton seminar attendees.

Table 7. *Planting-time* insecticide use for sugarbeet insect pest management in 2023

Location	Number of responses	Counter 20G	Midac FC	Mustang Maxx	Poncho Beta	Cruiser	NipsIt Inside	Other	None
			----------------	----------------	----------------	% of responses	----------------	----------------	----------------
Fargo	15	20	7	27	33	0	0	0	13
Grafton	53	19	21	4	42	6	6	0	4
Grand Forks	93	16	17	1	51	5	5	0	4
Wahpeton	76	18	3	18	16	1	1	3	39
Totals	237	18	13	9	36	4	4	1	16

Averaged across the Fargo, Grafton, Grand Forks, and Wahpeton seminar locations, the moderate (7.5 lb product/ac) rate of Counter 20G was used more frequently (12% of respondents) than any other granular insecticide application for insect management in 2023 (Table 8). Thimet 20G was used by just 2% of grower respondents, as averaged across all seminar locations. The majority of Fargo (71%), Grafton (55%), Grand Forks (72%), and Wahpeton (79%) respondents reported no use of a granular insecticide in 2023. However, 40% of the Fargo respondents that did use a granular insecticide applied Counter 20G at the 5.25-lb rate and 30% used the 7.5-lb rate, but no one at the Fargo seminar location reported applying Counter 20G at its high (8.9 lb product/ac) labeled rate.

At the Grafton seminar location, 45% of producers reported applying a granular insecticide in 2023. Eleven percent of Grafton respondents applied Counter at the high (8.9 lb) labeled rate, and 64% used it at the moderate rate of 7.5 lb product per acre. The Counter 20G use-rate patterns in 2023, as reported by Grafton respondents shifted dramatically compared to that reported for 2022, where 50% of respondents reported using the 8.9-lb rate and only 33% reported using the 7.5-lb rate.

At the Grand Forks grower seminar, 28% of respondents reported using a granular insecticide at planting in 2023. Thirty-nine percent of the Grand Forks attendees that used a granular insecticide in 2023 indicated that they applied Counter 20G at its high labeled rate. An additional 29% of respondents applied Counter at 7.5 lb product per acre, and 21% used it at the low labeled rate of 5.25 lb product per acre.

Table 8. Application rates of *granular* insecticides used for sugarbeet insect pest management in 2023

Location	Number of responses	Counter 20G			Thimet 20G		Other	None
		8.9 lb	7.5 lb	5.25 lb	7 lb	4.5 lb		
			----------------	----------------	% of responses	----------------	----------------	----------------
Fargo	17	0	6	12	0	0	12	70
Grafton	38	5	29	0	3	5	3	55
Grand Forks	64	11	8	6	0	0	3	72
Wahpeton	70	0	9	9	1	0	3	79
Totals	189	5	12	6	1	1	4	71

Averaged across the Fargo, Grafton, Grand Forks, and Wahpeton survey locations, 38% of respondents reported using a postemergence insecticide to manage the sugarbeet root maggot (SBRM) (Table 9). That reflected a 17% decline when compared to 2022. At the Fargo seminar site, 33% of respondents reported that they had applied Mustang Maxx for postemergence root maggot control in 2023, which accounted for 100% of all insecticide use reported for that purpose by Fargo grower respondents. That is somewhat surprising because there had been some limited use of Thimet 20G for root maggot control by Fargo seminar attendees in 2022.

At the Grafton seminar location, 71% of grower respondents indicated that they used some form of postemergence insecticide for SBRM control in 2023. That reflected an 8% increase in postemergence insecticide use by Grafton respondents when compared to the reported use for the previous growing season. The majority (34%) of Grafton seminar respondents applied Thimet 20G for postemergence root maggot management, which was 48% of all respondents who used a postemergence insecticide for that purpose in 2023. An additional 27% of the Grafton respondents reported that they applied Mustang Maxx for postemergence SBRM control, and 5% indicated that they used Asana XL for postemergence root maggot management.

A total of 40% of Grand Forks seminar attendees reported using a postemergence insecticide for root maggot management in 2023, which was a 33% increase over the reported use for this purpose during the previous growing season. About two-thirds of the producer respondents at Grand Forks that did apply an insecticide for postemergence SBRM control indicated that they used Mustang Maxx, whereas, 15% used Asana XL, and an additional 13% used Thimet 20G.

Table 9. *Postemergence* insecticide use for *sugarbeet root maggot* management in 2023

Location	Number of responses	Asana XL	Mustang Maxx	Counter 20G	Thimet 20G	Other	None
			----------	----------	% of responses	----------	----------
Fargo	15	0	33	0	0	0	67
Grafton	41	5	27	2	34	2	29
Grand Forks	65	6	26	3	5	0	60
Wahpeton	67	3	10	1	0	3	82
Totals	188	4	21	2	9	2	62

Averaged across the Fargo, Grafton, Grand Forks, and Wahpeton seminar locations, 81% of grower respondents rated their satisfaction with the insecticide applications they made for root maggot control in 2023 as good to excellent, which was a 29% increase in grower satisfaction with their SBRM management efforts when compared to survey results for the previous growing season (Table 10). An average of 12% of growers that attended the 2024 seminars rated the SBRM control performance of their insecticide program as being fair, but there were no responses indicating poor performance at any of the locations. An additional 4% of attendees across all grower seminar locations responded as being unsure of the success of their control programs for SBRM control.

Individually, grower satisfaction with insecticide performance for root maggot control in 2023 was rated as good to excellent by 50, 90, 79, and 78% of Fargo, Grafton, Grand Forks, and Wahpeton respondents, respectively. Satisfaction with insecticide performance for SBRM control was rated as fair by 33, 10, and 13, and 6% of respective respondents at the Fargo, Grafton, Grand Forks, and Wahpeton seminar locations. The most notable changes from the previous year's survey results were that the satisfaction from SBRM control efforts carried out by Fargo respondents decreased significantly, whereas the satisfaction of Grafton respondents increased by a large margin.

Table 10. *Satisfaction* with insecticide treatments for sugarbeet root maggot management in 2023

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		----------	---------- % of responses	----------	----------	
Fargo	14	0	50	33	0	17
Grafton	36	13	77	10	0	0
Grand Forks	66	19	60	13	0	8
Wahpeton	63	28	50	6	0	17
Totals	179	18	63	12	0	7

As presented in Table 11, a combined average of 60% of grower respondents at the Fargo, Grafton, Grand Forks, and Wahpeton grower seminar locations used an insecticide for planting-time protection against springtails. That figure reflects a 17% decrease when compared to the usage reported for 2022, but it is still slightly higher than what growers reported in previous years, when the use of insecticides for springtail management hovered around 50% of growers surveyed. The majority (33%) of respondents that used an insecticide for this purpose in 2023, as averaged across all seminar locations, planted seed treated with Poncho Beta insecticide. An additional 12% applied Counter 20G for springtail control, whereas 8% applied Midac FC for this purpose. A relatively small portion (3%) of respondents reported using Mustang Maxx for springtail control, and 40% of all growers surveyed at the four seminar locations reported not using any insecticide for springtail control, which was a significant increase in producers opting to forgo a springtail control when compared to that reported for the 2022 growing season.

At the Fargo seminar, Poncho Beta and Counter 20G were reported as being used for springtail control by 29 and 14% of respondents, respectively. About 7% of Fargo respondents indicated that they had applied Midac FC for this purpose in 2023. Somewhat surprisingly, there was no reported use of Mustang Maxx for springtail management by respondents at the Fargo grower seminar.

Most of the insecticide use for springtail management (29% of respondents), as reported by Grafton seminar attendees, involved planting seed treated with Poncho Beta. The other registered seed treatments were also used by some Grafton respondents, but at relatively low usage rates of 5% for NipsIt Inside and 2% for Cruiser. Counter 20G was reported as being used in 2023 for springtail control by 7% of Grafton respondents. The remaining use of insecticides for springtail control by attendees of the Grafton seminar included Midac FC (5% of respondents) and Mustang Maxx (2% of respondents). Thirty-four percent of Grafton attendees indicated that they did not use an insecticide for protection from springtail injury in 2023.

The highest incidence of insecticide use for springtail management in our surveys was reported by Grand Forks attendees, 84% of which used some form of insecticidal protection in their sugarbeet crop. A large majority (52%) of grower respondents at the Grand Forks seminar location indicated that Poncho Beta insecticidal seed treatment was their choice for springtail management during the 2023 growing season. That figure marked a significant (i.e., about 37%) increase in Poncho Beta use for springtail control when compared to the 2022 survey results. Most of the remaining reported insecticide use for springtail control by Grand Forks respondents involved applications of Counter 20G (17% of respondents) and Midac FC (12% of respondents). The remainder of reported insecticide use by Grand Forks attendees involved Mustang Maxx (4% of respondents).

Table 11. Insecticide use for *springtail* management in 2023

Location	Number of responses	Poncho Beta	Cruiser	NipsIt Inside	Midac FC	Mustang Maxx	Counter 20G	Other	None
		---	---	---	% of responses	---	---	---	---
Fargo	14	29	0	0	7	0	14	0	50
Grafton	44	39	2	5	11	2	7	0	34
Grand Forks	77	52	0	0	12	4	17	0	16
Wahpeton	68	10	0	1	1	4	10	1	71
Totals	203	33	0	1	8	3	12	0	40

As presented in Table 12, an overall average of 72% of grower respondents surveyed at the Fargo, Grafton, Grand Forks, and Wahpeton seminar locations rated their insecticide performance for springtail management as good to excellent, and only 4% of respondents across all locations viewed their insecticide performance as poor. Satisfaction with springtail control efforts among Fargo attendees was somewhat unusual, as 38% rated their insecticide performance as good, but the majority (62%) were unsure of the success of their control practice.

Among grower respondents at the Grafton location, most (81%) viewed their springtail control as being either good or excellent, and no respondents assessed their results as being fair or poor. About 19% of Grafton respondents were unsure of the performance of their springtail control tool(s).

Similar to the results from Grafton, grower respondents at the Grand Forks seminar expressed a relatively high rate (80% of respondents) of satisfaction with their springtail control by rating it as good to excellent. However, 6% of Grand Forks respondents rated their springtail control as being fair to poor.

Survey results from the Wahpeton seminar location indicated that 54% of grower respondents viewed their springtail control as being either good or excellent. No respondents rated their control success as fair, bur 13% viewed it as poor. Additionally, 33% of Wahpeton respondents were uncertain about their springtail control success.

Table 12. *Satisfaction* with insecticide treatments for springtail management in 2023

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		--------------------------------------% of responses		--------------------------------------		
Fargo	14	0	38	0	0	62
Grafton	31	50	31	0	0	19
Grand Forks	62	24	56	2	4	14
Wahpeton	65	27	27	0	13	33
Totals	172	27	45	1	4	23

As was the case in 2022, Lygus bugs were not a major production problem for Red River Valley producers in 2023. This was clearly illustrated by the combined average of 94% of survey respondents at the Fargo, Grafton, Grand Forks, and Wahpeton winter grower seminars reporting that they did not use an insecticide in 2023 for Lygus bug control (Table 13).

Although insecticide use for Lygus bug management was very low, 8% of Fargo seminar attendees reported using Movento, a relatively new foliar insecticide, for Lygus bug management during the 2023 growing season. No other insecticides were reported as being used by Fargo seminar respondents for Lygus bug control in 2023. Similarly, at the Grafton seminar location, 3% of respondents indicated that they used Asana XL for Lygus bug control in 2023, and no other insecticides were reported as being used for that purpose.

Attendees of the Grand Forks grower seminar also reported low levels of insecticide use for Lygus bug control. A total of 7% of Grand Forks respondents indicated that they sprayed for Lygus bugs in 2023, with the majority (5% of attendees) reporting that they chose Mustang Maxx for this use and 2% of respondents indicating that they applied the newly registered insecticide Transform.

Wahpeton seminar survey results determined that insecticide use for Lygus bug management was also very low in that portion of the growing region. Respondents indicated that insecticide use for this purpose in 2023 was evenly split (3% each) between Mustang Maxx and Transform, with an additional 2% of producers indicating that they used an insecticide that was not included as a choice in the survey.

Table 13. Insecticide use for Lygus *bug* management in 2023

Location	Number of responses	Asana XL	Dibrom	Movento	Mustang Maxx	Transform	Other	None
		--------------------------------------% of responses				--------------------------------------		
Fargo	12	0	0	8	0	0	0	92
Grafton	32	3	0	0	0	0	0	97
Grand Forks	63	0	0	0	5	2	0	93
Wahpeton	66	0	0	0	3	3	2	92
Totals	173	1	0	1	3	2	1	94

Survey results on satisfaction with insecticide performance for Lygus bug control are presented in Table 14. These results should be interpreted with a high degree of discretion because the exceptionally low frequency of insecticide use for that purpose resulted in a very small sample size. Overall, the results showed that, an average of 30% of respondents across all seminar locations viewed the success of their Lygus bug management insecticide in 2023 as good to excellent; however, a much greater proportion (62%) of them were unsure about the success of their efforts. Also, 8% of all seminar location respondents rated their Lygus bug control success as poor.

At the Fargo seminar location, 50% of respondents that used an insecticide for Lygus bug management in 2023 viewed its performance as good, and respondents (50%) were unsure about the effectiveness of their insecticide. All respondents at the Grafton grower seminar indicated that they were unsure about the success of the insecticide they used for managing Lygus bugs, however, as noted in Table 13, only 3% of the Grafton respondents used an insecticide for this purpose. At the Grand Forks location, 28% of respondents viewed their Lygus bug insecticide effectiveness as being either good or excellent, but 14% viewed it as poor and the remaining 58% were unsure. At the Wahpeton seminar, 33% of grower respondents assessed the performance of the insecticide they applied for Lygus bug control as excellent, but the remaining 67% were unsure regarding its effectiveness.

Table 14. *Satisfaction* with insecticide treatments for Lygus *bug* management in 2023

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		-------------------------------------% of responses------------------------------------				
Fargo	13	0	50	0	0	50
Grafton	32	0	0	0	0	100
Grand Forks	60	14	14	0	14	58
Wahpeton	64	33	0	0	0	67
Totals	169	15	15	0	8	62

For the second consecutive year, grasshoppers were problematic in 2023 for many Red River Valley sugarbeet producers; however, outbreaks were not as widespread as they had been during the 2021 growing season. Overall, 31% of all grower respondents at the Fargo, Grafton, Grand Forks, and Wahpeton grower seminars indicated that they used a foliar insecticide for grasshopper control in 2023 (Table 15). Mustang Maxx was the most widely used insecticide for grasshopper control in 2023, and it was applied to sugarbeet fields by 17% of all respondents at the four aforementioned 2024 winter grower seminars. An additional 6% of all survey respondents across all grower seminar locations indicated that they had used Asana XL for grasshopper control 2023.

A total of 32% of the Fargo grower seminar respondents reported that they had used an insecticide for grasshopper control in 2023. Survey responses indicated that insecticide use for this purpose was evenly split (8% each) between Asana XL, Mustang Maxx, and Vantacor, and an additional 8% of respondents indicated that they used an insecticide that was not included as a choice in this survey.

At the Grafton winter grower seminar, 22% of respondents indicated that they had used a foliar insecticide for grasshopper management in 2023. Of those producers that used an insecticide for this purpose, 73% applied Mustang Maxx, 14% used Asana XL, and an additional 14% of the respondents reported using an insecticide that was not offered as a choice in our survey.

The Grand Forks seminar survey results indicated that 30% of respondents used an insecticide to control grasshoppers in 2023. Of those respondents who used an insecticide for this purpose, 53% reported that they applied Mustang Maxx, and 17% used Asana XL. Additional insecticide use for grasshopper control was infrequent, but evenly split (7% each) among Lannate, Movento, and Vantacor. Also, 10% of producers that reported using an insecticide for grasshopper control indicated that they used an insecticide that was not included as a choice in the survey.

Reported insecticide use in 2023 for grasshopper management by Wahpeton grower seminar attendees was slightly higher than that reported at any of the other seminar locations. A total of 33% of all respondents at the Wahpeton seminar indicated that they had used an insecticide for grasshopper control in sugarbeet in 2023, and 64% of those respondents indicated that they used Mustang Maxx. Asana XL was reported as being applied to control grasshoppers in sugarbeet by 21% of those respondents, and an additional 3% reported using Vantacor for this purpose. Twelve percent of Wahpeton respondents that had used an insecticide for grasshopper control indicated that they chose to use an insecticide that was not included in our survey.

Table 15. Insecticide use for *grasshopper* management in 2023

Location	Number of responses	Asana XL	Lannate	Movento	Mustang Maxx	Vantacor	Other	None
		--% of responses--						
Fargo	13	8	0	0	8	8	8	68
Grafton	32	3	0	0	16	0	3	78
Grand Forks	61	5	2	2	16	2	3	70
Wahpeton	67	7	0	0	21	1	4	67
Totals	173	6	1	1	17	2	4	69

Good to excellent grasshopper control in 2023 was reported by 74% of all respondents that attended the four winter grower seminar locations (Table 16); however, 20% of all grower seminar respondents viewed their grasshopper control performance as being fair to poor. At the Fargo winter grower seminar, 67% of respondents rated their insecticide as having provided good to grasshopper control in 2023, but no respondents indicated that they viewed it as excellent. No Fargo seminar respondents that used an insecticide for grasshopper control in 2023 rated its performance as fair or poor.

Of the Grafton seminar respondents that applied an insecticide for grasshopper control in 2023, most (71%) viewed its performance as either good or excellent. Fourteen percent of survey respondents at the Grafton seminar location rated their insecticide performance for grasshopper management as fair. None of them rated their grasshopper insecticide performance as poor, but 14% of those that had used an insecticide for this purpose were unsure of the level of success achieved with the insecticide.

Results from the Grand Forks grower seminar location indicated that the majority (73%) of respondents viewed their insecticide performance in managing grasshopper infestations as being good to excellent, whereas 23% rated their grasshopper control as fair to poor. Six percent of Grand Forks respondents who applied an insecticide to manage grasshoppers were unsure of its success.

Survey results from the Wahpeton grower seminar were similar to those at the other locations. Seventy-seven percent of growers that used an insecticide for grasshopper control in 2023 viewed its performance as good to excellent. Twenty-three percent of Wahpeton attendees responded with the assessment that their insecticide program for grasshopper control was fair, but no respondents viewed their insecticide performance as being poor.

Table 16. *Satisfaction* with insecticide treatments for *grasshopper* management in 2023

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		-----------------	-----------------	-----% of responses-----	-----------------	-----------------
Fargo	13	0	67	0	0	33
Grafton	31	14	57	14	0	14
Grand Forks	59	6	67	17	6	6
Wahpeton	65	18	59	23	0	0
Totals	168	12	62	18	2	6

Attendees the 2024 winter sugarbeet grower seminars were asked about how their insecticide use for insect pest management compared to previous years. Overall, 64% of respondents at all (Fargo, Grafton, Grand Forks, and Wahpeton) seminar locations combined reported that their insecticide use in 2023 did not differ from that of the previous five years (Table 17). The most significant insecticide use change observed with this question was that 31% of Fargo seminar attendees reported an increase in insecticide usage in 2023 when compared to the previous five years. Similarly, 18% of respondents at both Grafton and Wahpeton also reported that their insecticide usage had increased in 2023 when compared to previous years. Increases in insecticide use by grower attendees of the Fargo, Grafton, and Grand Forks seminars could have been associated with producer responses to increasing intensity and geographic spread of sugarbeet root maggot populations, combined with several outbreaks of grasshoppers in 2023. The increased insecticide usage reported by Wahpeton seminar attendees was more likely a result of several outbreaks of sugarbeet webworm, beet armyworm, and grasshoppers during the 2023 growing season. Increased activity of several of those same pests motivated producers to increase their insecticide usage in 2022 as well.

Table 17. Insecticide use in sugarbeet during 2023 compared to the previous 5 years

Location	Number of responses	Increased	Decreased	No Change	No Insecticide Use
		--------------------------------------% of responses	-----------------------------------		
Fargo	13	31	8	61	0
Grafton	34	18	18	62	2
Grand Forks	60	18	2	78	2
Wahpeton	65	12	17	54	17
Totals	172	17	11	64	8

Grower seminar attendees were also asked about their use of various information sources for making sugarbeet insect pest management decisions. Averaged across the four grower seminar locations, 25% of respondents indicated that they used a publicly available decision-making tool or information source for sugarbeet insect management decision making during the 2023 growing season (Table 18). An average of 72% of attendees indicated that they used alternative sources for making insect management decisions, and 3% of respondents reported that they did not rely on any of them. The most commonly used decision-making tools and information sources used by attendees for insect pest management in 2023, as averaged across locations, included sugar cooperative-generated cellular text alerts (10% of respondents), the Sugarbeet Production Guide (8% of respondents), and the NDSU Crop & Pest Report (7% of respondents). Pest management information source usage was varied slightly among surveyed locations in 2023, with respondents that attended the Grand Forks seminar being the most dominant users (35% of attendees) of available information resources, and Grafton attendees being the second-most common users (23% of attendees) of the information.

Table 18. Use of information sources for sugarbeet insect pest management decision making in 2023

Location	Number of Responses	NDSU Crop & Pest Report	Sugarbeet Production Guide	Cellular text alerts	Other	None
		------------------------------------% of responses	------------------------------------			
Fargo	16	7	6	6	81	0
Grafton	38	10	3	10	74	3
Grand Forks	63	6	16	13	65	0
Wahpeton	70	7	4	9	74	6
Totals	187	7	8	10	72	3

Acknowledgement:

The authors greatly appreciate the valued and essential contributions of responses to this survey by the sugarbeet producers that attended the winter sugarbeet grower seminars.

SUGARBEET ROOT MAGGOT FLY MONITORING IN THE RED RIVER VALLEY IN 2023

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Sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), fly activity was monitored at 124 grower field sites throughout the Red River Valley (RRV) during the 2023 growing season. This effort was carried out as a collaborative effort between NDSU Sugarbeet Entomology personnel and American Crystal Sugar Company.

Sugarbeet root maggot fly activity, as averaged throughout the RRV, was slightly lower during the 2023 growing season when compared to that recorded during the two previous growing seasons (Figure 1). However, the SBRM fly levels observed in 2023 were the third-highest recorded in the past 17 years (i.e., since the expanded fly monitoring program began in 2007). The most intense SBRM fly activity levels in 2023 were observed in the central and northern Red River Valley, which is somewhat typical of what is annually observed on the distribution of this pest within the growing area. This suggests that control efforts between 2022 and 2023 had been somewhat successful in reducing overall population levels for many producers in those areas.

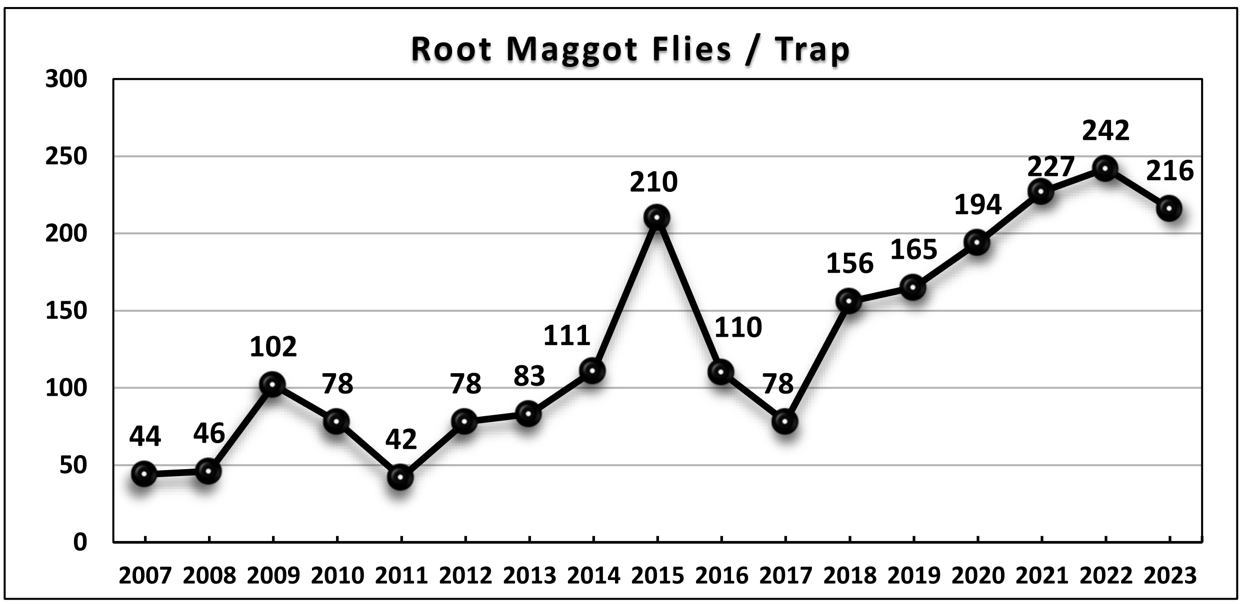

Figure 1. Yearly averages of sugarbeet root maggot flies captured on sticky-stake traps (Blickenstaff and Peckenpaugh, 1976) in the Red River Valley from 2007 to 2023.

High to severe levels of SBRM fly activity (i.e., cumulative capture of at least 200 flies per sticky stake) were observed in 2023 in fields near the following communities (listed in alphabetical order; cumulative flies per stake in parentheses): Auburn (597), Backoo (215), Bathgate (282), Bowesmont (388), Buxton (230), Cavalier (346), Crystal (431), Drayton (279), Hensel (257), Oakwood (476), Reynolds (456), St. Thomas (612), Thompson (409), Veseleyville (319), and Voss, ND (534), and Ada (520), Argyle (268), Climax (211), Crookston (469), Donaldson (222), East Grand Forks (420), Oslo (357), Sabin (1,217), Stephen (284), and Warren, MN (279).

Moderately high levels of activity were also recorded near Forest River (89), Glasston (197), Grand Forks (177), Hamilton (158), Manvel (51), Merrifield (94), Minto, ND (182), as well as Angus (195), Borup (171), Donaldson (165), Eldred (120), Euclid (165), Fisher (163), Kennedy (189), and Tabor, MN (177). Fly activity was either economically insignificant or undetectable at other monitored locations.

Figure 2 presents sugarbeet root maggot fly monitoring results from three representative sites (i.e., Sabin, MN; and Reynolds and St. Thomas, ND) during the 2023 growing season. Adult fly emergence started at the beginning of June at all three sites, irrespective of latitude. Although emergence onset was slightly later than historical averages (emergence typically begins within the last seven to 10 days in May), flight activity peaks in 2023 occurred between June 6 and 7, which was about one week earlier than the 15-year average date of June 13 for the production area as a whole.

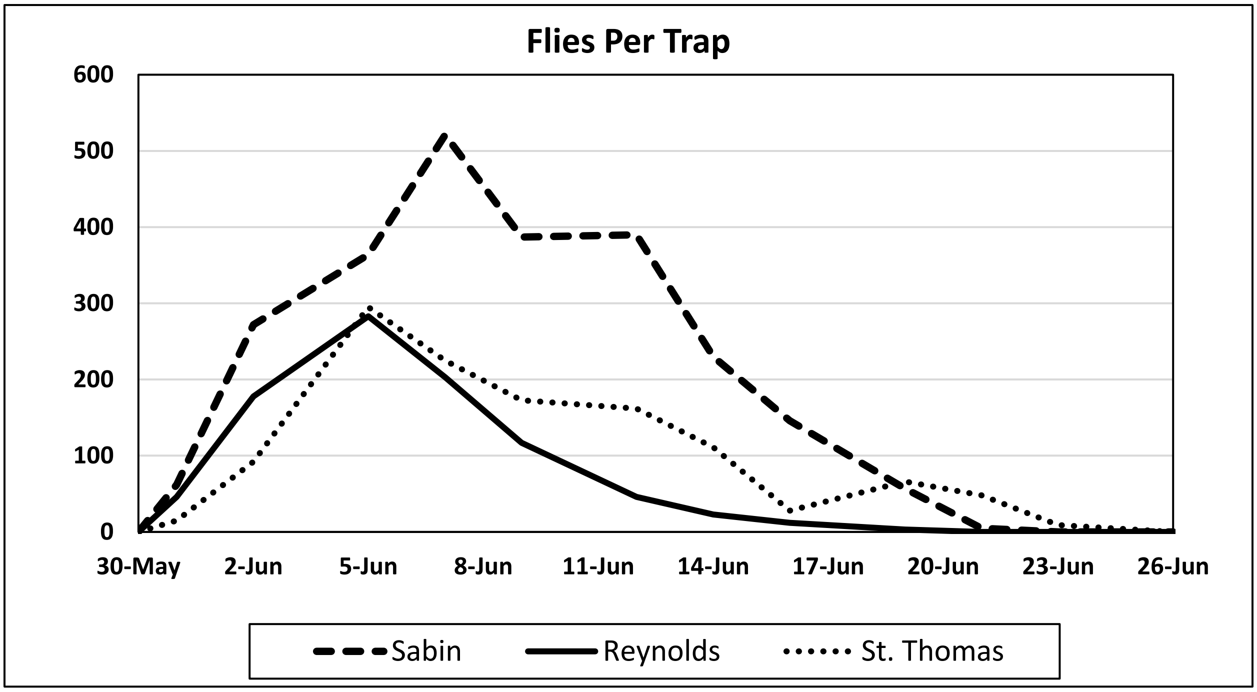

Fig. 2. Sugarbeet root maggot flies captured on sticky-stake traps at selected Red River Valley sites, 2023.

Between late-August and September of 2023, after which most SBRM larval feeding had ceased, 40 roots in 33 of the fly monitoring field sites were rated for root maggot larval 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. Six additional fields that were not part of the fly monitoring program were also rated to provide additional data points. The resulting data was subsequently overlaid with corresponding fly count data to develop the 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 1.85 on the 0 to 9 rating scale. That reflected a near doubling in SBRM feeding injury when compared to that recorded in the previous growing season. 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 284 flies/trap near Stephen, MN to a severe level of 1,217 flies/trap near Sabin, MN. The average root maggot larval feeding injury recorded for those fields ranged from a moderate rating of 2.8 at Stephen to a severe level of 6.9 at Auburn, which suggests that producers managing those fields had varying levels of success in controlling the SBRM infestations that developed in them. Other fields monitored for fly activity that had a combination of high fly activity and at least moderate SBRM feeding injury in 2023 included sites near Crystal, ND (431 cumulative flies/trap; average root rating = 3.9) and Veseleyville, ND (319 cumulative flies/trap; average root rating = 2.9). It should also be noted that the Cavalier location sustained high SBRM feeding injury as well, which suggests high risk for damaging root maggot infestations in that area for the 2024 growing season. Other areas within the monitoring network likely also sustained moderate to even high SBRM feeding injury; however, it was logistically impossible to conduct injury ratings at all fly monitoring locations.

Table 1. Sugarbeet root maggot fly activity and larval feeding injury in Red River Valley commercial sugarbeet fields where injury exceeded 2.5, 2023				
Nearest City	**Township**	**State**	**Flies/stake[a]**	**Average Root Injury Rating[b]**
Auburn	Martin	ND	N/A[c]	6.9
Cavalier	Cavalier N.	ND	N/A	5.0
Crystal	Elora	ND	431	3.9
Sabin	Elmwood	MN	1,217	3.7
St. Thomas	St. Thomas S.	ND	N/A	3.4
Veseleyville	Ops	ND	319	2.9
Stephen	Wanger	ND	284	2.8

[a]Cumulative number of flies captured per sticky stake trap throughout growing season.

[b]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).

[c]N/A: no fly activity monitoring conducted.

Although the collective results from root injury ratings of grower fields conducted in 2023 suggest that RRV sugarbeet growers were somewhat successful in managing the sugarbeet root maggot, continued vigilance and aggressive pest management practices will likely be necessary in the coming years. Careful monitoring of fly activity in moderate- and high-risk areas (see Forecast Map [Fig. 1] in subsequent report) will help prevent economic loss in 2024. 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 quickly develop into economically damaging infestations in the subsequent growing season. That assertion is substantiated by the significant increase in SBRM fly activity that occurred in the Sabin area between 2021 and 2023.

Acknowledgments:

Sincere appreciation is due to the numerous sugarbeet producers that allowed us to monitor SBRM fly activity in their fields. Thanks are also extended to the following American Crystal Sugar Company agriculturists for collaborating with NDSU on this project by monitoring dozens of commercial sugarbeet fields (in alphabetical order): Andrew Clark, Thomas Cymbaluk, Todd Cymbaluk, Mike Doeden, Tyler Driscoll, Curtis Funk, Tyler Hegg, Austin Holy , Bob Joerger, Joshua Knaack, Holly Kowalski, Kody Kyllo, Kyle Lindberg, Curt Meyer, Chris Motteberg, Alysia Osowski, Nolan Rockstad, Andrew Tweten, Dan Vagle, Dan Walters, and Scott Younggren.

Thanks are also due to the following NDSU summer aides for providing assistance with fly monitoring activities: Evan Dietrich, Bryce Friday, Nathan Hayes, and Reed Thoma. The Sugarbeet Research and Education Board of Minnesota and North Dakota, and American Crystal Sugar Company are also greatly appreciated 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 ND02374.

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SUGARBEET ROOT MAGGOT FORECAST FOR THE 2024 GROWING SEASON

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The 2024 map for anticipated risk of sugarbeet root maggot (SBRM) fly activity in the Red River Valley appears in the figure below. Root maggot fly activity has been on an upward trend for the past several years, and 2023 populations were the third-highest recorded in the past 17 growing seasons. The high infestations in 2023 suggest that many areas in the Valley are at high risk for having economically damaging SBRM infestations in 2024.

Areas at highest risk of SBRM problems in 2024 include rural Auburn, Backoo, Bathgate, Bowesmont, Buxton, Cavalier, Crystal, Drayton, Hensel, Oakwood, Reynolds, St. Thomas, Thompson, Veseleyville, and Voss, ND, as well as Ada, Argyle, Climax, Crookston, Donaldson, East Grand Forks, Oslo, Sabin, Stephen and Warren, MN. Moderate risk is expected in areas bordering high-risk zones, as well as fields near Forest River, Glasston, Grand Forks, Hamilton, Manvel, Merrifield, and Minto, ND, and Angus, Euclid, Kennedy, Borup, Tabor, Eldred, Fisher, and Tabor, MN. The rest of the area is at low risk.

Proximity to previous-year beet fields where populations were high and/or control was unsatisfactory can increase risk for damaging SBRM infestations. Areas where high fly activity occurred in 2023 should be monitored closely in 2024. Growers in high-risk areas should use an aggressive at-plant insecticide treatment (e.g., granular insecticide or a combination of tools) and expect the need to apply a postemergence rescue insecticide.

Those in moderate-risk areas using insecticidal seed treatments for at-plant protection should monitor fly 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 determine the need for a postemergence insecticide application.

NDSU Entomology personnel will continue to inform growers regarding SBRM activity levels and hot spots each year through radio reports, the NDSU "Crop and Pest Report" web postings, 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.

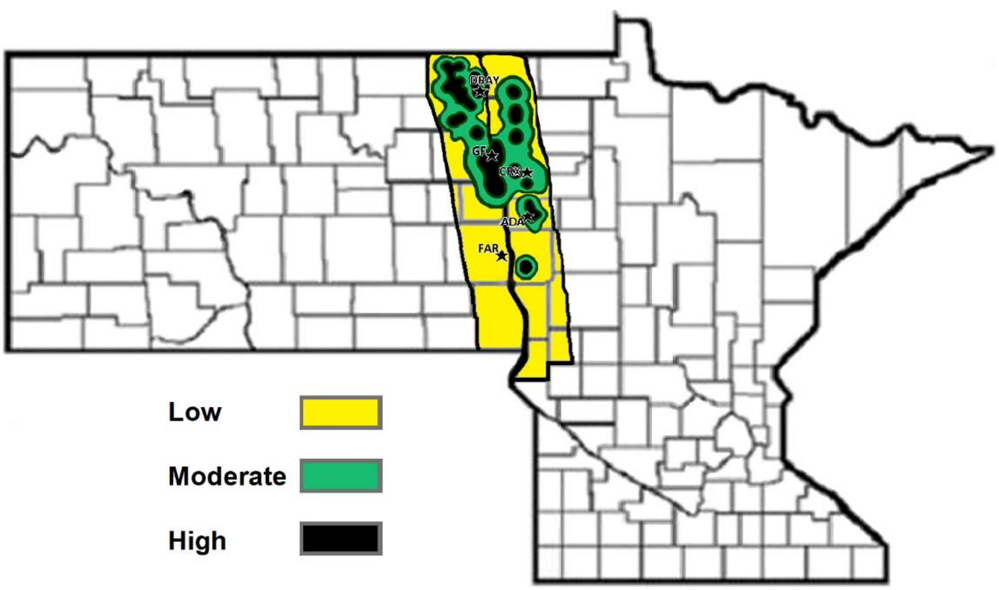

Fig. 1. Anticipated risk of SBRM fly activity and damaging larval infestations in the Red River Valley.

Acknowledgments:

The following sugar cooperative agriculturists are appreciated for their contributions to this forecast by monitoring several grower fields for sugarbeet root maggot fly activity (presented in alphabetical order): Andrew Clark, Thomas Cymbaluk, Todd Cymbaluk, Mike Doeden, Tyler Driscoll, Curtis Funk, Tyler Hegg, Austin Holy, Bob Joerger, Joshua Knaack, Holly Kowalski, Kody Kyllo, Kyle Lindberg, Curt Meyer, Chris Motteberg, Alysia Osowski, Nolan Rockstad, Andrew Tweten, Dan Vagle, Dan Walters, and Scott Younggren. Appreciation is also extended to the following NDSU summer aides for providing assistance with fly monitoring activities: Evan Dietrich, Bryce Friday, Nathan Hayes, and Reed Thoma. Sincere gratitude is also extended to 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 ND02374.

SCREENING ALTERNATIVE CHEMICAL TOOLS FOR SUGARBEET ROOT MAGGOT CONTROL

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is the most important insect pest of sugarbeet in the Red River Valley (RRV) growing area of North Dakota and Minnesota. Infestations of this pest in the RRV have been on an upward trend for well more than a decade, and they have also increased in geographic distribution. Successful SBRM management in areas affected by high to severe SBRM infestations typically requires aggressive insecticide-based control programs that consist of a granular insecticide and/or an insecticidal seed treatment at planting, followed by at least one postemergence insecticide application. Currently, RRV sugarbeet producers have a limited number of insecticide product options to use for both at-plant and postemergence SBRM control. This research was undertaken to evaluate registered and experimental insecticides, as well as an insecticide synergist, for efficacy at controlling this serious economic pest of sugarbeet.

Materials and Methods:

This report presents the findings from two field trials on registered and experimental insecticides for sugarbeet root maggot control. Both trials were conducted on a commercial sugarbeet field site near St. Thomas, ND during the 2023 growing season. Glyphosate- and Cercospora leaf spot-resistant seed (i.e., Betaseed 8018 CR+) was used for all treatments in both trials. Persistent early-season soil moisture delayed planting of both trials. Study I was planted on June 1 and Study II was planted on May 28. All plots were planted using a 6-row Monosem NG Plus 4 7x7 planter set to deliver seed at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. 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. Both experiments were arranged in a randomized complete block design with four replications of the treatments.

<u>Planting-time insecticides</u>. Counter 20G was the planting-time granular insecticide standard used in both trials, and it was applied at either a moderate rate of 7.5 lb product per acre or its maximum labeled rate of 8.9 lb/ac. 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 output was regulated by using a planter-mounted SmartBox™ electronic insecticide delivery system that had been calibrated on the planter before all applications.

Additional planting-time insecticides evaluated in Study I included Poncho Beta insecticidal seed treatment, and four sprayable liquid insecticides: Asana XL, Midac FC, Mustang Maxx, and Verimark, which all represented alternative insecticide classes to the organophosphate group that has been used for decades to control the sugarbeet root maggot. Asana XL and Mustang Maxx belong to the pyrethroid insecticide class, Midac FC is a neonicotinoid, and Verimark belongs to the diamides, a relatively new class of insecticides that involves a completely novel mode of action to that of the other classes.

All planting-time insecticides in Study I were applied by using dribble in-furrow (DIF) placement, which involved orienting microtubes (1/4" outside diam.) directly into the open seed furrow. Inline Teejet™ No. 20 orifice plates were used to provide backpressure for stabilizing the output rate of spray solutions from the microtubes, Insecticide solutions were delivered in a finished spray volume of 5 gallons per acre (GPA). Water was used as the carrier for all planting-time liquid insecticide applications, and it was adjusted to pH 6.0 before use.

<u>Postemergence insecticide applications</u>. The postemergence component in the only dual insecticide (i.e., planting-time + postemergence) program treatment in Study I involved a broadcast application of Mustang Maxx (active ingredient: zetacypermethrin). In Study II, postemergence insecticides evaluated included Asana XL, Exirel Insect Control, and Mustang Maxx. Treatments in Study II that included postemergence insecticides involved both single and dual postemergence spray applications, a combination of Mustang Maxx and Asana, and comparisons of the two pyrethroid insecticides (Asana XL and Mustang Maxx) that were either applied alone or in a tank mixture with Exponent. Exponent is a synergistic product that can increase the effectiveness of pyrethroid insecticides by interfering with the ability of insects to detoxify insecticides.

The aforementioned delayed planting that resulted from excessive spring soil moisture, combined with slow seedling emergence and unseasonably early SBRM fly emergence, led to corresponding delays with executing postemergence insecticide applications in both Studies I and II. The first postemergence applications in these studies were made 6 days after peak SBRM fly activity. Additionally, one treatment combination in Study II included a 10-day post-peak application of Asana XL, which was the second application in a rotated postemergence insecticide regime in plots that had received an initial application of Mustang Maxx at 6 days post-peak. All postemergence liquid insecticides were applied with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ XR 110015VS nozzles calibrated to deliver applications in a finished output volume of 10 GPA.

Plant stand counts: Treatments in each study were evaluated on the basis of plant stand establishment and survival by conducting precise visual counts at several points in the growing season. This effort was undertaken to screen for any potential insecticide impacts on seedling emergence or on protection from plant losses due to SBRM feeding injury. Stand counts involved quantifying all living plants within the four 35-ft-long rows of each plot. Stand counts were carried out in Study I on June 29 and on July 6, 11, and 18, 2023, which were 28, 35, 40, and 47 days after planting (DAP), respectively. Stands were counted in Study II on June 30, July 10, and July 17, 2023, which equated to 33, 43, and 50 DAP, respectively.

Root injury ratings. Sugarbeet root maggot feeding injury ratings were conducted in Test I on July 27 and in Test II on July 26, 2023. A random sample of ten beet roots (five from each of the outer two treated rows) was collected from each plot, hand-washed, and scored 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. Both studies were harvested on October 2, 2023. 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) according to the general linear models (GLM) procedure (SAS Institute, 2012). Treatment means were compared by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

Study I. Stand count data from Study I are presented in Table 1. At the first stand count (28 DAP), the highest stand counts in this experiment were recorded in plots that received the treatment combination of Poncho Beta-treated seed plus a planting-time application of Midac FC followed by a postemergence application of Mustang Maxx. Excellent plant stands were also recorded for the following entries, all of which were not statistically different from the top-ranked treatment in the experiment (listed in descending order of surviving stand count):

1) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (DIF, 9.6 fl oz/ac);
2) Poncho Beta-treated seed + Midac FC (DIF, 13.6 fl oz/ac);
3) Verimark (DIF, 10 fl oz/ac); and
4) Counter 20G (planting-time band, 7.5 lb product/ac).

Those same treatments continued to provide excellent stand protection through all remaining stand count dates, with no significant differences among them at any date. Additionally, plots protected by Poncho Beta seed treatment resulted in surviving plant stands that were not significantly different from any of the aforementioned treatments at the remaining three stand evaluations (35, 40, and 47 DAP). At the final (47 DAP) stand count, the lowest plant densities per 100 row feet included the untreated check, Mustang Maxx, Mustang Maxx plus Exponent, Midac FC, Counter 20G plus a tank-mixed combination of Asana XL and Exponent, and Verimark at its lower (5 fl oz/ac) rate. Plant stands did not differ significantly among any of these treatments.

Table 1. *Plant stand counts* from an evaluation of experimental and registered insecticides for sugarbeet

root maggot control, St. Thomas, ND, 2023

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[b] (plants / 100 ft)			
				28 DAP	35 DAP	40 DAP	47 DAP
Poncho Beta + Midac FC + Mustang Maxx	Seed DIF 6d Post-peak Broad.	 13.6 fl oz 4 fl oz	68 g a.i./ unit seed 0.18 0.025	190.4 a	189.5 a	195.5 a	197.9 a
Counter 20G + Asana XL	B DIF	7.5 lb 9.6 fl oz	1.5 0.05	178.9 abc	175.9 ab	185.0 ab	188.9 ab
Poncho Beta + Midac FC	Seed DIF	 13.6 fl oz	68 g a.i./ unit seed 0.18	181.4 ab	180.5 a	191.8 a	188.6 ab
Verimark	DIF	10 fl oz	0.13	176.1 a-d	176.6 ab	185.7 ab	181.8 abc
Counter 20G	B	7.5 lb	1.5	172.5 a-e	173.0 abc	176.1 abc	179.1 a-d
Poncho Beta	Seed		68 g a.i./ unit seed	153.9 b-f	162.0 a-d	170.2 abc	173.0 a-e
Verimark	DIF[b]	5 fl oz	0.065	161.6 a-f	167.0 a-d	175.7 abc	169.1 b-e
Counter 20G + Asana XL + Exponent	B DIF	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	147.7 c-f	147.5 bcd	153.9 bcd	160.0 cde
Midac FC	DIF	13.6 fl oz	0.18	144.6 def	147.7 bcd	155.7 bcd	159.5 cde
Mustang Maxx + Exponent	DIF	4 fl oz 4 fl oz	0.025 0.25	140.2 f	144.3 cd	148.8 cd	153.6 de
Mustang Maxx	DIF	4 fl oz	0.025	141.1 ef	143.2 d	150.4 cd	151.6 de
Check	-----	----	-----	135.0 f	137.5 d	133.8 d	146.3 e
LSD (0.05)				32.0	29.6	32.2	27.8

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; DIF = dribble in-furrow; Post-Peak Broad. = postemergence broadcast at 6 days after peak SBRM fly activity.

[b] Surviving plant stands were counted on 29 June, and 6, 11, and 18 July, 2023 (i.e., 28, 35, 40, and 47 days after planting [DAP], respectively).

Sugarbeet root maggot feeding injury ratings in the untreated check plots in Study I averaged 5.00 on the 0 to 9 scale of Campbell et al. (2000) (Table 2), suggesting that a moderate SBRM infestation was present. Most insecticide treatment combinations evaluated resulted in significant reductions in sugarbeet root maggot feeding injury when compared to the untreated check.

Table 2. *Larval feeding injury* in an evaluation of experimental and registered insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Asana XL	B DIF	7.5 lb 9.6 fl oz	1.5 0.05	1.00 e
Counter 20G + Asana XL + Exponent	B DIF	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	1.78 de
Counter 20G	B	7.5 lb	1.5	1.85 de
Poncho Beta + Midac FC	Seed DIF	68 g a.i./ unit seed 13.6 fl oz	68 g a.i./ unit seed 0.18	2.48 cd
Mustang Maxx + Exponent	DIF	4 fl oz 4 fl oz	0.025 0.25	2.78 bcd
Poncho Beta + Midac FC + Mustang Maxx	Seed DIF 6d Post-peak Broad.	68 g a.i./ unit seed 13.6 fl oz 4 fl oz	68 g a.i./ unit seed 0.18 0.025	2.88 bcd
Poncho Beta	Seed	68 g a.i./ unit seed	68 g a.i./ unit seed	3.10 bc
Midac FC	DIF	13.6 fl oz	0.18	3.20 bc
Verimark	DIF	10 fl oz	0.13	3.20 bc
Verimark	DIF[b]	5 fl oz	0.065	3.50 bc
Mustang Maxx	DIF	4 fl oz	0.025	3.90 ab
Check	-----	----	-----	5.00 a
LSD (0.05)				1.19

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; DIF = dribble in-furrow; Post-Peak Broad. = postemergence broadcast at 6 days after peak SBRM fly activity.

The best root protection from SBRM feeding injury in Study I was provided by the treatment combination of Counter 20G (7.5 lb product/ac) plus a DIF application of Asana XL applied at its maximum labeled rate (9.6 fl oz/ac) at planting time. Other treatments that performed well with respect to protection from SBRM feeding injury included the triple-component planting-time treatment of Counter 20G (7.5 lb/ac) plus the tank mixture of Asana XL and Exponent (the insecticide synergist), and Counter 20G at 7.5 lb alone. It appears that the most impactful common component in the best-performing treatments in this trial was the planting-time application of Counter 20G. The only treatment that failed to provide a significant reduction in SBRM feeding injury in comparison to the untreated check was the single, at-plant DIF application of Mustang Maxx. Combining Mustang Maxx with Exponent resulted in much lower levels of root maggot feeding injury than those observed in the Mustang Maxx-only plots; however, the reduction was not statistically significant.

Yield and gross economic return (i.e., excluding product and application costs) results from Study I are presented in Table 3. The highest recoverable sucrose yield and root tonnage in Study I were observed in plots treated with the single-component treatment of Counter 20G at 7.5 lb product per acre. Excellent performance, with regard to yield parameters, was also observed in the following treatments, which were not significantly different from the Counter-only treatment or each other in recoverable sucrose yield or root yield produced:

1) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (DIF, 9.6 fl oz/ac) + Exponent (8 fl oz/ac);

2) Poncho Beta-treated seed + Midac FC (DIF, 13.6 fl oz/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac);

3) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (DIF, 9.6 fl oz/ac);

4) Verimark (DIF, 10 fl oz/ac); and

5) Verimark (DIF, 5 fl oz/ac).

Although the two Verimark treatments resulted in yields that were not statistically different from the 7.5-lb rate of Counter 20G, it should be noted that neither rate of Verimark resulted in a significant increase in sucrose or root yield when compared with the untreated check, thus suggesting that this product provides moderate SBRM control. Other treatments that produced yields that were not significantly different from the check included Poncho Beta plus Midac FC, Poncho Beta alone, Mustang Maxx plus Exponent, Mustang Maxx alone, and Midac FC alone.

Table 3. *Yield parameters* from an evaluation of experimental and registered insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023

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	12,073.5 a	37.8 a	16.98 a	2,943
Counter 20G + Asana XL + Exponent	B DIF	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	11,132.2 ab	36.2 ab	16.40 a	2,618
Poncho Beta + Midac FC + Mustang Maxx	Seed DIF 6d Post-peak Broad.	 13.6 fl oz 4 fl oz	68 g a.i./ unit seed 0.18 0.025	10,964.2 abc	35.4 abc	16.55 a	2,597
Counter 20G + Asana XL	B DIF	7.5 lb 9.6 fl oz	1.5 0.05	10,943.4 abc	35.2 abc	16.58 a	2,603
Verimark	DIF	10 fl oz	0.13	10,907.5 a-d	34.8 a-d	16.70 a	2,612
Verimark	DIF[b]	5 fl oz	0.065	10,842.9 a-d	34.7 a-d	16.70 a	2,592
Poncho Beta + Midac FC	Seed DIF	 13.6 fl oz	68 g a.i./ unit seed 0.18	10,297.2 bcd	33.3 bcd	16.48 a	2,431
Poncho Beta	Seed		68 g a.i./ unit seed	10,050.5 bcd	32.2 bcd	16.55 a	2,396
Mustang Maxx + Exponent	DIF	4 fl oz 4 fl oz	0.025 0.25	9,894.2 bcd	32.1 bcd	16.38 a	2,333
Mustang Maxx	DIF	4 fl oz	0.025	9,845.0 bcd	31.6 cd	16.50 a	2,343
Midac FC	DIF	13.6 fl oz	0.18	9,377.1 cd	31.3 cd	16.08 a	2,145
Check	-----	----	-----	9,293.5 d	30.6 d	16.25 a	2,156
LSD (0.05)				1,623.4	4.5	NS	

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

[a] B = 5-inch at-plant band; DIF = dribble in-furrow; Post-Peak Broad. = postemergence broadcast at 6 days after peak SBRM fly activity.

As observed with the SBRM feeding injury rating results, Counter 20G appeared to be a major factor in the success of most of the better-performing treatments in this trial. Another pattern observed in Study I was that additive insecticide applications in plots planted with Poncho Beta-treated seed provided large numerical yield and revenue increases. For example, the triple-component combination treatment that included Poncho Beta-treated seed, a planting-time application of Midac FC, and a postemergence broadcast of Mustang Maxx yielded 667 lb more recoverable sucrose and generated a revenue increase of $166/ac when compared to a similar treatment that lacked the postemergence application of Mustang Maxx. Similarly, plots protected by the triple-component treatment produced an increase of 1,082 lbs/ac in recoverable sucrose when compared to the Poncho Beta-only treatment. The revenue increase provided by Midac FC and Mustang Maxx in that comparison was $254/ac.

<u>Study II</u>. Stand count results from Study II are presented in Table 4. There were no significant differences between any treatments in the experiment, even though average stands between some entries differed by over 30%. That was the case in all three stand count dates. The absence of statistically significant differences, despite widely disparate average stand counts between treatments, was a product of high within-treatment variability in stand counts between replicates in the experiment.

There are some encouraging inferences that can be made on treatment performance regarding sugarbeet root maggot control, as well as some potential plant health impacts that can be at least suggested from the data in Study II. For example, numerically higher plant densities per unit row length were observed in plots protected by the following treatment combinations: Counter 20G at its moderate rate (7.5 lb product/ac) plus a postemergence application of either Mustang Maxx or Asana tank mixed with Exponent insecticide synergist, and Counter 20G (7.5 lb/ac) plus postemergence-applied Mustang Maxx, followed by an application of Asana XL. Another interesting and concerning result was that plots treated with Counter 20G at its high labeled rate (8.9 lb product/ac) had the lowest average stands in the experiment at each stand count date.

Another encouraging observation in Study II was that postemergence applications of Exirel Insect Control, a product that has never previously been evaluated for SBRM control in the Red River Valley, resulted in comparable surviving plant stands to those of several of the conventional insecticides. This was an unexpected result, because applications of Exirel, as well as those of all other postemergence insecticides in this experiment, were applied atypically late (i.e., between 6 and 10 days after SBRM peak fly activity), which was well after SBRM females had been laying eggs for over a week.

Table 4. *Plant stand counts* from an evaluation of planting-time and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[b] (plants / 100 ft)		
				33 DAP[c]	43 DAP[c]	50 DAP[c]
Counter 20G + Mustang Maxx + Exponent	B 6d Post-peak Broad.	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.25	102.7 a	103.4 a	104.3 a
Counter 20G + Mustang Maxx + Asana XL +	B 6d Post-peak Broad. 10d Post-peak Broad.	7.5 lb 4 fl oz 9.6 fl oz	1.5 0.025 0.05	102.3 a	100.1 a	103.6 a
Counter 20G Asana XL + Exponent	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	104.8 a	105.4 a	101.3 a
Mustang Maxx	6d Post-peak Broad.	4 fl oz	0.025	101.3 a	97.9 a	98.6 a
Exirel Insect Control	6d Post-peak Broad.	20 fl oz		98.0 a	95.5 a	96.4 a
Counter 20G + Mustang Maxx	B 6d Post-peak Broad.	7.5 lb 4 fl oz	1.5 0.025	96.4 a	98.0 a	96.1 a
Exirel Insect Control	6d Post-peak Broad.	13 fl oz		96.1 a	93.9 a	92.7 a
Counter 20G Asana XL	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz	1.5 0.05	88.6 a	91.3 a	92.1 a
Counter 20G	B	7.5 lb	1.5	85.7 a	88.9 a	89.5 a
Check	---	---	---	74.1 a	73.4 a	74.5 a
Counter 20G	B	8.9 lb	1.8	69.1 a	68.4 a	69.82 a
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 = 5-inch at-plant band; Post-Peak Broad. = postemergence broadcast at either 6 or 10 days after peak SBRM fly activity.

[b]Surviving plant stands were counted on June 30, and July 10 and 17, 2023 (i.e., 33, 43, and 50 days after planting [DAP], respectively).

Sugarbeet root maggot feeding injury rating results from Study II appear in Table 5. Performance patterns associated with protection from SBRM larval feeding injury corresponded well with stand count data, but there were several statistically significant differences among treatments. All insecticide entries, except the lower (5 fl oz/ac) of Exirel Insect Control, provided significant reductions in SBRM feeding injury when compared to that sustained in the untreated check. The following treatments provided the greatest levels of protection from root maggot feeding injury in this experiment, and they were not significantly different from each other (listed in descending order of performance):

1) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac) + Asana XL (10-day post-peak broadcast, 9.6 fl oz/ac);

2) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac)

3) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (6 day Post-peak Broadcast, 9.6 fl oz/ac); and

4) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac; tank-mixed with Exponent at 4 fl oz/ac).

Interestingly, the root protection from SBRM feeding injury provided by Exirel Insect Control at its high (10 fl oz/ac) rate was not significantly different from that provided by Counter at either its moderate (7.5 lb product/ac) or high (8.9 lb/ac) rate. This result is somewhat surprising and quite encouraging because, as previously mentioned, there was no planting-time insecticide protection in the Exirel plots and the postemergence application of that insecticide was made at six days after peak SBRM fly activity.

Table 5. *Larval feeding injury* ratings from an evaluation of planting-time and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Mustang Maxx + Asana XL +	B 6d Post-peak Broad. 10d Post-peak Broad.	7.5 lb 4 fl oz 9.6 fl oz	1.5 0.025 0.05	0.73 e
Counter 20G + Mustang Maxx	B 6d Post-peak Broad.	7.5 lb 4 fl oz	1.5 0.025	1.28 de
Counter 20G Asana XL	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz	1.5 0.05	1.48 cde
Counter 20G + Mustang Maxx + Exponent	B 6d Post-peak Broad.	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.25	1.55 cde
Counter 20G Asana XL + Exponent	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	1.83 cd
Counter 20G	B	8.9 lb	1.8	2.35 bc
Counter 20G	B	7.5 lb	1.5	2.90 b
Exirel Insect Control	6d Post-peak Broad.	20 fl oz		3.13 b
Mustang Maxx	6d Post-peak Broad.	4 fl oz	0.025	3.13 b
Exirel Insect Control	6d Post-peak Broad.	13 fl oz		4.20 a
Check	---	---	---	4.93 a
LSD (0.05)				0.98

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; Post-Peak Broad. = postemergence broadcast at either 6 or 10 days after peak SBRM fly activity.

Yield, quality, and gross revenue results from Study II are presented in Table 6. Insecticide program performance patterns in relation to yield parameters corresponded closely to those from stand count and SBRM feeding injury assessments. Despite the late planting date for this experiment, yields from several insecticide-protected plots were high. The single-component treatment of Counter 20G, applied at planting at its moderate rate (7.5 lb product/ac) was the only insecticide treatment in Study II that did not provide a significant increase in recoverable sucrose yield when compared to the untreated check. The greater-performing treatments in the experiment, none of which were significantly different from each other with regard to recoverable sucrose yield, included the following (listed in descending order of performance):

1) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac; tank-mixed with Exponent at 4 fl oz/ac);
2) Counter 20G (planting-time band, 7.5 lb product/ac) + Asana XL (6-day Post-peak Broadcast, 9.6 fl oz/ac; tank-mixed with Exponent at 4 fl oz/ac);
3) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac) + Asana XL (10-day post-peak broadcast, 9.6 fl oz/ac); and
4) Counter 20G (planting-time band, 7.5 lb product/ac) + Mustang Maxx (6-day Post-peak Broadcast, 4 fl oz/ac).

As observed with SBRM feeding injury results, postemergence applications of Exirel Insect Control provided encouraging yield benefits, especially when the product was applied at its high (10 fl oz per acre) rate. The only treatment combination in Study II that significantly outperformed the high rate of Exirel was the treatment comprised of Counter 20G applied at planting at its moderate (7.5 lb) rate plus a postemergence tank mixture of Mustang Maxx (4 fl oz/ac) and Exponent (4 oz/ac).

Table 6. *Yield parameters* from an evaluation of planting-time and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2023							
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 + Mustang Maxx + Exponent	B 6d Post-peak Broad.	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.25	11,309.3 a	36.5 a	16.70 a	2,680
Counter 20G Asana XL + Exponent	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz 8 fl oz	1.5 0.05 0.25	10,808.8 ab	35.9 ab	16.25 a	2,484
Counter 20G + Mustang Maxx + Asana XL +	B 6d Post-peak Broad. 10d Post-peak Broad.	7.5 lb 4 fl oz 9.6 fl oz	1.5 0.025 0.05	10,346.5 ab	33.5 ab	16.63 a	2,444
Counter 20G + Mustang Maxx	B 6d Post-peak Broad.	7.5 lb 4 fl oz	1.5 0.025	9,660.6 ab	31.8 ab	16.37 a	2,238
Counter 20G Asana XL	B 6d Post-peak Broad.	7.5 lb 9.6 fl oz	1.5 0.05	9,570.6 b	31.7 ab	16.32 a	2,204
Exirel Insect Control	6d Post-peak Broad.	13 fl oz		9,529.3 b	31.9 ab	16.16 a	2,169
Mustang Maxx	6d Post-peak Broad.	4 fl oz	0.025	9,367.7 bc	31.9 ab	15.90 a	2,095
Exirel Insect Control	6d Post-peak Broad.	20 fl oz		9,166.5 bc	30.7 bc	16.13 a	2,087
Counter 20G	B	8.9 lb	1.8	9,112.3 bc	31.6 ab	15.65 a	1,994
Counter 20G	B	7.5 lb	1.5	7,683.0 cd	26.1 c	15.82 a	1,723
Check	---	---	---	6,355.1 d	20.5 d	16.47 a	1,503
LSD (0.05)				1,714.8	5.40	NS	

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

[a] B = 5-inch at-plant band; Post-Peak Broad. = postemergence broadcast made at either 6 or 10 days after peak SBRM fly activity.

The results of Studies I and II should be interpreted with discretion, in large part, due to the atypically late planting dates (June 1 and May 28, respectively). In addition to late planting, seedlings were slow to emerge because of a lack of post-planting rainfall. Unfortunately, unseasonably warm spring weather accelerated SBRM development and emergence, which led to peak fly activity occurring about one weak earlier than the historical average. It is likely that a limited amount of emerged sugarbeet seedlings were available for egg deposition by adult female SBRM flies. Thus, some insecticide treatment performance results in these trials could appear more favorable than might have otherwise occurred under more average conditions. However, the root injury and yield results in both studies were encouraging with regard to planting-time-only treatment combinations (Study I) and multi-component treatments involving integrations of planting-time and postemergence treatments (Study II), despite the late (i.e., 6 and/or 10 days post-peak) timing for those additive insecticide applications.

Another finding of concern occurred in Study II, in which the high (8.9 lb product/ac) rate of Counter 20G resulted in disappointingly low plant stands when compared to those in plots treated with the moderate (7.5-lb) rate of Counter. This could suggest that, in some years, a moderate rate of Counter 20G, followed by a more aggressive approach to postemergence insecticide use, could optimize the resulting impacts on sugarbeet yield, quality, and revenue, and help avoid potential negative yield/quality effects.

Sugarbeet producers who perennially experience the threat of economically damaging SBRM infestations should consider an integrated at-plant insecticide strategy, such as combining an insecticide seed treatment with an at-plant sprayable liquid insecticide or combining a granular and seed treatment insecticide, and then following it with an aggressive postemergence liquid insecticide approach that involves one to two insecticide applications. Another viable, although more expensive, option would be to invest in equipment for applying postemergence applications of a granular organophosphate insecticide product. Finally, the results of these experiments demonstrate that the root protection, yield, and revenue benefits from additive postemergence insecticides are cost-effective control strategies that would easily pay for themselves in areas where moderately high to severe SBRM populations occur.

Acknowledgments:

The authors thank Wayne and Austin Lessard for allowing us to conduct this research on their farms. Appreciation is also extended to the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing partial funding to support this project. We also thank Evan Dietrich, Bryce Friday, Nathan Hayes, and Reed Thoma for assistance with plot maintenance, stand counting, root sample collection, and data entry. Gratitude is also extended to the American Crystal Quality Tare Laboratories (East Grand Forks and Moorhead, MN) for performing sucrose content and quality analyses on harvest samples. This work was also partially supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, under Hatch project number ND02398.

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AN EVALUATION OF SUGARBEET ROOT MAGGOT CONTROL AND PLANT HEALTH ASSOCIATED WITH INSECTICIDE, FUNGICIDE, AND STARTER FERTILIZER COMBINATIONS

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Introduction:

A common approach many sugarbeet producers use to save on input costs during the growing season is to combine pesticide and fertilizer applications into a single pass through the field, either during planting or after emergence of the crop. However, the impacts of such combinations on plant health or pest control efficacy are not always well understood, especially as new crop management materials enter the marketplace.

Several insect pests, including wireworms, springtails, white grubs, and the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) are annual threats to sugarbeet production in the Red River Valley (RRV) growing area. Sugarbeet producers typically manage these root-feeding pests by applying a prophylactic insecticide during sugarbeet planting. This at-plant protection usually involves a granular or sprayable liquid insecticide, insecticide-treated seed, or a combination thereof. In situations where there is moderate to high risk of damaging SBRM infestations, most producers also supplement the initial at-plant insecticide(s) with a postemergence granular or sprayable liquid insecticide application.

Fungicides are also frequently used in sugarbeet, but with the goal of managing soil-borne root diseases of sugarbeet 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 to manage root-feeding insect pests, fungicides targeting Rhizoctonia management in sugarbeet also can be delivered as planting-time and/or early-season postemergence applications, and some are also formulated as fungicidal seed treatments.

Starter fertilizer is also used commonly at planting time by RRV sugarbeet producers. However, little is known about the crop safety of combining fertilizer and pesticide applications, or if they either complement or interfere with pesticide performance. If demonstrated as safe for the crop and at least neutral in impact on pest control performance, consolidating the delivery of these products into tank-mixed combinations or concurrent (i.e., single-pass) applications would provide major time savings and reduce application-associated input costs for sugarbeet growers.

The primary goal of this experiment was to evaluate the impact of 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, banded at planting with a concurrently applied (i.e., at same time through a separate delivery system) dribble-in-furrow application of 10-34-0 starter fertilizer, with and without AZteroid (i.e., azoxystrobin) fungicide;

2) Mustang Maxx insecticide applied as a postemergence band in a tank mixture with Quadris (i.e., azoxystrobin) fungicide; and

3) Thimet 20G insecticide applied as a postemergence band with a concurrent, banded application of Quadris fungicide.

Materials and Methods:

This experiment was conducted in a commercial sugarbeet field site near St. Thomas in rural Pembina County, ND during the 2023 growing season. Plots were planted on May 31, 2023, and Betaseed 8018 CR+ glyphosate-and Cersospora leaf spot-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 by 35 ft long with the four centermost rows treated. The outer “guard” row on each side of the plot served as an untreated buffer. Thirty-five-foot tilled, plant-free alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with four replications. AZteroid fungicide was used for all treatments that included an at-plant fungicide, and Quadris was used in all treatments that included a postemergence fungicide. These two products were chosen for the experiment because they are commonly used azoxystrobin-based fungicides used by RRV producers for at-plant and postemergence root diseases, respectively, 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™ electronic insecticide delivery system that had been calibrated on the planter before all applications.

Planting-time liquid spray applications were delivered by using dribble in-furrow (DIF) placement. Dribble in-furrow treatments were applied in a 3:2 gallon ratio of 10-34-0 starter fertilizer/water spray solution, and the applications were made by orienting microtubes (1/4" outside diam.) directly into the open seed furrows. An electric ball valve system, equipped with inline Teejet™ No. 24 orifice plates was used to propel spray output from the microtubes at a finished volume of five gallons per acre (GPA).

Postemergence insecticide applications. Additive postemergence insecticides applied in this trial included Mustang Maxx (active ingredient: zeta-cypermethrin) and Thimet 20G (active ingredient: phorate). Treatment combinations that included postemergence applications of Thimet and/or Quadris fungicide were applied on June 8, which was about two days after peak SBRM fly activity (i.e., "post-peak"). That timing is not recommended for applications of Thimet (recommended for 5-14 days pre-peak); however, the wet early-spring soil conditions that delayed planting operations in this experiment also led to unusually late plant emergence, thus delaying the postemergence fungicide/insecticide applications. Postemergence applications of Mustang Maxx insecticide and/or Quadris fungicide were also made on June 8 (i.e., 2d post-peak). Those applications were also carried out later than preferred, and for the same reasons. As such, and the timing of Mustang applications was also considered suboptimal for achieving good SBRM control.

Postemergence liquid treatments were delivered with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ XR 110015VS nozzles. The system was calibrated to deliver a finished output volume of 10 GPA. Postemergence granular insecticide 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 into the soil by using two pairs of metal rotary tines that straddled each row. One pair of tines was positioned ahead of each bander, and a second pair was mounted behind it.

Plant stand counts: To determine treatment impacts on seedling emergence and survival throughout the growing season, surviving plant stands were counted on June 29 and July 5, 12, and 19, 2023 (i.e., 29, 35, 42, and 49 days after planting [DAP], respectively). 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 was assessed in this experiment on August 1, 2023. 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. All plots were harvested on October 2, 2023. 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 plant stand counts, root injury ratings, and harvest samples were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2012), and treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

The results from four counts of surviving plant stands are shown in Table 1. These data, as well as those involving SBRM larval feeding injury ratings and harvest results, should be interpreted with the aforementioned fact that unfavorable soil conditions prevented timely planting operations, which subsequently led to delayed applications of postemergence insecticides and fungicides. The most likely negative impact of those factors on these results was probably reduced efficacy of postemergence insecticides, because they could not be applied at an optimal interval ahead of peak SBRM fly activity to maximize control.

At the first stand count, which was carried out at 29 days after planting (29 DAP), the highest plant densities ranged between 120 and 146 plants per 100 linear row feet. Interestingly, the highest average stand count recorded during the first count was from the untreated check plots. Other treatments that resulted in comparable plant densities that were not significantly different from the check or each other included the following (listed in descending order of surviving stand):

1) Counter 20G (7.5 lb/ac, banded at planting);
2) Counter 20G (8.9 lb/ac, banded at planting);
3) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb product/ac, banded, 2d pre-peak) + Quadris (banded, 10 fl oz/ac, 2 d pre-peak)
4) Counter 20G (8.9 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d post-peak); and
5) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb product/ac, banded, 2d pre-peak).

Table 1. *Plant stand counts* from an evaluation of tank-mixed and concurrent applications of planting-time granular and liquid insecticides with starter fertilizer and azoxystrobin for sugarbeet root maggot control, St. Thomas, ND, 2023

Treatment/form.[a]	Placement[b]	Rate (product/ ac)	Rate (lb a.i./ac)	Stand count[c] (plants / 100 ft)			
				29 DAP[c]	35 DAP[c]	42 DAP[c]	49 DAP[c]
Counter 20G	B	7.5 lb	1.5	141.3 ab	141.1 a	138.8 a	147.1 a
Counter 20G	B	8.9 lb	1.8	137.1 ab	137.5a	134.3 ab	139.8 ab
Check	-----	----	-----	145.9 a	137.9 a	133.4 abc	135.7 ab
Counter 20G + Thimet 20G + Quadris	B 4" Post B, 2 d Pre-peak 10" Post B	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	126.3 abc	130.2 ab	133.2 abc	132.5 abc
Counter 20G + Mustang Maxx	B 10" Post B, 2 d Post-peak	8.9 lb 4 fl oz	1.8 0.025	129.3 abc	128.0 ab	123.0 a-d	127.3 a-d
Counter 20G + Thimet 20G	B 4" Post B, 2 d Pre-peak	8.9 lb 7 lb	1.8 1.4	121.4 a-d	121.8 abc	117.7 a-e	123.9 a-d
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	106.8 cde	105.2 bc	108.2 cde	117.5 bcd
Counter 20G + Mustang Maxx + Quadris	B 10" Post B, 2 d Post-peak	8.9 lb 4 fl oz 10 fl oz	1.8 0.025 0.17	115.9 b-e	114.5 abc	109.5 b-e	114.8 bcd
10-34-0 fertilizer check	DIF	5 GPA		104.8 cde	106.6 bc	106.6 de	114.5 bcd
Counter 20G + AZteroid FC+ 10-34-0	B DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.0625	95.0 de	96.6 c	97.9 de	104.8 cd
Counter 20G + AZteroid FC+ 10-34-0	B DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.0625	96.6 de	96.3 c	94.1 e	101.8 d
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	93.6 e	94.3 c	95.4 e	100.7 d
LSD (0.05)				27.3	27.9	26.0	27.8

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 sprayable liquid formulations); DIF = dribble in-furrow
[c]Surviving plant stands were counted on June 29, and July 5, 12, and 19, 2023 (i.e., 29, 35, 42, and 49 days after planting [DAP], respectively).

General patterns in the results from the first stand count indicated that treatment plots which contained significantly lower surviving plant stands than the untreated check at the first count were usually treated at planting time with either 10-34-0 starter fertilizer, Counter 20G at its high (8.9 lb product/ac) rate, and/or a planting-time combination of Counter 20G (either 7.5 or 8.9 lb product/ac) with a concurrently applied tank mixture of 10-34-0 and AZteroid fungicide.

The same patterns with regard to surviving plant stands continued through all four counts, although by 49 DAP, stand losses associated with SBRM feeding injury were slightly more apparent. As a result, there were fewer significant differences among treatments. However, the above-listed treatments, including the untreated check, continued to maintain the highest stand counts in the experiment.

At every stand count, plots that received a planting-time application of Counter 20G at its moderate rate (7.5 lb product/ac) and a concurrent application of 10-34-0 starter fertilizer had significantly lower plant stands than similar Counter-treated plots where the starter fertilizer was excluded.

Similarly, at all four stand counts conducted in this experiment, there was a significant stand reduction at in plots treated with concurrent applications of Counter 20G insecticide and the tank mixture of 10-34-0 starter fertilizer and AZteroid fungicide in comparison to similar plots that did not receive the fertilizer/fungicide combination. That was the case regardless of whether Counter was applied at 7.5 or 8.9 lb product per acre.

In the last series of stand counts, which were conducted on July 19 (49 DAP), the highest overall stand counts were recorded in plots that treated solely with a planting-time application of Counter 20G at its moderate (7.5 lb product/ac) rate. However, excellent stands were also maintained in several other treatments, including the following that had surviving plant stands that were not statistically different from the single, 7.5-lb rate of Counter 20G (listed in descending order of mean surviving plant stand):

1) Counter 20G (8.9 lb/ac, banded at planting);
2) Untreated check;
3) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb product/ac, banded, 2d post-peak) + Quadris (banded, 10 fl oz/ac, 2 d post-peak);
4) Counter 20G (8.9 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d after peak fly); and
5) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb product/ac, banded, 2d post-peak);

The treatment combinations involving Counter 20G and a concurrent at-plant application of AZteroid, which was tank mixed with 10-34-0 starter fertilizer, were the only insecticide treatments in which stand counts at 49 DAP were significantly reduced when compared to that recorded in plots treated with the stand-alone planting-time application of Counter 20G (8.9 lb product/ac). This finding was consistent, regardless of whether the Counter 20G was applied at the 7.5- or 8.9-lb rate.

Sugarbeet root maggot feeding injury results from this trial appear in Table 2. The average SBRM feeding injury sustained in the true untreated check and the fertilizer-only check plots (5.45 and 5.90, respectively, on the 0 to 9 scale of Campbell et al. [2000]) indicated the presence of a moderate SBRM 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 and the fertilizer-only check. The lowest average SBRM feeding injury (i.e., the highest level of root protection) was observed in plots that received the combination of a planting-time application of Counter 20G at its high labeled rate (8.9 lb product/ac) plus a postemergence application of Thimet 20G.

However, because only a moderate SBRM infestation developed for this trial, there were very few significant differences among treatments that included an insecticide. One unusual and concerning result involved the treatment combination of Counter 20G at its high (8.9 lb product/ac) rate when it was accompanied by a concurrent application of AZteroid fungicide tank mixed with 10-34-0 starter fertilizer. Root maggot feeding injury sustained by plants in this treatment (mean rating = 3.98) was significantly greater than the injury in similar (i.e., Counter, AZteroid, and 10-34-0) plots when the Counter was applied at 7.5 lb/ac (mean rating = 3.18). Additionally, roots in the plots that received the treatment combination of Counter 20G (8.9 lb) plus a concurrent tank-mixed application of AZteroid and 10-34-0 incurred significantly greater SBRM feeding injury than those in similar plots when the AZteroid was excluded. This finding could suggest potential antagonistic impacts from the fungicide. As such, this phenomenon should be investigated further.

Root protection from SBRM feeding injury was not significantly impaired by including concurrent dribble-in-furrow applications of 10-34-0 starter fertilizer with banded applications of Counter 20G at planting time, irrespective of whether the insecticide was applied at 7.5 or 8.9 lb product per acre. There also were no significant reductions in SBRM control when Quadris was applied concurrently with Thimet 20G applications or when it was tank mixed with Mustang Maxx.

Table 2. ***Larval feeding injury*** **from an evaluation of tank-mixed and concurrent applications of planting-time granular and liquid insecticides with starter fertilizer and azoxystrobin for sugarbeet root maggot**

control, St. Thomas, ND, 2023				
Treatment/form.[a]	**Placement[b]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Counter 20G + Thimet 20G	B 4" Post B, 2 d Pre-peak	8.9 lb 7 lb	1.8 1.4	2.65 d
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	2.95 cd
Counter 20G + Mustang Maxx + Quadris	B 10" Post B, 2 d Post-peak	8.9 lb 4 fl oz 10 fl oz	1.8 0.025 0.17	2.95 cd
Counter 20G + Thimet 20G + Quadris	B 4" Post B, 2 d Pre-peak 10" Post B	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	2.95 cd
Counter 20G + Mustang Maxx	B 10" Post B, 2 d Post-peak	8.9 lb 4 fl oz	1.8 0.025	2.98 cd
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	2.98 cd
Counter 20G + AZteroid FC+ 10-34-0	B DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.0625	3.18 cd
Counter 20G	B	8.9 lb	1.8	3.20 cd
Counter 20G	B	7.5 lb	1.5	3.48 bc
Counter 20G + AZteroid FC+ 10-34-0	B DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.0625	3.98 b
Check	-----	----	-----	5.45 a
Fertilizer check	DIF	5 GPA		5.90 a
LSD (0.05)				0.71

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 sprayable liquid formulations); DIF = dribble in-furrow

Yield data from this experiment are presented in Table 3. Overall performance patterns observed in relation to recoverable sucrose yield and root tonnage indicated that postemergence applications of either Thimet 20G or Mustang Maxx performed slightly better than those that lacked a post-applied insecticide. Another distinct pattern observed was that average recoverable sucrose yields and root yields from treatments that included either 10-34-0 starter fertilizer or a combination of the fertilizer and AZteroid fungicide were all numerically lower than that of the untreated check plots, although the differences were rarely significant. One notable and concerning exception was the treatment combination of Counter 20G at its high (8.9 lb product/ac) rate when it was accompanied by a concurrent application of AZteroid fungicide that was tank mixed with 10-34-0 starter fertilizer. Plots treated with that combination produced significantly lower sucrose and root yields than those treated solely with Counter 20G (i.e., at either 7.5 or 8.9 lb product/ac) and even the untreated check, which further suggests either phytotoxic impacts of the insecticide/fungicide/fertilizer combination on plant health or antagonistic impacts on the insecticidal activity of Counter 20G.

Other patterns in the yield results of this experiment could also provide cause for concern. For example, when Mustang Maxx was used for postemergence SBRM control, tank mixing the insecticide with Quadris fungicide resulted in numerical reductions in recoverable sucrose yield (938.6-lb loss) and root tonnage (2.3-ton loss) when compared to similar plots that lacked the fungicide, although the yield differences were not statistically significant. Similarly, applying Quadris fungicide concurrently to the application of Thimet 20G resulted in numerical reductions in recoverable sucrose yield and root tonnage, which translated to an $88/ac reduction in gross revenue when compared with a similar treatment combination that excluded the Quadris application, even though the yield differences were not significant.

Table 3. *Sugarbeet yield parameters and gross economic return* from an evaluation of tank-mixed and concurrent applications of planting-time granular and liquid insecticides with starter fertilizer and azoxystrobin for sugarbeet root maggot control, St. Thomas, ND, 2023

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 + Mustang Maxx	B 10" Post B, 2 d Post-peak	8.9 lb 4 fl oz	1.8 0.025	10,711.6 a	36.5 a	15.83 a	2,392
Counter 20G	B	7.5 lb	1.5	10,137.8 ab	34.1 ab	15.92 a	2,294
Counter 20G + Thimet 20G	B 4" Post B, 2 d Pre-peak	8.9 lb 7 lb	1.8 1.4	10,119.1 ab	33.9 abc	16.15 a	2,303
Counter 20G + Thimet 20G + Quadris	B 4" Post B, 2 d Pre-peak 10" Post B	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	10,089.6 ab	34.9 ab	15.66 a	2,215
Counter 20G	B	8.9 lb	1.8	9,938.8 abc	34.8 ab	15.50 a	2,145
Counter 20G + Mustang Maxx + Quadris	B 10" Post B, 2 d Post-peak	8.9 lb 4 fl oz 10 fl oz	1.8 0.025 0.17	9,773.0 abc	34.2 ab	15.57 a	2,117
Check	-----	----	-----	9,466.6 abc	31.4 a-d	16.04 a	2,181
Counter 20G + AZteroid FC+ 10-34-0	B DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.0625	8,870.5 bcd	30.0 bcd	15.67 a	1,996
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	8,866.5 bcd	29.9 bcd	15.92 a	2,005
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	8,631.2 bcd	29.3 bcd	15.67 a	1,935
Fertilizer check	DIF	5 GPA		8,343.2 cd	28.3 cd	15.83 a	1,870
Counter 20G + AZteroid FC+ 10-34-0	B DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.0625	7,498.8 d	25.9 d	15.59 a	1,645
LSD (0.05)				1,667.0	5.7	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 sprayable liquid formulations); DIF = dribble in-furrow

The overall findings of this experiment suggest that combining a dribble-in-furrow application of 10-34-0 starter fertilizer with a concurrently applied planting-time banded application of Counter 20G will likely be safer if the insecticide is applied at a reduced rate of 7.5 lb/ac or lower. These findings further suggest that applying Counter at higher rates in such combinations could pose significant risk of reduced plant populations and corresponding yield and revenue losses. Additionally, the observations of numerical, and occasionally significant, root protection and yield impacts associated with applying azoxystrobin fungicide/10-34-0 starter fertilizer tank mixtures concurrently with planting-time tank applications of Counter 20G in sugarbeet are also concerning. Those trends also involved the maximum labeled rate (8.9 lb/ac) of Counter insecticide.

Similarly, these findings also suggested the possibility of deleterious impacts on yield and revenue occurring when applying azoxystrobin fungicide concurrently with postemergence banded applications of Thimet 20G or tank mixing the fungicide with Mustang Maxx. Therefore, research on concurrent and tank-mixed applications of these or similar treatment combinations should be further explored. Additional study should also include evaluating starter fertilizer products with alternative NPK concentrations.

Finally, it bears noting that this trial was conducted in an environment that involved a moderate SBRM infestation. The net impacts of the treatment combinations tested should also be evaluated under low SBRM pressure and probably in its absence to more fully understand the crop safety of these treatment combinations.

Acknowledgments:

Appreciation is extended to Wayne and Austin Lessard for allowing us to conduct this research on their farm. The authors also thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing partial funding to support this project. We also appreciate the contributions of Evan Dietrich, Bryce Friday, Nathan Hayes, and Reed Thoma for assistance with plot maintenance, sample collection, and data entry. Thanks are also extended to the American Crystal Quality Tare Laboratory (East Grand Forks, MN) for performing sucrose content and quality analyses on harvest samples. This work was also partially supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, under Hatch project number ND02374.

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SPRINGTAIL CONTROL IN SUGARBEET USING GRANULAR, SPRAYABLE LIQUID, AND SEED-APPLIED INSECTICIDES

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Introduction:

Subterranean (soil-dwelling) springtails have been recognized as major pests of sugarbeet in the Red River Valley (RRV) of Minnesota and North Dakota since the late-1990s. They are capable of causing serious crop damage associated with early season plant injury and, occasionally, major plant stand losses. Springtails belong to the order Collembola, a group of organisms that resemble insects, but are so unique that they are not considered true insects. These tiny, nearly microscopic, blind, and wingless pests spend their entire lives below the soil surface (Boetel et al. 2001).

Although subterranean springtails are present in many fields throughout the sugarbeet production areas of North Dakota and Minnesota, the occurrence of damaging infestations tends to be spotty and is most commonly associated with heavy-textured, high organic matter soils. Persistently cold and wet spring weather conditions can be conducive to springtail infestation buildups, because those conditions slow sugarbeet seed germination and seedling development, rendering plants more vulnerable to attack by springtails. This research was conducted to evaluate the performance of a conventional granular insecticide, an at-plant liquid insecticide, and three neonicotinoid insecticidal seed treatments for springtail control in sugarbeet.

Materials & Methods:

This field experiment was established on the NDSU Experiment Farm near Prosper, ND. Plots were planted on July 7, 2023 using a 6-row Monosem NG Plus 7x7 planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Betaseed 8018 CR+, a glyphosate- and Cercospora leaf spot-tolerant seed variety, was used for all treatments.

Individual treatment plots were two rows (22-inch spacing) wide and 25 feet long, and 25-ft wide tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with four replications of the treatments. Two-row plots are the preferred experimental unit size in springtail trials because infestations of these pests are typically patchy in distribution. Therefore, a smaller test area increases the likelihood of having a sufficiently uniform springtail infestation among plots within each test replicate.

Granular insecticide treatments were applied by using band placement (Boetel et al. 2006), which consisted of 5-inch swaths that were delivered through Gandy™ row banders. Output rates of the planting-time standard granular material used this experiment were regulated by using a planter-mounted SmartBox™ electronic insecticide delivery system that was calibrated on the planter immediately before all applications. Midac FC and Mustang Maxx were applied by using dribble in-furrow (DIF) placement through microtubes directed into the open seed furrow. Delivery of planting-time liquid insecticides was achieved by using a planter-mounted, CO_2-propelled spray system calibrated to deliver a finished spray volume output of 5 GPA. Teejet® No. 20 orifice plates were installed inline within check valves to achieve the correct spray output volume. The postemergence application of Movento HL was delivered in 10-inch bands by using a CO_2-propelled spray system that was mounted on a tractor-drawn four-row toolbar. The insecticide was lightly incorporated into the soil with two pairs of metal rotary tines straddling each row. One pair of tines was positioned ahead of each bander, and a second was mounted behind it. The spray system was calibrated to at a finished spray volume output of 10 GPA through Teejet® 8001E nozzles.

Treatments were compared according to surviving plant stands and yield parameters because subterranean springtails can cause stand reductions that lead to yield loss. Stand counts involved counting all live plants in both 25-ft long rows of each plot. Stands were counted July 28, and August 4 and 11, 2023 (i.e., 14, 21, and 28 days after planting [DAP], respectively). Raw stand counts were converted to plants per 100 linear row ft for the analysis.

Harvest operations, which were conducted on October 10, involved initially removing the foliage from all plots by using a commercial-grade mechanical defoliator immediately (i.e., between 10 and 60 minutes) beforehand. Plots were harvested by using a 2-row mechanical harvester to collect all beets from both rows of each plot. Representative subsamples of 12-18 randomly selected beets were sent to the American Crystal Sugarbeet Quality Laboratory (East Grand Forks, MN) for quality analyses. All stand and yield 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 0.1 level of significance.

Results and Discussion:

Data from counts of surviving plant stands for this trial are presented in Table 1. Results from the first stand count date (14 DAP), indicated that the treatment combination of Poncho Beta insecticidal seed treatment plus a planting-time application of Mustang

Maxx at 4 fl oz per acre resulted in the highest number of surviving plants in the trial. Similarly, plots treated with the high (8.9 lb product/ac) rate of Counter 20G had the second-highest stand counts, and those counts were not statistically different from those in plots protected by the Poncho Beta/Mustang Maxx combination. These same results for those two treatments also occurred during the 21- and 28-DAP counts. Additionally, at every stand count date, the plant densities in plots treated with Poncho Beta/Mustang Maxx combination were significantly greater than those in any other treatment, except those in plots treated with Counter 20G at the 8.9-lb rate.

It should be noted that, although plots treated with Counter at its high (8.9 lb product/ac) rate resulted in surviving plant stands that were not significantly different from the top-performing treatment in the experiment (i.e., Poncho Beta + Mustang Maxx), there were no statistically significant differences in plant stands between any of the Counter 20G treatments, irrespective of application rate.

One encouraging result from the stand count data involved the combination of Poncho Beta seed treatment plus a postemergence 10-inch band of Movento HL. Plots protected by this treatment had the 3rd-highest stands at all stand count dates, and it was the only other treatment (other than Poncho Beta + Mustang Maxx and the high rate of Counter 20G) that resulted in significantly greater plant densities than the untreated check at the 14 DAP count.

The 4th-ranked treatment in the trial, according to surviving plant stands, involved a combination of Poncho Beta plus a planting-time DIF application of Midac FC at 13.6 fl oz per acre. When assessments were made at 21 and 28 DAP, it was the only other treatment (in addition to the three above-mentioned treatments) that resulted in surviving plant stands that were statistically greater than those in the untreated check plots. Less-than-desired performance, with regard to plant stand protection, mostly involved single-component insecticide treatments, including Midac FC, Poncho Beta, and the two lower rates of Counter 20G (i.e., 4.5 and 5.9 lb product/ac).

Table 1. *Plant stand counts* from an evaluation of planting-time granular, liquid, and seed treatment insecticides, and a postemergence sprayable liquid for springtail control, Prosper, ND, 2023

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[b] (plants / 100 ft)		
				14 DAP[c]	21 DAP[c]	28 DAP[c]
Poncho Beta + Mustang Maxx	Seed DIF	4 fl oz	68 g a.i./ unit seed	146.5 a	152.0 a	155.0 a
Counter 20G	B	8.9 lb	1.5	122.0 ab	128.5 ab	126.5 ab
Poncho Beta + Movento HL	Seed 10" Post B	2.5 fl oz	68 g a.i./ unit seed	96.5 bc	100.5 bc	102.0 bc
Poncho Beta + Midac FC	Seed DIF	13.6 fl oz	68 g a.i./ unit seed 0.18	92.5 bcd	99.0 bc	98.0 bc
Mustang Maxx	DIF	4 fl oz		86.0 bcd	94.5 bcd	95.5 bcd
Counter 20G	B	5.9 lb	1.2	84.0 bcd	93.0 bcd	94.5 bcd
Counter 20G	B	4.5 lb	0.9	82.0 bcd	79.5 cd	82.0 bcd
Poncho Beta	Seed		68 g a.i./ unit seed	66.5 cd	68.0 cd	76.5 bcd
Midac FC	DIF	13.6 fl oz	0.18	68.0 cd	70.5 cd	72.0 cd
Check	---	---	---	47.5 d	46.5 d	47.0 d
LSD (0.1)				48.0	48.4	50.13

Means within a column sharing a letter are not significantly (P = 0.1) different from each other (Fisher's Protected LSD test).

[a]Seed = insecticidal seed treatment; B = 5-inch band at planting; DIF = dribble in-furrow at planting; Post B = postemergence band

[b]Surviving plant stands were counted on July 28 and August 4 and 11, 2023 (i.e., 14, 21, and 28 days after planting [DAP], respectively).

[c]DAP = Days after planting

Yield results from this experiment are presented in Table 2. NOTE: the springtail infestation at this site was detected in late-June. Subsequently, soil samples were collected and processed to confirm an adequate springtail infestation for screening trials. Upon that confirmation, the field was tilled and the trial was planted shortly thereafter on July 7, which was much later than a typical grower's field would be planted in the Red River Valley growing area. However, the treatment performance patterns associated with yield in these results should still reflect what can be expected in a more typically established grower's sugarbeet field where an economically significant springtail infestation is present.

The top-performing treatment in this trial, with regard to recoverable sucrose yield and root tonnage, was the combination involving Poncho Beta-treated seed plus Mustang Maxx applied via dribble-in-furrow placement. The planting-time application of Counter 20G, applied at the maximum labeled rate of 8.9 lb product per acre was the only other treatment in the experiment that produced recoverable sucrose and root yields that were not statistically different from the Poncho Beta/Mustang Maxx treatment combination. These performance patterns corresponded closely to those observed in the stand count results.

Other treatments that performed comparably to, and were not significantly outperformed by, the high rate of Counter 20G included Counter at the 5.9-lb rate, Poncho Beta plus a postemergence band of Movento HL, Counter at the 4.5-lb rate, Poncho Beta plus Midac FC, and the single-component treatment of Mustang Maxx. All of the above-mentioned treatments provided significant increases in recoverable sucrose yield and root yield when compared with the untreated check. The only treatments that did not result in statistically significant recoverable sucrose yield were Poncho Beta alone and Midac FC alone.

Table 2. *Yield parameters* from an evaluation of planting-time granular, liquid, and seed treatment insecticides, and a postemergence sprayable liquid for springtail control, Prosper, ND, 2023

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 + Mustang Maxx	Seed DIF	 4 fl oz	68 g a.i./ unit seed	6,586 a	26.2 a	13.77 ab	937
Counter 20G	B	8.9 lb	1.5	5,054 ab	19.9 ab	13.86 a	733
Counter 20G	B	5.9 lb	1.2	4,735 b	19.5 b	13.31 abc	641
Poncho Beta + Movento HL	Seed 10” Post Band	 2.5 fl oz	68 g a.i./ unit seed	4,671 b	18.9 b	13.49 abc	650
Counter 20G	B	4.5 lb	0.9	4,523 b	18.5 b	13.39 abc	615
Poncho Beta + Midac FC	Seed DIF	 13.6 fl oz	68 g a.i./ unit seed 0.18	4,447 b	18.5 b	13.14 bcd	588
Mustang Maxx	DIF[b]	4 fl oz		4,354 b	18.3 b	13.09 cd	564
Midac FC	DIF	13.6 fl oz	0.18	4,093 bc	17.1 b	13.26 abc	539
Poncho Beta	Seed		68 g a.i./ unit seed	3,552 bc	15.4 bc	12.54 d	438
Check	---	---	---	2,553 c	10.5 c	13.04 cd	342
LSD (0.1)				1,724.7	6.5	0.66	

Means within a column sharing a letter are not significantly (P = 0.1) different from each other (Fisher’s Protected LSD test).

[a]Seed = insecticidal seed treatment; B = 5-inch band at planting; DIF = dribble in-furrow at planting; Post B = postemergence band

Gross economic return results from this trial followed similar patterns to those observed in plant stand and yield results. The Poncho Beta plus Mustang Maxx treatment generated $937/ac in gross economic return, which was a revenue gain of $595/ac over that of the untreated check. Additionally, the Poncho Beta/Mustang Maxx treatment combination generated a $373/ac in increased revenue over the Mustang-only treatment and $499 more gross revenue than the Poncho Beta-only treatment.

All three rates of Counter resulted in relatively high levels of gross economic return, but the high rate (8.9 lb product/ac) was economically superior, generating $391/ac more revenue than the untreated check, as well as $92 and $118/ac over that generated by the moderate (5.9 lb) and low (4.5 lb) rates of Counter, respectively.

As was observed with stand count and yield assessments, the treatment combination of Poncho Beta plus a postemergence rescue application of Movento HL provided an encouraging revenue increase. This combination generated a gross economic benefit of $308/ac when compared to the untreated check and $212 in additional gross revenue when compared to that from the Poncho Beta-only treatment.

The increased plant survival, yield, and revenue provided by the better-performing insecticide treatments in this experiment demonstrate that effective, economically justified tools are available to producers for managing subterranean springtails in sugarbeet. These findings also illustrate the significance of subterranean springtails as sugarbeet pests and the economic benefits that can be achieved by effectively managing them, even under the late-planted scenario in which this experiment was conducted.

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Acknowledgments:

The authors greatly appreciate the contributions of Evan Dietrich, Bryce Friday, Nathan Hayes, and Reed Thoma for assistance with plot maintenance, stand counting, data entry, and harvest. Sincere gratitude is extended to the Sugarbeet Research and

Education Board of Minnesota and North Dakota for providing significant funding to support this project. This work was also partially supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, under Hatch project accession number 1012990.

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

Location:	St. Thomas (Pembina County), ND –Lessard Farms – *Sugarbeet Root Maggot Trials* 48.5645937N, -97.4580947W	
Seed variety:	Betaseed 8018 CR+	
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 = 4.0% pH = 8.0	
Soil texture:	41.0% sand 41.0% silt 18.0% clay	
Previous crop:	Wheat (2022)	
Soil preparation:	Field cultivator (1x)	
Planting depth:	1.25"	
Rescue insecticide maintenance):	June 26	Mustang Maxx (4 fl oz/ac) applied to all plots to control armyworm/cutworm **(plot** infestation
Herbicides applied:	June 11	Roundup PowerMAX (32 fl oz/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)
	July 13	Roundup PowerMAX (32 fl oz/ac) + Gateway Plus (2.5% v/v) + Interlock (6 fl oz/ac)
Rainfall (after seedbed preparation)**:**	May 29	0.55”
	May 30	0.14”
	May 31	0.44”
	Total/May	**1.13”**
	June 1	0.01”
	June 4	0.17”
	June 5	0.07”
	June 6	0.01”
	June 7	0.01”
	June 9	0.16”
	June 7	0.01”
	June 7	0.01”
	June 22	0.17”
	June 23	0.02”
	June 24	3.45”
	June 25	1.10”
	June 26	0.10
	June 28	0.26”
	Total/June	**5.46”**
	July 6	0.08”
	July 13	0.04”

July 18	0.04”
July 23	0.10
July 25	0.04”
July 26	0.03”
Total/July	**0.33”**
August 1	0.04”
August 8	0.02”
August 10	0.06”
August 11	0.04”
August 13	0.01”
August 20	0.03”
August 21	0.62”
August 24	0.08”
August 27	0.08”
Total/August	**0.98”**
September 4	0.41”
September 5	0.44”
September 10	0.01”
September 11	0.27”
September 14	0.01”
September 21	0.28”
September 22	0.17”
September 23	0.24”
September 24	0.20”
September 25	0.01”
September 29	0.01”
Total/September	**2.05”**

Damage ratings: July 26-7; August 1

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

Location:	Prosper (Cass County), ND – NDSU Experiment Farm 47.00050N, -97.11066W	
Seed variety:	Betaseed 8018 CR+	
Plot size:	Two 25-ft long rows	
Design:	Randomized complete block, 4 replications	
Soil name:	Kindred-Bearden silty clay loam	
Soil test:	Organic matter = 3.8% pH = 7.8	
Soil texture:	32.5% sand 40.5% silt 27.0% clay	
Previous crop:	Wheat (2022)	
Soil preparation:	Field cultivator (2x)	
Planting depth:	1.25"	
Planting date:	July 7	
Postemergence insecticide trt.:	Aug. 4	Movento HL
Rescue insecticide maintenance):	July 28	Mustang Maxx (3 fl oz/ac) applied to all plots to control flea beetle infestation **(plot** (tank mixed with herbicide application #1)
Herbicides applied:	July 28	Roundup PowerMAX (32 fl oz/ac) + Gateway Plus (2.5% v/v) + Interlock (6 fl oz/ac)
	August 23	Roundup PowerMAX (32 fl oz/ac) + Induce (1% v/v) + Interlock (6 fl oz/ac)
Fungicides applied:	August 23	Agri Tin (8 fl oz/ac) + Badge SC (2 pts/ac)
Rainfall: (after seedbed preparation)**:**	July 11	0.08”
	July 12	0.02”
	July 13	0.02”
	July 21	0.01”
	July 25	0.21”
	July 28	0.03”
	July 30	0.01”
	Total/July	**0.38”**
	August 5	0.78”
	August 6	0.04”
	August 8	0.02”
	August 10	0.02”
	August 11	0.16”
	August 13	1.44”
	August 15	0.01”
	August 21	0.02”
	August 24	0.02”
	August 27	0.02”
	August 31	0.04”

Total/August	**2.57”**
September 4	0.01”
September 5	0.02”
September 11	0.15”
September 14	0.01”
September 20	0.15”
September 21	0.08”
September 22	0.03”
September 23	0.95”
September 24	0.23”
September 25	0.15”
September 29	0.07”
Total/September	**1.85”**
October 4	0.14”
October 5	0.04”
October 6	0.15”
Total/October	**0.33”**

Stand counts: T1 – July 21 and July 28, and August 4 (14, 21, and 28 days after planting)

Harvest date: October 10
Yield sample size: 2 rows x 25 ft length (50 row-ft total)

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 2023

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The ninth annual fungicide practices live polling questionnaire was conducted using Turning Point Technology at the 2024 Winter Sugarbeet Growers' Seminars held during January and February 2024. Responses are based on production practices from the 2023 growing season. The survey focuses on responses from growers in attendance at the Fargo, Grafton, Grand Forks, Wahpeton, ND and Willmar, MN Grower Seminars. Respondents from each seminar indicated the county in which the majority of their sugarbeets were produced (Table 1-4). The average sugarbeet acreage per respondent grown in 2023 was calculated from Table 6 at between 400 and 599 acres and 1,000 and 1,499 acres at 17% each.

Survey respondents were asked about soilborne disease and control practices. Fifty-five percent said their fields were affected by Rhizoctonia, six percent said Aphanomyces was the biggest issue, two percent said they had issues with fusarium and another two percent listed rhizomania as the biggest problem. Ten percent said multiple diseases including Rhizoctonia, Aphanomyces, Fusarium and Rhizomania and 25% said they had no soilborne disease issues (Table 10). Additionally, participants were asked about the prevalence of Rhizoctonia in sugarbeet with which preceding crops. Sixty percent of respondents said they saw more rhizoctonia when soybeans preceded their sugarbeet crop. Eighteen percent reported more Rhizoctonia following edible beans, six percent saw more Rhizoctonia following field corn, eleven percent said any crop, 4% said small grains, eleven percent said other crop as the crop preceding sugarbeets they saw the most Rhizoctonia develop (Table 11). Of the respondents to the question regarding whether a specialty variety was used for Rhizoctonia, 71% of respondents said yes they did use a specialty variety for Rhizoctonia while 29% said no (Table 12).

Participants were asked what methods were used to control Rhizoctonia and 42% said they used a seed treatment only, 19% used a seed treatment and a POST fungicide and another 24% used a seed treatment plus an in-furrow fungicide while 13% also said they used a seed treatment, in-furrow fungicide and a POST fungicide while two percent used a seed treatment followed by an in-furrow spray and two POST applications (Table 13).

Respondents were asked what POST fungicides were used to control Rhizoctonia and 43% did not use a POST fungicide to control Rhizoctonia. Twenty two percent used Quadris or generic, 20% used Azteroid, nine percent used Proline, four percent used Excalia and 1% used Azterknot while one percent used other (Table 14). Participants were then asked to grade the effectiveness of the POST fungicides that were used. Forty one percent were unsure of their results, 30% said they had good results, 12% reported fair results, 16% said the fungicides performed excellently and 1% said they performed poorly (Table 15). Respondents were also asked how they applied POST fungicides and 16% stated they used a band application and 31% used a broadcast application while 53% said that they did not use a POST application (Table 16).

Participants were also asked about use of waste lime to control Aphanomyces. Sixty three percent of participants did not use waste lime in their fields while 28% used between 6 and 10 tons/acre and 10% used less than 5 tons/acre (Table 17). The growers were asked how effective their waste lime application was. Fifty five percent of respondents did not apply lime, 19% said they had good results and another 14% were unsure of their results, 8% said excellent and 3% reported fair results (Table 18).

Survey participants were then asked a series of questions regarding their CLS fungicide practices on sugarbeet in 2023. Thirty seven percent said that they used 3 sprays to control CLS, 28% used four applications, 21% used two applications, 4% used zero applications, 6% used one application while 4% used five applications (Table 19). Survey participants were also asked how many CLS applications were made to control CLS on non-CR+ varieties. Twenty seven percent said four applications, 18% used three applications, 14% used five applications, 11% used six applications, six percent said two applications, while three percent said seven sprays and two percent said one spray on non-CR+ varieties. Twenty one percent said they applied no sprays but that includes growers who did not grow and CR+ varieties (Table 20).

Respondents were asked about when their CLS application started and ended. Forty six percent of respondents said that they began their CLS sprays between June 25 and July 1. Thirty four percent said between July 2 and July 10, 10% said before June 25 while nine percent said after July 10 (Table 21). Fifty percent said their late CLS spray was between September 1 and 10. Twenty two percent said between August 21 and 31, 19% between September 11 and 20, seven percent said before August 21 and two percent said after September 20 (Table 22).

Seventy one percent of survey respondents made 100% of their CLS applications by ground application. Sixteen percent of respondents made between 1% and 20% of their applications by aerial application, five percent between 21% and 40%, four percent made all of their CLS applications by air, three percent between 41% and 60% and one percent between 61% and 80% (Table 23). Regarding water usage in gallons per acre as applied by tractor, 45% of respondents used 20 gallons per acre in applying CLS fungicides, 30% between 11 and 15 gallons per acre, 19% between 16 and 19 gallons per acre and six percent used more than 20 gallons per acre (Table 24).

Table 1. 2024 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2023.

County	Number of Responses	Percent of Responses
Barnes	1	6
Becker	1	6
Cass	4	24
Clay	6	35
Norman/Mahnomen	5	29
Ransom	-	-
Richland	-	-
Steele	-	-
Trail	-	-
Wilkin/Otter Tail	-	-
Total	17	100

Table 2. 2024 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2023.

County	Number of Responses	Percent of Responses
Cavalier	1	3
Grand Forks	2	6
Kittson	3	9
Marshall	1	3
Nelson	-	-
Pembina	13	39
Polk	-	-
Ramsey	-	-
Walsh	13	39
Other	-	-
Total	33	99

Table 3. 2024 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2023.

County	Number of Responses	Percent of Responses
Grand Forks	16	24
Mahnomen	-	-
Marshall	6	9
Nelson	-	-
Pennington/Red Lake	-	-
Polk	29	44
Steele	-	-
Traill	6	9
Walsh	3	5
Other	6	9
Total	66	100

Table 4. 2024 Wahpeton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2023.

County	Number of Responses	Percent of Responses
Cass	6	8
Clay	11	14
Grant	7	9
Otter Tail	1	1
Ransom	-	-
Richland	13	16
Roberts	1	1
Stevens	-	-
Traverse	3	4
Wilkin	37	47
Total	79	101

Table 5. 2024 Willmar Grower Seminar - Number of survey respondents by county growing sugarbeet in 2023.

County	Number of Responses	Percent of Responses
Chippewa	20	32
Kandiyohi	7	11
Pope	1	2
Redwood	4	6
Renville	19	31
Yellow Medicine	-	-
Stevens	4	6
Swift	6	10
Other	1	2
Total	62	100

Table 6. Total sugarbeet acreage operated by respondents in 2023.

		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	15	13	13	7	13	27	20	-	7	-	-
Grafton	30	-	10	-	7	13	10	7	37	10	7
Grand Forks	65	11	9	5	11	17	11	12	12	5	8
Wahpeton	71	3	8	10	13	21	15	6	15	8	-
Willmar	65	8	5	6	14	14	14	12	15	11	2
Total	246	7	8	6	12	17	13	9	17	8	3

Table 7. What crop preceded most of your sugarbeet acreage in 2023?

Location	Respondents	Field Corn	Sweet Corn	Dry Bean	Peas	Soybean	Wheat
		---% of respondents------------------------------------					
Fargo	17	18	-	-	-	6	77
Grafton	30	-	-	10	-	3	87
Grand Forks	65	2	-	2	-	2	95
Wahpeton	77	23	1	-	-	10	65
Willmar	66	71	14	2	2	12	-
Total	255	27	4	2	<1	7	59

Table 8. What was your most serious production problem?

Location	Respondents	Aph	CLS	Emergence	Herbicide Injury	Rhizoc	Rhizomania	Root Maggot	Weeds
			---% of respondents---						
Fargo	15	-	7	27	-	-	-	13	53
Grafton	32	-	9	38	-	3	-	3	47
Grand Forks	65	-	12	31	3	2	2	-	51
Wahpeton	82	-	4	32	5	5	1	1	52
Willmar	65	2	2	20	2	9	-	-	66
Total	259	<1	6	29	3	5	1	2	55

Table 9. What is your primary method of tillage?

Location	Respondents	Conventional	No-Till	Strip Tillage
		---% respondents---		
Fargo	17	100	-	-
Grafton	35	100	-	-
Grand Forks	67	96	1	2
Wahpeton	74	96	-	4
Willmar	62	94	2	5
Total	255	96	1	3

Table 10. What soil-borne diseases affected your sugarbeet production in 2023?

		Root disease					
Location	Respondents	Rhizoctonia	Aphanomyces	Fusarium	Rhizomania	All	None
		---% of respondents---					
Fargo	16	38	-	13	-	25	25
Grafton	35	60	9	3	-	-	29
Grand Forks	62	50	6	2	2	5	35
Wahpeton	73	59	5	1	1	18	15
Willmar	63	57	8	-	3	8	24
Total	249	55	6	2	2	10	25

Table 11. With which of the preceding crops did you see the most rhizoctonia in 2023?

Location	Respondents	Edible Beans	Field Corn	Sweet Corn	Small Grains	Soybeans	Any Crop
		---% of respondents---					
Fargo	14	-	29	-	14	57	-
Grafton	32	47	3	3	3	44	9
Grand Forks	55	27	5	-	7	51	9
Wahpeton	64	3	2	2	-	83	11
Willmar	57	12	9	-	2	63	14
Total	222	18	6	1	4	60	11

Table 12. Did you use a specialty variety to control Rhizoctonia in 2023?

Location	Respondents	Yes	No
		---% respondents---	
Fargo	16	81	19
Grafton	33	67	33
Grand Forks	64	56	44
Wahpeton	74	85	15
Willmar	61	70	30
Total	248	71	29

Table 13. What methods were used to control *Rhizoctonia solani* in 2023?

Location	Respondents	Seed Treatment Only	Seed Treatment + In-Furrow	Seed Treatment + POST	Seed Treatment + In-Furrow + POST	Seed Treatment + In-Furrow + 2xs POST
			---------------------% respondents---------------------			
Fargo	14	14	36	43	-	7
Grafton	34	26	29	12	26	6
Grand Forks	63	30	30	22	17	-
Wahpeton	70	79	13	6	3	-
Willmar	65	28	26	28	15	3
Total	246	42	24	19	13	2

Table 14. Which POST fungicide did you use to control R. solani in 2023?

Location	Respondents	Azteroid	Azterknot	POST fungicide					
				Excalia	Quadris or generic	Proline	Elatus	Other	None
			------------------------------% of respondents----------------------------						
Fargo	16	6	-	6	56	6	-	-	25
Grafton	35	31	-	6	14	17	-	-	31
Grand Forks	62	35	5	5	23	6	-	-	26
Wahpeton	67	9	-	1	7	10	-	-	72
Willmar	62	15	-	5	32	5	-	5	39
Total	242	20	1	4	22	9	-	1	43

Table 15. How effective were your POST fungicides at controlling Rhizoctonia solani in 2023?

Location	Respondents	Effectiveness of fungicides				
		Excellent	Good	Fair	Poor	Unsure
		------------------------------% of respondents----------------------------				
Fargo	14	14	57	14	-	14
Grafton	31	16	45	16	-	23
Grand Forks	57	26	32	14	-	28
Wahpeton	49	6	16	10	2	65
Willmar	51	16	24	8	2	51
Total	202	16	30	12	1	41

Table 16. How did you apply POST fungicides to control Rhizoctonia in 2023?

Location	Respondents	Band	Broadcast	None
			---------------------% respondents---------------------	
Fargo	15	-	67	33
Grafton	35	17	49	34
Grand Forks	62	23	37	40
Wahpeton	73	7	15	78
Willmar	59	24	25	51
Total	244	16	31	53

Table 17. What rate of precipitated calcium carbonate (waste lime) did you use in 2023?

Location	Respondents	Lime use rate		
		None	>5 T/A	6-10 T/A
		------------------------------% of respondents----------------------------		
Fargo	16	69	6	25
Grafton	36	67	-	33
Grand Forks	65	65	3	32
Wahpeton	74	51	11	38
Willmar	61	70	21	8
Total	252	63	10	28

Table 18. How effective was waste lime at controlling aphanomyces in 2023?

Location	Respondents	Waste lime effectiveness					
		Excellent	Good	Fair	Poor	Unsure	No Lime
		-------------------------------% of respondents----------------------------					
Fargo	16	13	19	6	-	6	56
Grafton	37	8	22	-	-	16	54
Grand Forks	65	11	8	3	-	18	60
Wahpeton	70	10	31	4	-	11	43
Willmar	61	3	16	2	-	13	66
Total	249	8	19	3	-	14	55

Table 19. How many fungicide application did you make on CR+ varieties to control CLS in 2023?

Location	Respondents	Number of applications					
		0	1	2	3	4	5
		-----------------------------% of respondents-------------------------					
Fargo	17	6	-	35	41	12	6
Grafton	34	-	21	56	24	-	-
Grand Forks	56	7	9	20	29	34	2
Wahpeton	73	3	3	7	41	42	4
Willmar	61	3	2	15	48	26	7
Total	241	4	6	21	37	28	4

Table 20. How many fungicide application did you make on non-CR+ varieties to control CLS in 2023?

Location	Respondents	Number of applications								
		0	1	2	3	4	5	6	7	>7
		-----------------------------% of respondents-------------------------								
Fargo	14	21	14	7	14	14	29	-	-	-
Grafton	33	3	3	21	52	18	3	-	-	-
Grand Forks	60	7	-	3	23	48	15	3	-	-
Wahpeton	37	78	-	3	3	14	-	3	-	-
Willmar	55	7	-	2	2	20	25	33	11	-
Total	199	21	2	6	18	27	14	11	3	-

Table 21. What date was your first CLS application?

Location	Respondents	Date of first CLS application			
		Before June 25	June 25 – July 1	July 2-10	After July 10
		-----------------------------% of respondents-----------------------------			
Fargo	16	-	56	38	6
Grafton	34	-	12	62	26
Grand Forks	64	3	48	36	13
Wahpeton	69	12	52	30	6
Willmar	60	25	53	20	2
Total	243	10	46	34	9

Table 22. What date was your last CLS application in 2023?

		Date of last CLS application				
Location	Respondents	Before August 21	August 21-31	September 1-10	September 11-20	After September 20
		------------------------------% of respondents------------------------------				
Fargo	15	-	20	60	13	7
Grafton	35	9	9	63	17	3
Grand Forks	65	6	20	46	22	6
Wahpeton	69	7	25	54	15	-
Willmar	61	7	30	41	23	-
Total	245	7	22	50	19	2

Table 23. What percent of total fungicide applications for CLS were made by an aerial applicator?

Location	Respondents	0%	1%-20%	21%-40%	41%-60%	61%-80%	81%-99%	100%
		------------------------------% of respondents------------------------------						
Fargo	16	56	25	13	-	-	-	6
Grafton	37	70	14	3	8	-	-	5
Grand Forks	63	73	10	5	5	3	-	5
Wahpeton	70	70	20	6	-	1	-	3
Willmar	64	73	17	3	3	-	-	3
Total	250	71	16	5	3	1	-	4

Table 24. How many gallons per acre of water per acre did you use to apply CLS fungicides by tractor?

Location	Respondents	11-15	16-19	20	20+
		------------------------------% of respondents----------------------------			
Fargo	15	67	27	7	-
Grafton	34	44	26	26	3
Grand Forks	62	61	13	21	5
Wahpeton	71	11	28	58	3
Willmar	65	3	11	72	14
Total	247	30	19	45	6

EVALUATION OF FUNGICIDE SPRAY PROGRAMS TO MANAGE CERCOSPORA LEAF SPOT USING CR+ AND NON-CR+ SUGARBEET VARIETIES, 2023

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INTRODUCTION

Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola*, continues to be a challenge to sugarbeet growers in Minnesota and North Dakota, especially when growing conditions are warm and humid. The management of CLS must incorporate integrated practices such as conventional tillage, crop rotation, and spatial separation from previous sugarbeet fields when possible. Variety selection is also a critical aspect in managing CLS, but each variety has unique characteristics regarding yield, sugar quality, and disease tolerance. Additionally, the use of effective fungicides and proper timing of applications can significantly delay CLS development and reduce the extent of economic losses. However, with the increasing incidence of fungicide-resistance in *C. beticola* isolates across sugarbeet growing regions of Minnesota and North Dakota (Secor et al. 2023), the use of highly tolerant sugarbeet varieties (i.e., CR+ varieties) may be vital in managing CLS disease (Mettler and Bloomquist 2021, 2022).

In 2021, conidia of *C. beticola* had been identified in spore traps as early as May 03 in some growing regions (Secor et al. 2022). Several weeks before leaf spot symptoms were visible, the DNA of *C. beticola* was also detected in sugarbeet leaves in early June of 2020 (Bloomquist et al. 2021) and June of 2021 (Secor et al. 2022). Once the detached conidia land on the sugarbeet leaf or petiole, the fungus can initiate infection under favorable environmental conditions. Results from Rivera-Varas (2021) indicate that conidia can germinate within 2 hours even at 10°C; however, optimal temperatures for germination and infection are 25-35°C (Jacobson and Franc 2009). Following infection, leaf spot symptoms can develop within 5 days (Solel and Minz 1971), and secondary conidia can form after 7 days under favorable conditions (Jacobson and Franc 2009). The development of CLS symptoms and secondary conidia are highly influenced by temperature, humidity, light, leaf age, and disease tolerance of the host. Generally, infection cycles are prolonged as CLS tolerance of the host increases (Jacobson and Franc 2009). Although pathogen growth is not completely stopped in CLS-tolerant varieties, the plants have less ROS production and express lower levels of disease severity compared to CLS-susceptible varieties (Bhuiyan et al., 2023). Bhuiyan et al. (2021, 2023) also reported that infection of *C. beticola* and the hypersensitive response of the host is delayed in a CLS-tolerant variety, implying that the development of secondary conidia is also delayed. In field conditions, Bhandari et al. (2023) reported that the first CLS symptoms were observed on CLS-susceptible varieties 13 days prior to CLS-tolerant varieties. Metzger (2021) reported that the final CLS disease severity of CR+ varieties is significantly less compared to susceptible varieties in the 2020 Minn-Dak Farmers Cooperative (MDFC) CLS Nursery near Foxhome, MN. Two trials in separate locations were conducted in 2020 and 2021 by the Southern Minnesota Beet Sugar Cooperative (SMBSC) to determine the best fungicide program to pair with varieties with differing levels of CLS tolerance. Mettler and Bloomquist (2021, 2022, 2023) report from the field trials that highly tolerant varieties do not need the same rigorous fungicide program that moderately susceptible varieties need to produce good yields. Lien et al. (2023) also reported that disease pressure on a CLS-tolerant variety was very low, and yields were similar regardless of the fungicide spray programs, ranging from 1 to 6 applications, in a field trial conducted in Crookston, MN.
Since 2021, CR+ sugarbeet varieties with traits that impart improved tolerance to CLS are now available to growers throughout Minnesota and North Dakota. Promisingly, these newly released varieties are coupled with improved performance and can produce a recoverable sucrose per acre that is comparable to susceptible varieties. Additionally, it is hoped that the cost of fungicide management can be reduced by integrating these varieties and decreasing the number of fungicide applications.

OBJECTIVES

The trial objective is to evaluate a CR+ variety and standard fungicide programs with different timings for 1) the relative control of CLS disease on sugarbeet, and 2) the effect on harvestable root yield and sucrose quality.

MATERIALS AND METHODS

The trial was established as a randomized complete block design with 4 replicates at the University of Minnesota Northwest Research and Outreach Center in Crookston, MN. Field plots were fertilized for optimal yield and quality. A moderately susceptible (MS) variety (Crystal 912RR) with a 2-year average Cercospora rating of 5.0 (Brantner and Moomjian 2023) and a CR+ variety (Crystal 021RR) with a 2-year average Cercospora rating of 2.2 (Brantner and Moomjian 2023) was used. All seed was treated with standard seed treatments and were sown in 6-row by 35-feet long plots at 4.5-inch spacing in 22-inch rows on May 10. Plant stands were evaluated June 01 by counting the number of plants in the center two rows of each plot to verify an average plant population of 192 plants per 100 ft of row for Crystal 021 and 224 plants per 100 ft of row for Crystal 912.

On June 27 (14 to 16-leaf stage), all rows within each plot were inoculated with a mixture of fine talc and dried ground CLS-infected sugar beet leaves (1:2 weight by weight) using a Nalgene® 1L bottle to deliver a rate of 4.5 lbs. per acre (3 grams of mixture per 35 feet of row). CLS-infected sugar beet leaves used for the inoculum were collected from nontreated rows at the end of 2022 growing season. Fungicide treatments (see tables) were applied to the center four rows using a tractor-mounted 3-point sprayer with XR TeeJet 11002 VS flat fan nozzles calibrated to deliver 17.1 gallons water/A at 100 psi. Fungicides were applied approximately every 12 days depending on weather conditions. Fungicide applications began when weather was conducive for disease development and coincided with canopy closure, except for the first applications on June 23, 4 days prior to inoculation. Fungicide treatments were applied on June 23, June 30, July 12, July 24, Aug 07, and Aug 23. CLS disease severity was evaluated beginning July 11 and continued through Sept 18 using the following scale based on infected leaf area: 1=0.1% (1-5 spots/leaf), 2=0.35% (6-12 spots/leaf), 3=0.75% (13-25 spots/leaf), 4=1.5% (26-50 spots/leaf), 5=2.5% (51-75 spots/leaf), 6=3%, 7=6%, 8=12% 9=25%, 10=50%; rating scale is outlined by Jones and Windels (1991). CLS severity ratings were used to calculate the standardized area under disease progress stairs for statistical analysis (Simko and Piepho 2012, Simko 2021). On Sept 19, plots were defoliated, and the center two rows of each plot were harvested mechanically and weighed for root yield. Twelve representative roots from each plot were analyzed for sugar quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. Statistical analysis was conducted in R (v 4.3.1, R Core Team 2023). A mixed-model analysis of variance was performed using the package *lmerTest* (v 3.1-3), with treatment defined as the fixed factor and replication as the random factor. Means were separated at the 0.05 significance level using the package *emmeans* (v 1.8.7) adjusted for Tukey's honest significant difference (HSD).

RESULTS AND DISCUSSION

In 2023, the Northwest Research and Outreach Center (NWROC), Crookston, MN, recorded a total rainfall of 1.71 in. for April, similar to the 30-year average of 1.32 in. However, 0.87 in. of rainfall was received in May, much less than the 30-year average of 2.81 in. The rest of the growing season was slightly drier than the 30-year average, receiving only 4.7 in. of total rainfall in June, July, and August, less than half of the 30-year average of 9.6 in. May and June were 7.6°F and 6.7°F warmer, respectively, whereas July was 4.1°F cooler compared to the 30-year averages.

Following inoculation, daily infection values monitored by the Eldred NDAWN station had risen to a moderate level; the prolonged warm temperatures and high humidity provided conditions that favored the establishment of the *Cercospora* inoculum. Despite less-than-average rainfall, disease pressure rapidly increased during the month of August. Standard fungicide programs significantly reduced total CLS severity (sAUDPS), especially the MS variety (Table 2). Disease pressure progressed in the MS nontreated control to a level above the known economic threshold of 3% severity (equivalent to a rating of 6.0) by Aug 16 and reached a rating of 9.8 by Sept 08 with complete defoliation and emergence of new foliage (Fig. 2). Fungicide programs in the MS variety that received only 3 applications beginning July 24 reached disease levels above the economic threshold by 25 Aug; whereas, the fungicide programs with 4, 5, or 6 applications remained below the economic threshold (Table 1). Disease pressure became apparent in the nontreated CR+ variety by the end of August, reaching a rating of 2.2 by Sept 08 (Fig. 2). Overall, disease pressure in the CR+ variety was minimal throughout the season, and CLS severity was very low, regardless of the fungicide spray program (Fig. 1); however, numerical differences were present in which the nontreated control and the treatment with only 1 application in the CR+ variety had a higher CLS rating than the treatment with 6 fungicide applications in the MS variety (Fig. 2) and also resulted in a higher sAUDPS compared to treatments with 2 or more fungicide applications in the CR+ variety (Table 2). There were no significant differences in percent sugar, sugar loss to molasses (SLM), root yield, or recoverable sucrose per acre; though, numerical differences show that the nontreated control in the MS variety resulted in the lowest recoverable sucrose (Table 2).

Table 1. Select Cercospora leaf spot (CLS) 0-10 ratings associated with fungicide spray programs to manage CLS of sugarbeets in a CLS-inoculated field trial planted on May 10, 2023 at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Variety and Program [z]	Treatment(s) and timing [y]	CLS ratings (0-10)					
		Jul 11	Jul 20	Aug 03	Aug 16	Aug 25	Sept 08
CR+ 6-Spray	Provysol **A +** Manzate Pro-Stick **ABDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	0.00	0.05	0.05	0.45	0.55	1.05
CR+ 6-Spray (Skip 3 & 5)	Provysol **A +** Manzate Pro-Stick **AD** + Super Tin **BF** + Topsin 4.5 FL **B** + Proline 480 SC **D** + Priaxor **F**	0.05	0.25	0.00	0.45	0.75	0.95
CR+ 6-Spray (Skip 2, 4, & 5)	Provysol **A +** Manzate Pro-Stick **A** + Super Tin **C** + Topsin 4.5 FL **C** + Proline 480 SC **F** + Priaxor **F**	0.05	0.15	0.05	0.70	0.85	1.15

CR+ 5-Spray	Provysol **B +** Manzate Pro-Stick **BDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	0.10	0.20	0.00	0.70	0.80	0.85
CR+ 5-Spray (Skip 3)	Provysol **B +** Manzate Pro-Stick **BE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **E** + Priaxor **F**	0.05	0.15	0.00	0.60	0.90	1.00
CR+ 5-Spray (Skip 3 & 4)	Provysol **B +** Manzate Pro-Stick **B** + Super Tin **C** + Topsin 4.5 FL **C** + Proline 480 SC **F** + Priaxor **F**	0.05	0.10	0.05	0.65	0.85	1.55
CR+ 4-Spray	Provysol **C +** Manzate Pro-Stick **CE** + Super Tin **DF** + Topsin 4.5 FL **D** + Proline 480 SC **E** + Priaxor **F**	0.05	0.00	0.05	1.05	1.55	1.00
CR+ 4-Spray (Skip 3)	Provysol **C +** Manzate Pro-Stick **C** + Super Tin **D** + Topsin 4.5 FL **D** + Proline 480 SC **F** + Priaxor **F**	0.00	0.10	0.00	0.90	0.85	1.50
CR+ 4-Spray (Skip 2 & 3)	Proline 480 SC **C** + Manzate Pro-Stick **C** + Super Tin **F** + Priaxor **F**	0.10	0.00	0.00	0.90	0.85	1.25
CR+ 3-Spray (Skip 2)	Proline 480 SC **D** + Manzate Pro-Stick **D** + Super Tin **F** + Priaxor **F**	0.15	0.05	0.00	0.45	0.80	1.15
CR+ 2-Spray	Proline 480 SC **E** + Manzate Pro-Stick **E** + Super Tin **F** + Priaxor **F**	0.00	0.05	0.10	0.80	0.85	1.25
CR+ 3 Spray	Provysol **D +** Manzate Pro-Stick **D** + Super Tin **E** + Topsin 4.5 FL **E** + Proline 480 SC **F** + Priaxor **F**	0.05	0.00	0.00	0.95	1.15	1.30
CR+ 1-Spray	Proline 480 SC **F** + Priaxor **F**	0.05	0.05	0.00	1.05	1.55	2.00
CR+ Nontreated	Nontreated Control	0.00	0.00	0.25	0.90	1.70	2.20
MS 6-Spray	Provysol **A +** Manzate Pro-Stick **ABDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	0.15	1.00	0.20	1.00	1.60	1.65
MS 5-Spray	Provysol **B +** Manzate Pro-Stick **BDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	0.10	0.60	0.30	1.35	2.65	2.45
MS 4-Spray	Provysol **C +** Manzate Pro-Stick **CE** + Super Tin **DF** + Topsin 4.5 FL **D** + Proline 480 SC **E** + Priaxor **F**	0.35	0.95	0.65	4.00	6.15	4.90
MS 3-Spray (ACSC 1)	Provysol **D +** Manzate Pro-Stick **D** + Super Tin **E** + Topsin 4.5 FL **E** + Proline 480 SC **F** + Priaxor **F**	0.50	1.25	2.15	5.95	7.80	7.65
MS 3-Spray (ACSC 2)	Super Tin **DF** + Topsin 4.5 FL **D** + Proline 480 SC **E** + Manzate Pro-Stick **E** + Priaxor **F**	0.35	1.20	2.25	5.70	7.25	7.00
MS Nontreated	Nontreated Control	0.45	1.10	2.40	7.10	9.35	9.75
	P-value	***	***	***	***	***	***

[z] Crystal 021RR with two-year Cercospora rating of 2.2 (CR+) and Crystal 912 with two-year Cercospora rating of 5.0 (MS)

[y] Treatment rates per acre are as follows: Provysol = 5 fl oz, Manzate Pro-Stick = 2 lb, Super Tin = 8 fl oz, Topsin 4.5 FL = 10 fl oz, Proline 480 SC = 5.7 fl oz, Priaxor = 6.7 fl oz; Non-ionic surfactant (NIS; Permeate) was used at a rate of 0.125% v/v with Provysol and Proline 480 SC; letters represent the following dates: **A**= Jun 23, **B**= Jun 30, **C**= Jul 12, **D**= Jul 24, **E**= Aug 07, **F**= Aug 23

[x] Significance codes: 0.0001 (***), 0.001 (**), 0.01 (*)

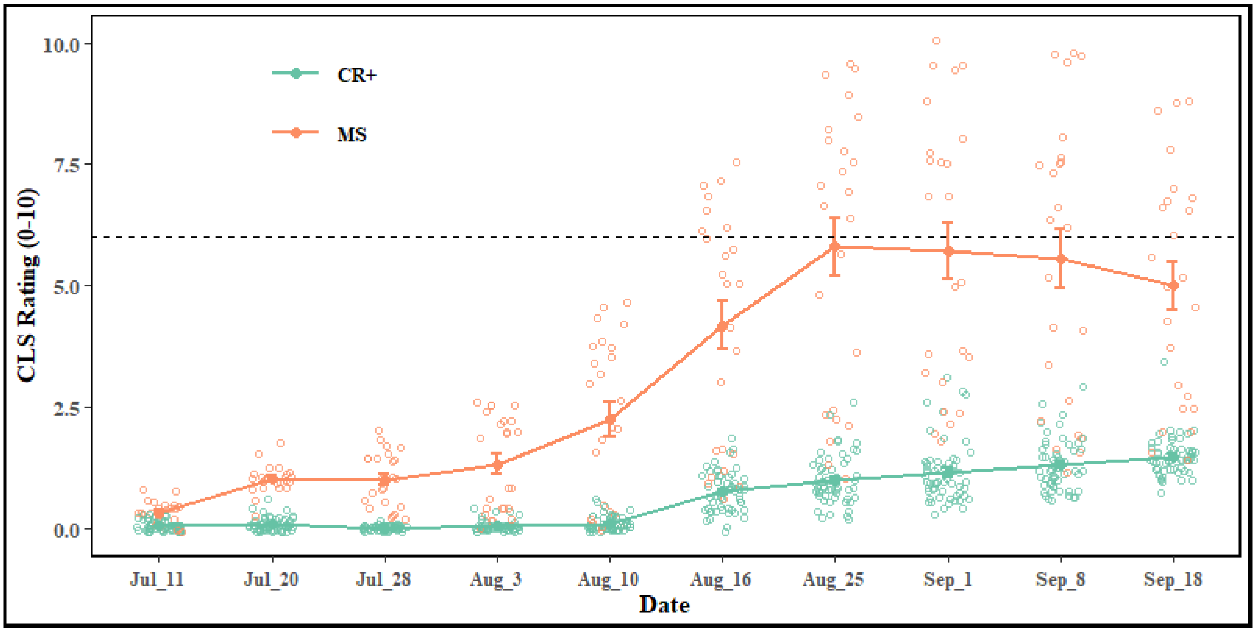

Figure 1. Cercospora leaf spot (CLS) disease severity ratings throughout the 2023 growing season for sugarbeet varieties sown on May 10 in a field trial inoculated with CLS-infested leaves on June 27 at the University of Minnesota, NWROC, Crookston, MN. Hollow dots represent each data point; filled dots represent treatment means and error bars represent the standard error of each variety. The dashed horizontal line represents the known CLS economic threshold of 3% severity, equivalent to a rating of 6.0.

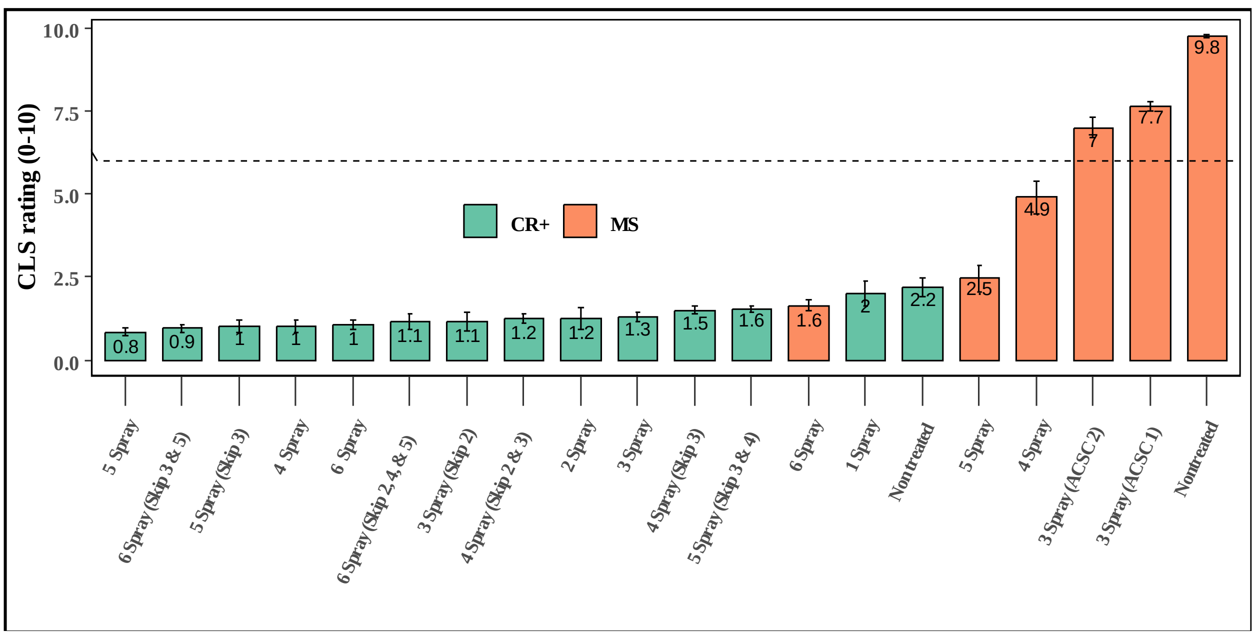

Figure 2. Cercospora leaf spot (CLS) disease severity ratings on Sept 8, 2023, for fungicide spray programs in sugarbeet varieties sown on May 10 in a field trial inoculated with CLS-infested leaves on June 27 at the University of Minnesota, NWROC, Crookston, MN. Columns display the mean for each treatment; error bars represent the standard error of each treatment. The dashed horizontal line represents the known CLS economic threshold of 3% severity, equivalent to a rating of 6.0.

Table 2. Effects of fungicide spray programs on CLS disease, harvestable yield, and sucrose quality of sugarbeets in a CLS-infested field trial planted on May 10, 2023 at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Variety and Program[z]	CLS Severity (sAUDPS) [y,x]	Sugar (%)	SLM (%)	Yield (tons/A)	Sucrose (lb/A)	Gross Rev. ($/ton)[w]	Gross Rev. ($/A)[w]	Fung. Cost ($/A)[v]	Net Rev. ($/A)[w]
CR+ 6-Spray	0.4 a	18.6	0.8	27.8	9904	95.68	2659.50	115.42	2544
CR+ 6-Spray (Skip 3 & 5)	0.5 a	19.4	0.9	24.7	9148	102.47	2529.78	101.82	2428
CR+ 6-Spray (Skip 2, 4, & 5)	0.6 a	19.1	0.8	31.9	11635	99.54	3180.00	88.46	3092
CR+ 5-Spray	0.5 a	18.7	0.8	30.2	10801	96.28	2907.77	108.62	2799
CR+ 5-Spray (Skip 3)	0.5 a	19.0	0.8	30.0	10914	99.59	2977.30	101.82	2875
CR+ 5-Spray (Skip 3 & 4)	0.7 ab	19.1	1.0	27.0	9948	100.60	2736.51	88.46	2648
CR+ 4-Spray	0.6 ab	18.3	0.9	30.3	10481	91.14	2748.71	101.82	2647
CR+ 4-Spray (Skip 3)	0.6 ab	18.9	0.9	28.4	10319	98.01	2810.29	88.46	2722
CR+ 4-Spray (Skip 2 & 3)	0.6 a	18.3	0.9	30.0	10487	92.10	2770.51	62.89	2708
CR+ 3-Spray (Skip 2)	0.6 ab	18.8	0.9	27.6	9880	96.44	2658.70	62.89	2596
CR+ 2-Spray	0.5 a	19.1	0.8	29.9	10896	99.83	2976.97	62.89	2914
CR+ 3 Spray	0.7 ab	18.9	0.8	29.0	10504	98.53	2853.50	88.46	2765
CR+ 1-Spray	0.9 bc	19.2	0.8	29.3	10782	101.41	2969.79	49.53	2920
CR+ Nontreated	1.0 cd	19.1	0.9	27.1	9880	99.52	2700.86	0.00	2701
MS 6-Spray	1.0 cd	18.7	0.8	30.4	10910	96.47	2945.28	115.42	2830
MS 5-Spray	1.4 d	19.0	0.7	29.2	10659	99.66	2912.10	108.62	2803
MS 4-Spray	2.9 e	18.0	0.8	30.5	10430	89.05	2711.01	101.82	2609
MS 3-Spray (ACSC 1)	4.5 f	18.9	0.8	28.4	10266	98.29	2790.19	88.46	2702
MS 3-Spray (ACSC 2)	4.3 f	19.0	0.7	27.2	9967	100.62	2733.80	72.89	2661
MS Nontreated	5.5 g	18.4	0.8	25.8	9081	93.44	2411.09	0.00	2411
P-value	<0.0001	0.5625	0.3385	0.0678	0.2974	0.6593	0.5583	NA	0.6601

[z] Crystal 021RR with two-year Cercospora rating of 2.2 (CR+) and Crystal 912 with two-year Cercospora rating of 5.0 (MS); fungicides and application dates for each program are listed in Table 1.

[y] Standardized Area Under Disease Progress Stairs (sAUDPS) is a mid-point combination of all CLS ratings and represents total CLS severity.

[x] Means within a column followed by a common letter are not significantly different by Tukey's Honest Significant Difference test at the 0.05 level of significance

[w] Revenue is based on the November 2023 American Crystal Sugar Company (ACSC) beet payment;

[v] Fungicide cost is based on 2023 prices and does not include application costs.

ACKNOWLEDGMENTS

We thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for funding this research; BASF, UPL, and Bayer for providing chemical products; Crystal Beet Seed for providing seed; Germains Seed Technology for treating seed; the University of Minnesota Northwest Research and Outreach Center, Crookston for providing land, equipment, and other facilities; Jeff Nielsen for plot maintenance; James Deleon, Zahra Pagiri, Stephanie Melby, and Kenan McQueen for technical assistance; American Crystal Sugar Company Quality Laboratory, East Grand Forks, MN for sugarbeet quality analysis.

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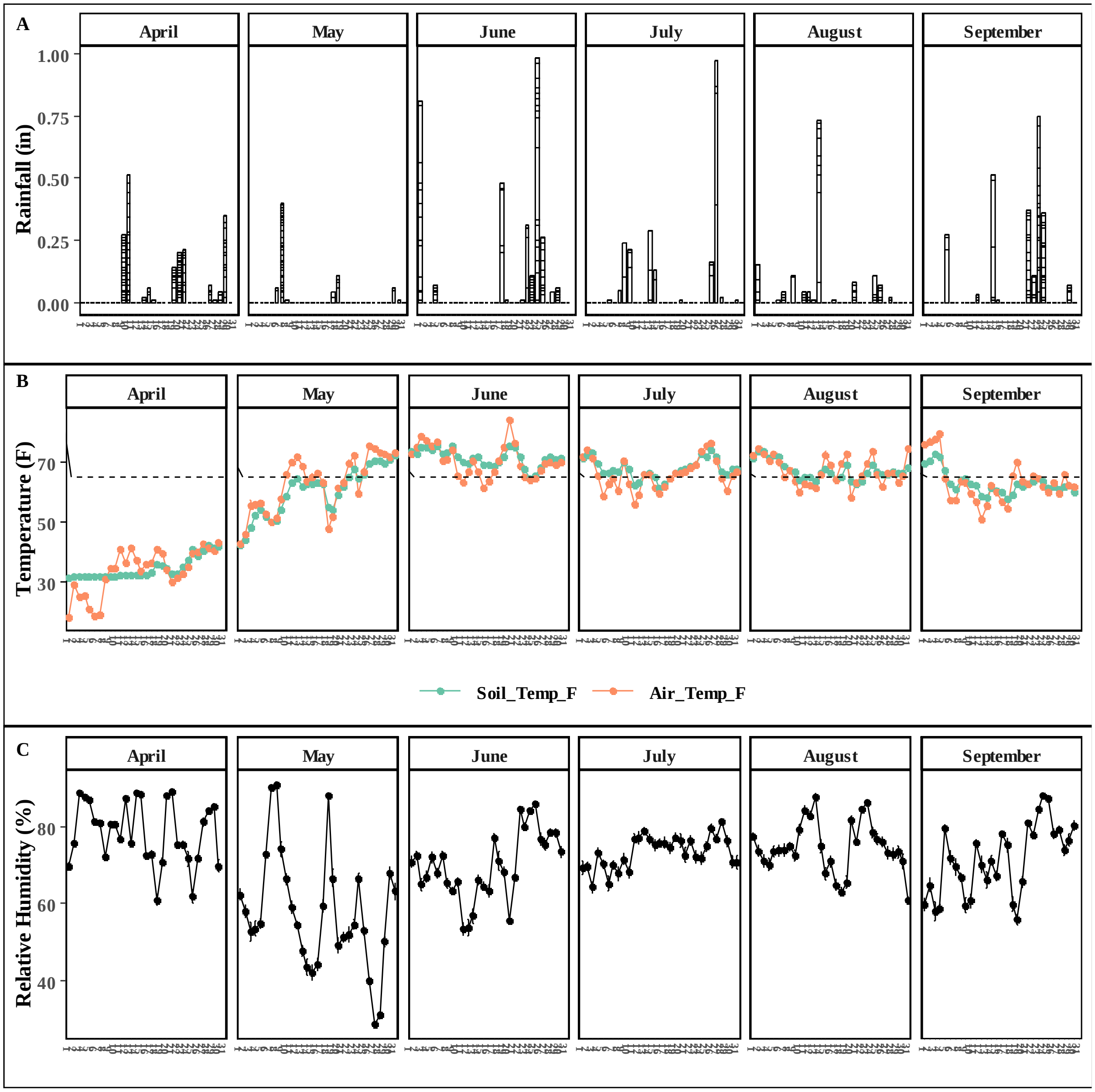
SUPPLEMENTARY FIGURES



Supplementary Fig. S1. Daily rainfall totals (A), daily mean air temperature and 4-inch soil temperature (B), and daily mean relative humidity (C) for the 2023 growing season at the NWROC weather station in Crookston, MN. The dotted horizontal line represents 65°F.

IDENTIFICATION OF NEW GENETIC SOURCES FROM SEA BEET TO IMPROVE SUGARBEET RESISTANCE TO CERCOSPORA LEAF SPOT

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Introduction

Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola* Sacc., is the most widespread foliar disease in sugarbeet (*Beta vulgaris* L.) and yield losses due to CLS can be as high as 42 - 50% (Verreet et al., 1996). Application of host resistance for CLS control would be more effective with a lower cost. Vogel et al. (2018) found that recent breeding efforts have made CLS resistant cultivars comparable to susceptible ones in terms of yield performance, consequently, the resistant cultivars thus have a relatively better economic performance since no fungicide needs to be applied.

Many studies were conducted to identify germplasms resistant to CLS and some accessions of *Beta vulgaris* spp. *maritima*, the wild ancestor of sugar beet, were found to have a high level of resistance and were used as a source of CLS resistance (Leuterbach et al., 2004). Our findings in the last year also indicated that a cluster of 355 *B. maritima* accessions showed a further genetic distance to sugarbeet and have much greater potential for improving CLS resistance and broadening the genetic base (Tehseen et al., 2023).

In this research, we analyzed genetic diversity of all available *B. maritima* accessions and selected 300 accessions as an association panel for identifying CLS resistance through genome-wide association study (GWAS), and this report summarized the evaluation in 2023 with preliminary results from association study.

Materials and methods

A total of 599 *B. vulgaris* L. ssp. *maritima* accession from NPGS (National Plant Germplasm System) and USDA-ARS sugarbeet genetics program at Fargo, ND (**Table 1**) were used for genetic diversity analysis, which led to the identification of 300 accessions planted in field nurseries at Fargo, ND, and Foxhome and Kent, MN to evaluate their resistance to Cercospora leaf spot. In addition, 30 sugarbeet lines were used as a reference cluster to indicate genetic distance between sea beet clusters with cultivated beets.

Table 1. List and origin of wild beet accessions used in the current study with their putative geographic regions.

Region	Countries (no. of lines)	Total
Africa	Egypt (26), Morocco (31), Tunisia (1)	58
Asia	China (1), India (2), Israel (1)	4
Northern Europe	Denmark (21), Ireland (49), Jersey Island (2), Unite Kingdom (108)	180
Southern Europe	Croatia (1), Cyprus (1), Greece (56), Italy (102), Portugal (6). Spain (8), Turkey (6)	182
Western Europe	Belgium (3), France (146), Germany (2), Netherlands, (2), Guernsey Island (1)	154
Eastern Europe	Poland (1), Russian Federation (3)	4
North America	California in the United States (15)	15

Field evaluation of CLS resistance was conducted as randomized complete block designs with two replications included. The two-row plots were 10 feet long, with 22-inch row spacing and 8 – 10 inches for plant space within a row. The trial was planted on May 31st at Foxhome, MN, and June 1st at Kent, MN in 2023. Inoculation was performed on July 18th and repeated after two weeks by spraying ground disease leaf mixed with Talca powder at the ratio of 1:3. Disease ratings were made on September 28th using a 0 – 9 scale with 0 as no CLS spots observed, 1 – 3 as resistant (a few scattered spots to some dieback on lower leaves), 4 - 6 as moderately resistant/susceptible (increasing amounts of dead and disease tissue on several to most plants of the row), and 7 - 9 as susceptible (diseased leaf has 50 - 100% of area necrosed on most plants of the row) (Ruppel & Gaskill, 1971).

Genotyping in all accessions was previously done using GBS platform (Tehseen et al., 2023). Briefly, approximately 0.1 g of fresh leaf tissue was collected from 7 – 10 plants of each accession and was dried in a freeze drier 35EL (SP Scientific, Inc., Warminster, PA, USA) for 72 hrs. Dried tissues were ground using a 1600 MiniG SPEX homogenizer (SPEX, Inc., Metuchen, NJ, USA). Genomic DNA was extracted from dried tissue using a DNA purification system (KingFisher, Inc., Falls Church, VA, USA), and DNA samples were fragmented by co-digestion using restriction enzymes *NsiI* and *BfaI* to produce DNA fragments. Barcoded adapters were ligated to DNA fragments from each accession to identify fragments generated from each individual accession. GBS sequencing libraries were constructed according to Hilario et al. (2015) by PCR amplification of barcode ligated DNA using a 96-plex plate followed by purification and quantification of the PCR product before sequencing. An Illumina HiSeq 2000 sequencing system (Illumina, Inc., San Diego, CA, USA) was used to sequence about 150 base pairs at both ends of fragments. The obtained fragmental sequences were anchored to the reference sugarbeet genome sequence assembly EL10.2 of sugarbeet line EL10 (McGrath et al., 2022) and compared among accessions to identify genome-wide SNPs through reference-based Tassel pipeline (Glaubitz et al., 2014). Raw SNP data were filtered by removing SNPs with a missing data rate of over 20%, followed by genotype imputation through the computer program Beagle (v5.0) (Browning & Browning, 2007) that achieved a data-missing rate of 0% and only the bi-allelic SNPs were kept.

For analyzing population structure in the *B. maritima*, the computer program STRUCTURE v. 2.3.4 (Pritchard et al., 2000) and R package *adegenet* v.2.3.4 (Jombart and Ahmed, 2011) were both used. The analysis using STRUCTURE implemented model-based Bayesian cluster analysis to estimate the number of subpopulations in all *B. maritima* accessions. It uses ten independent replicated runs for each putative number of subpopulations ranged from $K = 2 – 10$ under the admixture model and assessed using a burn-in period of 5000 and 50,000 Markov Chain Monte Carlo (MCMC) replications. The best K value representing the optimum number of sub-populations was estimated based on Delta K (ΔK) changes between successive structure iterations calculated using Structure Harvester (https://taylor0.biology.ucla.edu/structureHarvester/). R package *adegenet* was used to conduct discriminant analysis of principal components (DAPC) to classify all *B. maritima* accessions into clusters, which verifies population structure estimated from the program STRUCTURE.

GWAS was carried out using a R package GAPIT (Genome Association and Prediction Integrated Tool) (Lipka et al., 2012). Briefly, a standardized mixed linear model (MLM) (Yu et al., 2006) was used as $y = X\beta + Qv + u + e$,
where y is the vector of observed phenotypes, X is the vector of SNP markers, β is the marker fixed effects vector to be estimated, Q is the population matrix derived from PCA analysis, v is the vector of fixed effects due to population, u is random effects vector and e is the residual vector. The variance of u is estimated as Var $(u) = 2KVg$, where K is the kinship matrix derived from individuals based on the proportion of shared alleles and Vg is the genetic variance. K matrices were generated using TASSEL v 5.0 (Bradbury et al., 2007).

Results & discussion

Genotypic data

A set of 147,764 reliable SNP markers were previously obtained from GBS pipeline and marker distribution across all nine chromosomes was shown in Fig. 1. The maximum number of SNPs were observed on chromosomes 6 (19,140) and 5 (19,115), and chromosome 9 had the minimum SNPs (14,277). The average density of markers across the whole genome was 3.81 markers per kb. The lowest density was observed on chromosome 5 (4.07 marker/kb), whereas the highest density was on chromosome 1 (3.54 markers/kb).

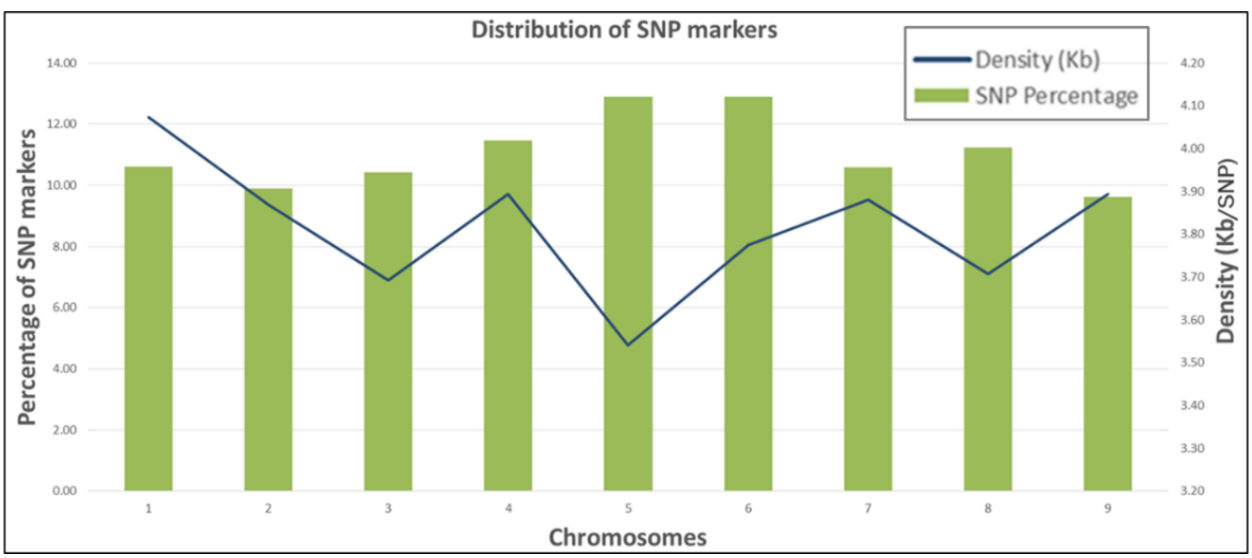

Fig. 1. Distribution of SNP markers across the genome in 599 *B. maritima* accessions.

Population structure

According to on ΔK assay using the STRUCTURE program, the 599 *B. maritima* accessions and 30 sugarbeet lines used in the current study likely contained 5 or 8 sub-populations (Fig. 2).

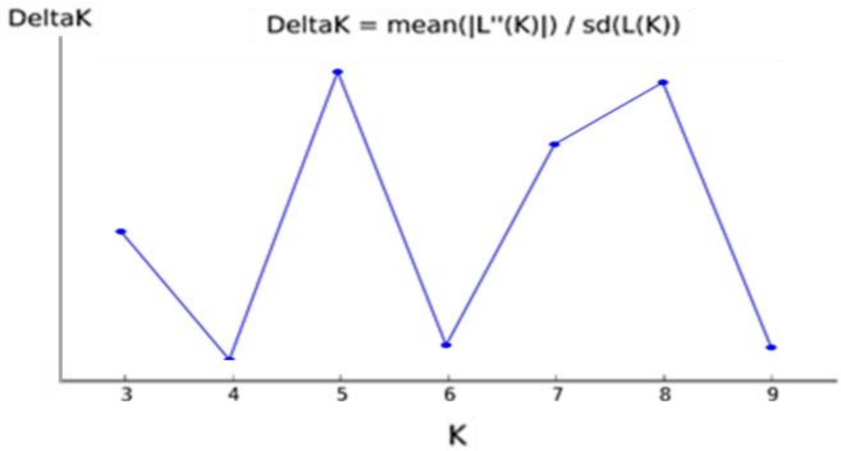

Fig. 2. Population structure analysis of materials included 599 wild beet accessions and 30 sugarbeet lines using the computer program STRUCTURE indicated 5 or 8 subpopulations in the collection.

The DAPC analysis proved eight clusters in the collection (Fig. 3) with cluster 1 mainly from northern and northwestern Europe, cluster 2 from southern and Western Europe, cluster 3 from Morocco and southwestern Europe, cluster 4 from southern Europe, cluster 5 from northern and western Europe, cluster 6 from sugarbeet lines, cluster 7 from Egypt and southern Europe, and cluster 8 from Morocco. Of those clusters, 2, 3 and 4 were very close to sugarbeet group, indicated their close genetic distance. Clusters 1, 5, 7 and 8 showed farther genetic relationship to sugarbeet with 7 is more distinct from the others.

The seven clusters of *B. maritima* accessions are strongly associated with geography location where the materials were collected, which also highly agreed with ocean current direction in north Atlantic Ocean and Mediterranean Sea (Fig.4) as *B. maritima* accessions are mostly grow along seashore and seeds were mainly spread by ocean current.

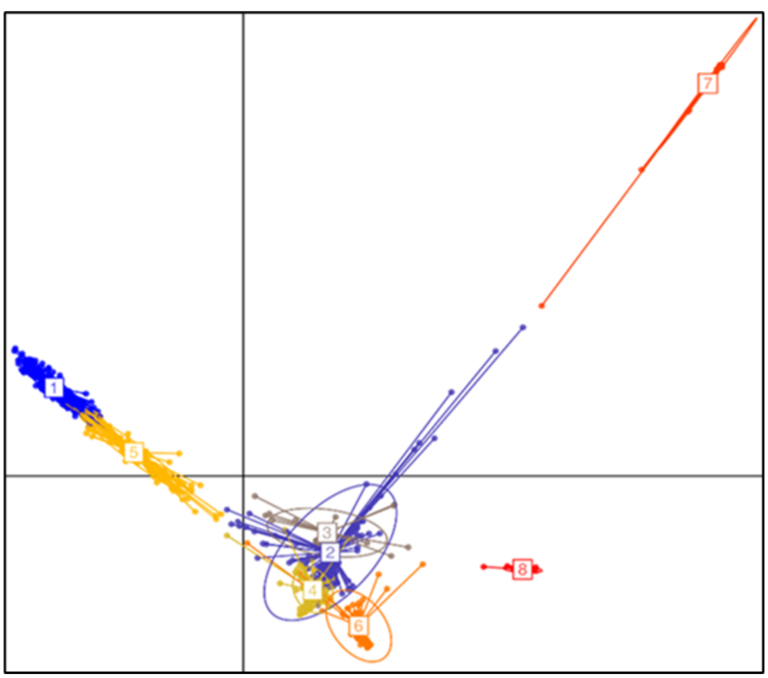

Fig. 3. Population structure analysis through discriminant analysis of principal components (DAPC) indicated eight clusters in the 599 *B. maritima* accessions and 30 sugarbeet lines. The numbers indicated cluster names, and the farther distance between clusters indicated the more distinct genetic difference.

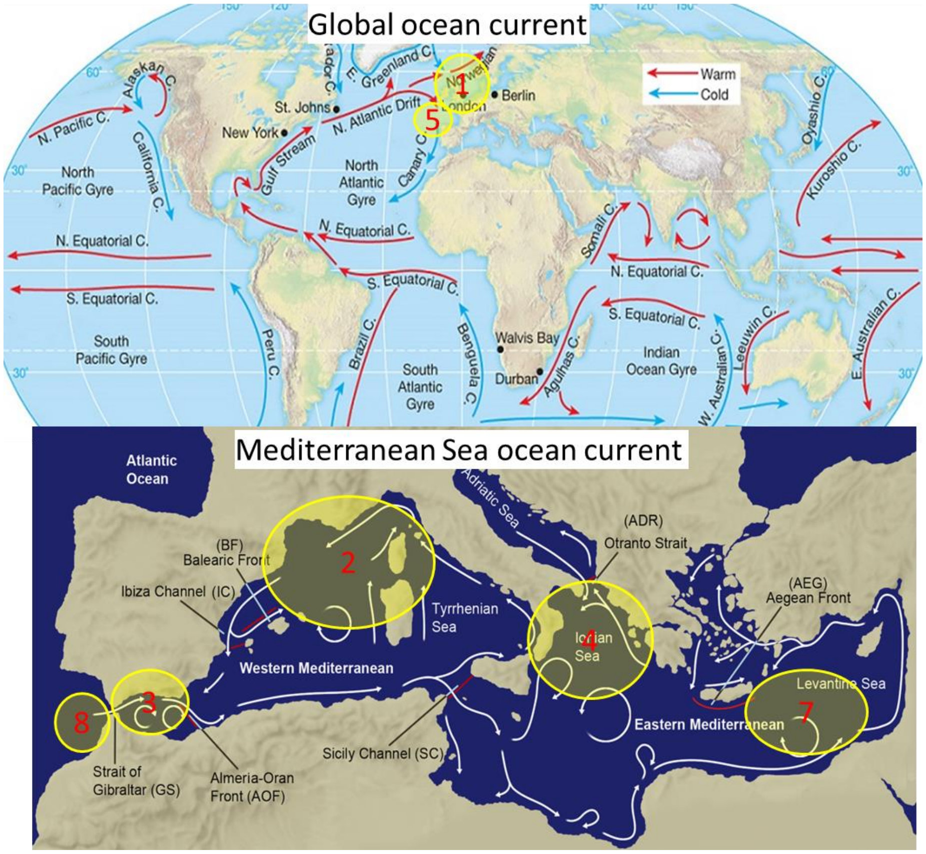

Fig. 4. The geographic location of *B. maritima* clusters determined by discriminant analysis of principal components (DAPC) and ocean surface current directions in global (above, Global Solo Challenge, 2023) and Mediterranean Sea (below, Pascual at al., 2017).

CLS evaluation

According to genetic diversity analysis, a set of 300 accessions was selected for CLS evaluation. Disease severity in field nursery at Fargo, ND is too light, and data were discarded for analysis. Disease at Foxhome location is severer than CLS at Kent location with much less accessions had rating less than 3 (Fig. 5). However, disease ratings in two replications at two locations showed the similar trend. Also, observation of the accessions with disease ratings over 7 suggested the high disease pressure at both locations though Foxehome is much higher, which due to the plenty of rainfall during inoculation at the beginning of August (data not shown). Overall, very small amount of the accessions with disease ratings as “1” in all experiments indicated that the high level of resistance was existed in the collection. This needs to be verified in future evaluations.

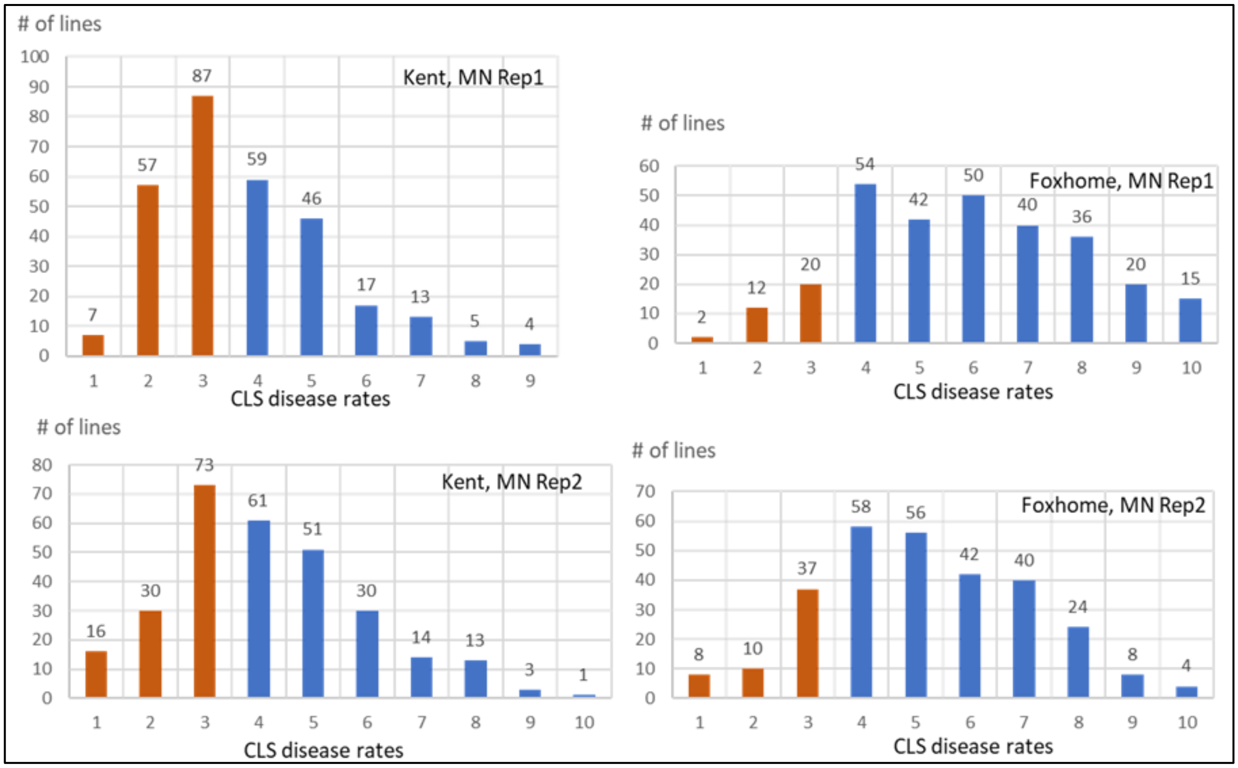

Fig. 5. Distribution of resistance to Cercospora leaf spot (CLS) in 300 *B. maritima* accessions evaluated in field nurseries located at Foxhome and Kent, MN in 2023.

Genome-wide association study (GWAS)

Association study indicated genomic regions on chromosomes 1, 2, 5, 8, and 9 are significantly associated with the resistance, which was repeatedly shown in at least two experiments (Fig. 6). This agreed that CLS resistance is likely a quantitative trait governed by 4-5 genes as indicated by Nielsen et al. (1997) and Smith & Gaskill (1970). Previously, Nilsson et al. (1999) reported five QTL on chromosomes 1, 2, 3 and 9 with phenotypic variability ranging from 7% - 18.3%. Schäfer-Pregl et al. (1999) detected seven QTL on chromosomes 2, 4, 5, 6, and 9. Setiawan et al. (2000) reported four QTL on chromosomes 3, 4, 7 and 9 and explained phenotypic variance ranging from 6.2% to 25.1%. Since this is an ongoing project and continuous evaluation will be conducted in future years to verify current results as well as detecting the new resistance associated regions.

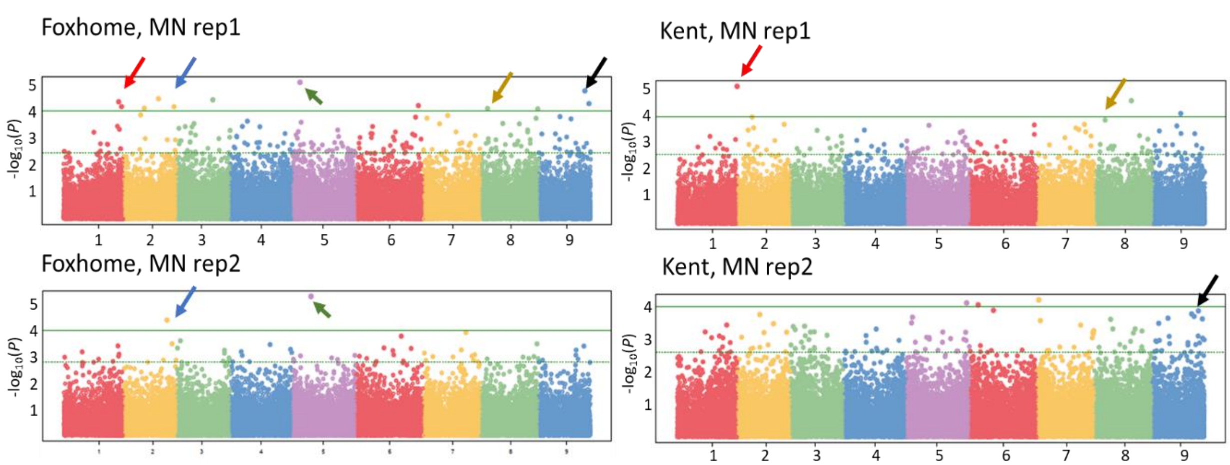

Fig. 6. Manhattan plots of GWAS showing genomic regions significantly associated with resistance to CLS in wild beet accessions.

Acknowledgements

Thanks to Dr. Barbara Hellier at the USDA - NPGS in Pullman, WA for providing all germplasm lines. This research is supported by the Sugarbeet Research and Education Board of Minnesota and North Dakota, the Beet Sugar Development Foundation (BSDF), and the USDA-ARS CRIS project No. 3060-21000-044-000-D. Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the US Department of Agriculture. The US Department of Agriculture is an equal opportunity provider and employer.

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EARLY SPORE DETECTION AND SENSITIVITY OF *CERCOSPORA BETICOLA* TO FOLIAR FUNGICIDES IN 2023

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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, cultural practices, resistant varieties and timely fungicide applications. *Cercospora* leaf spot usually appears in the last half of the growing season, but recent work has shown that spore production and infection happen much earlier necessitating earlier fungicide application. 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), Provysol (mefentrifluconazole) and Headline (pyraclostrobin). In 2023, most of the DMI fungicides were applied as mixtures with either mancozeb or copper.

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 2023, 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.

5) Monitor *Cercospra beticola* spore production in commercial sugar beet fields early in the growing season

METHODS AND MATERIALS

In 2023, with financial support of the Sugarbeet Research and Extension Board of MN and ND, we tested 673 *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.

For the third year in a row, we placed Spornado spore traps in six commercial sugar beet fields to monitor early detection of C. beticola spores from early May to early July.

It is interesting to note that a higher number of leaves (14%) with infection by small spore Alternaria species was found this year compared to previous years.

RESULTS AND DISCUSSION

CLS pressure was low in most locations in 2023 and many growers applied first fungicide application earlier than normal based on recommendations by cooperative agronomists. C. beticola spores were detected in spore traps in all field locations (two in ACSC, two in MinnDak and two in SMBSC) in early may and all of June.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=673) 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 resistance to tin increased dramatically in 2020 (68.3%) and 2021 (98.9%) and 2022 (100%) and but declined dramatically in 2023 (31.5%) **(Figure 1).** The severity of resistance, as expressed as percent germination of spores from fields with resistant isolates, also increased dramatically in 2020 (40%) and 2021 (63%) and 2022 (65%) but declined dramatically in 2023 (18%). The incidence of fields with tin resistance decreased in all factory districts (**Figure 2**). These decreases are likely due to a fitness penalty present in resistant isolates that lowers survival rate from one year to the next.

DMI (triazoles). Resistance as measured by RF values (EC50/baseline EC50) in 2023 remained steady for Inspire, Proline and Provysol, but increased 32% for Eminent (**Figure 3**). Resistanace profiles of Inspire and Provysol remained about the same as in 2022 (**Figure 4**), but the resistance profiles for both Eminent and Proline increased at the highest resistance values (>100) **(Figure 4**) Interestingly, Eminent EC50 resistance values increased from zero in 2022 to 30% in 2023. Resistance profiles were relatively consistent across all factory districts, with some variability. The low RF values and high resistance profile for Proline are not a concern because these values are likely due to using technical grade prothioconazole for testing instead of the active metabolic product desthioconazole. We do not know if sugar beet converts prothioconazole to desthioconazole as other plants do, but we do know that resistance profile EC50 values of isolates is 15-fold higher to prothioconzaloe compared to desthioconazole. This is the subject of future research.

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 in field populations increased dramatically from 2016 to 2022, and continued in 2023 (**Figure 5)**. Resistance to Headline did not decline in 2023 (**Figure 5**). 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. It appears there is a fitness penalty associated with the G143A mutationbassed on reduced Headline resistance in isolates collected at the beginning of the season compared to higher resistance in isolates collected at the end of the season.

SUMMARY

1. The number fields with tin resistance increased in 2021 to 2022 to almost 100%, and but declined dramatically in 2023by 31.5%. reduced to about stabilized in 2022. The percentage of spores with resistance/field declined from 65% in 2021 and 2022 to 18% in 2023.

2. Resistance profiles of Inspire and Provysol remained about the same as in 2022, but the resistance profiles for both Eminent and Proline increased at the highest resistance values (>100). Eminent EC50 resistance values increased from zero in 2022 to 30% in 2023. Similar across all factory districts.

3. The presence of isolates in a population with the G143A mutation that results in resistance to Headline continued to be prevalent and widespread in 2023 as in past years.

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.

5. We also recommend first fungicide application much earlier than previously recommended as we have detected *C. beticola* spores in commercial fields even prior to emergence. Since the fungicides used are all protectants, they need to be in place before spore arrive. 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 1998 to 2023

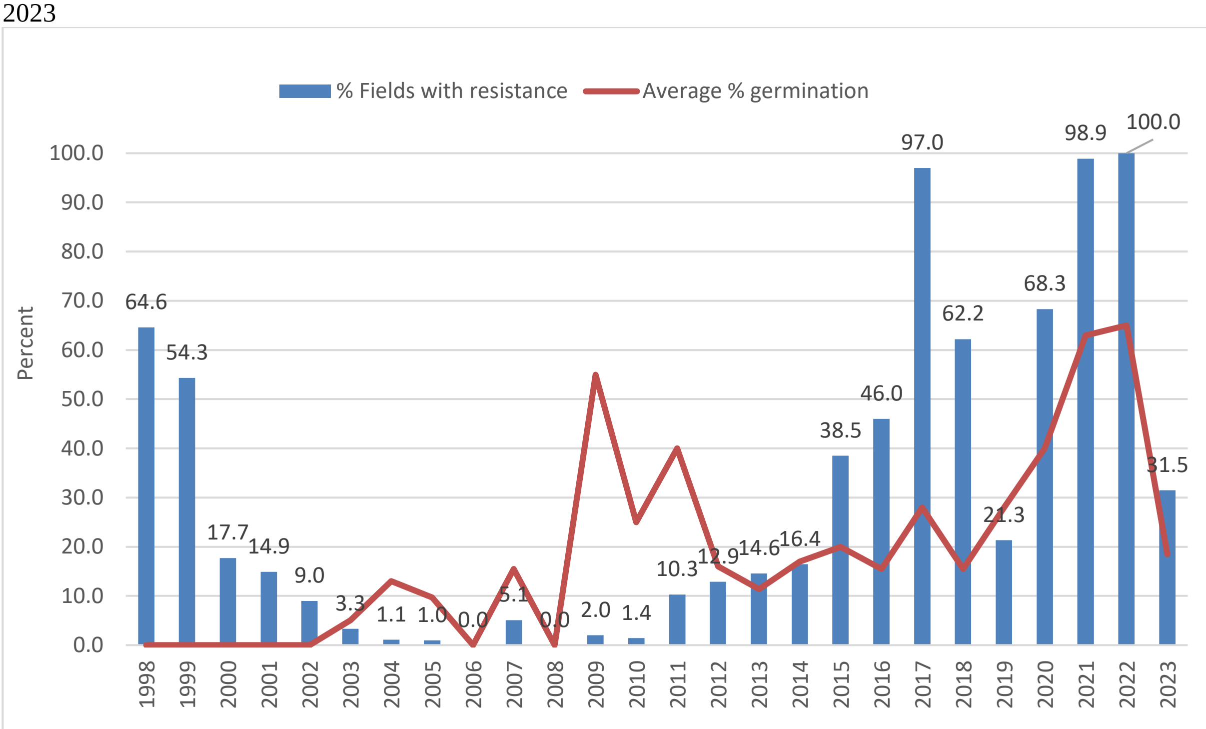


Figure 2. Incidence of fields with *C. beticola* isolates resistant to tin collected in ND and MN from 2020 to 2023 by factory district

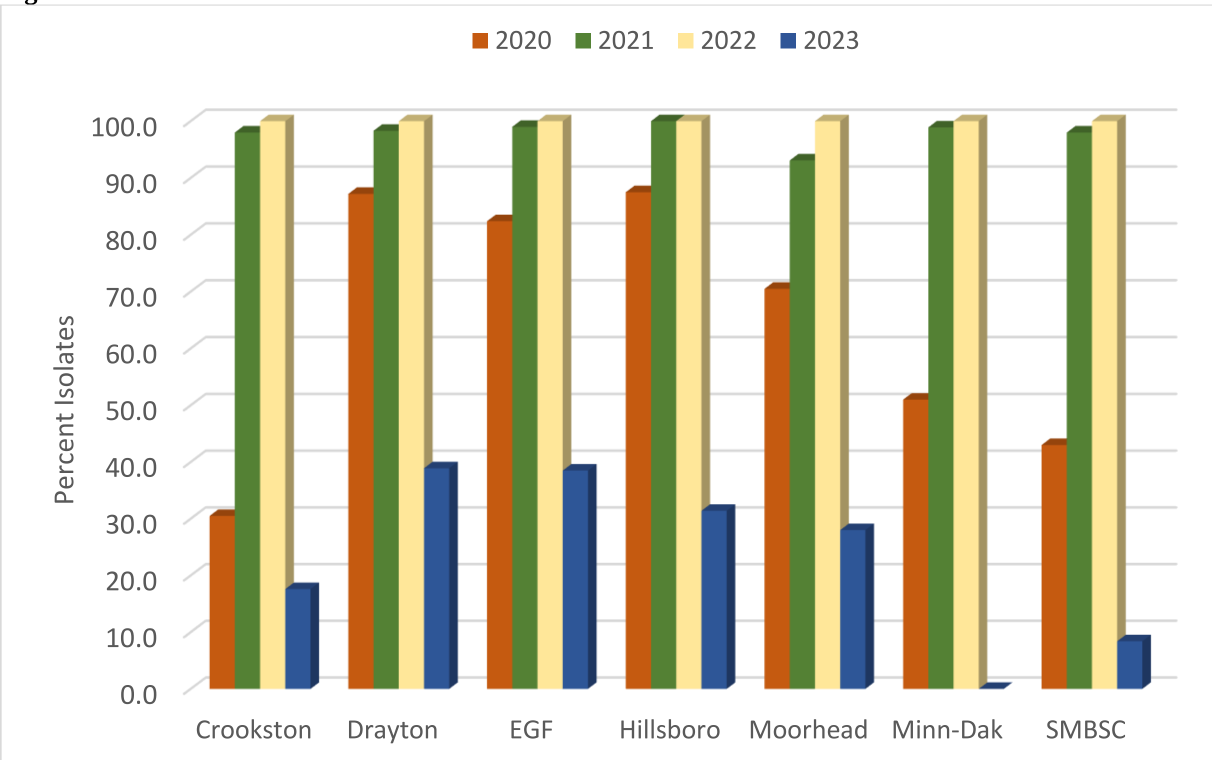


Figure 3. Resistance Factor of *C. beticola* isolates collected in ND and MN from 2019 to 2023 to Eminent, Inspire, Proline and Provysol

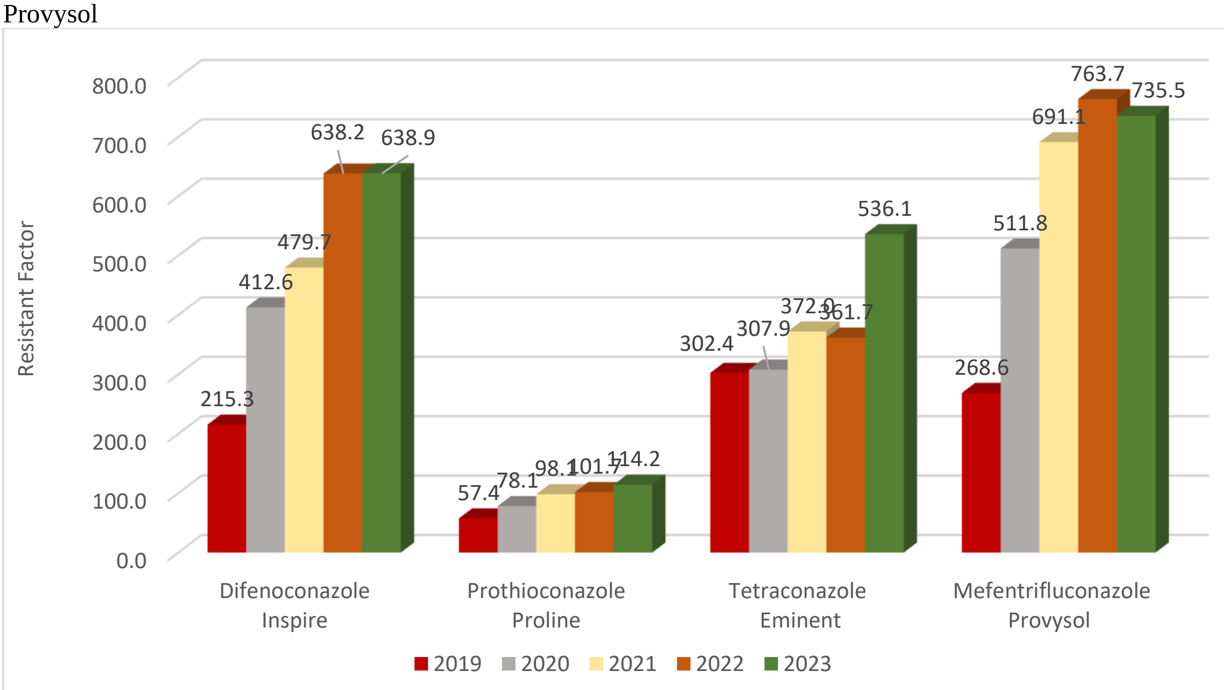


Figure 4. Sensitivity/resistance profile of Eminent, Inspire , Proline and Provysol as measured by EC50 values in 2022 and 2023

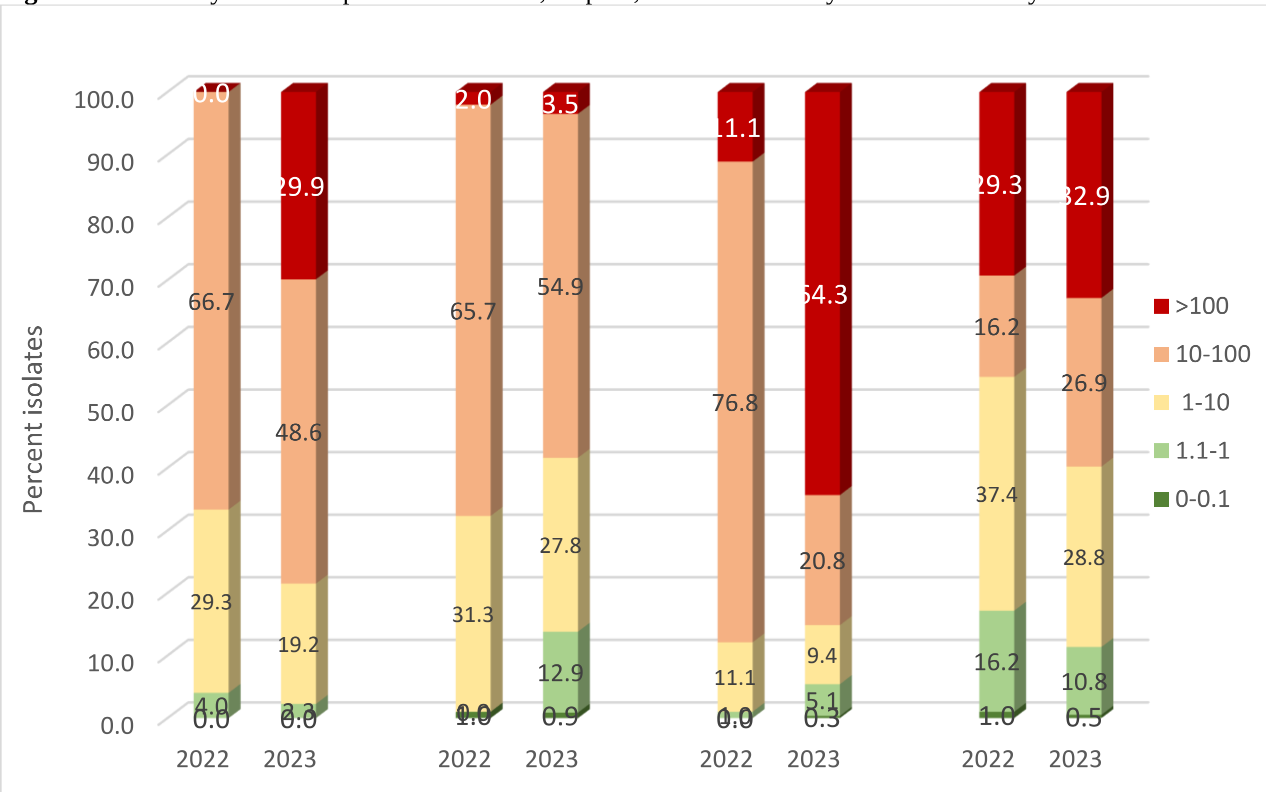
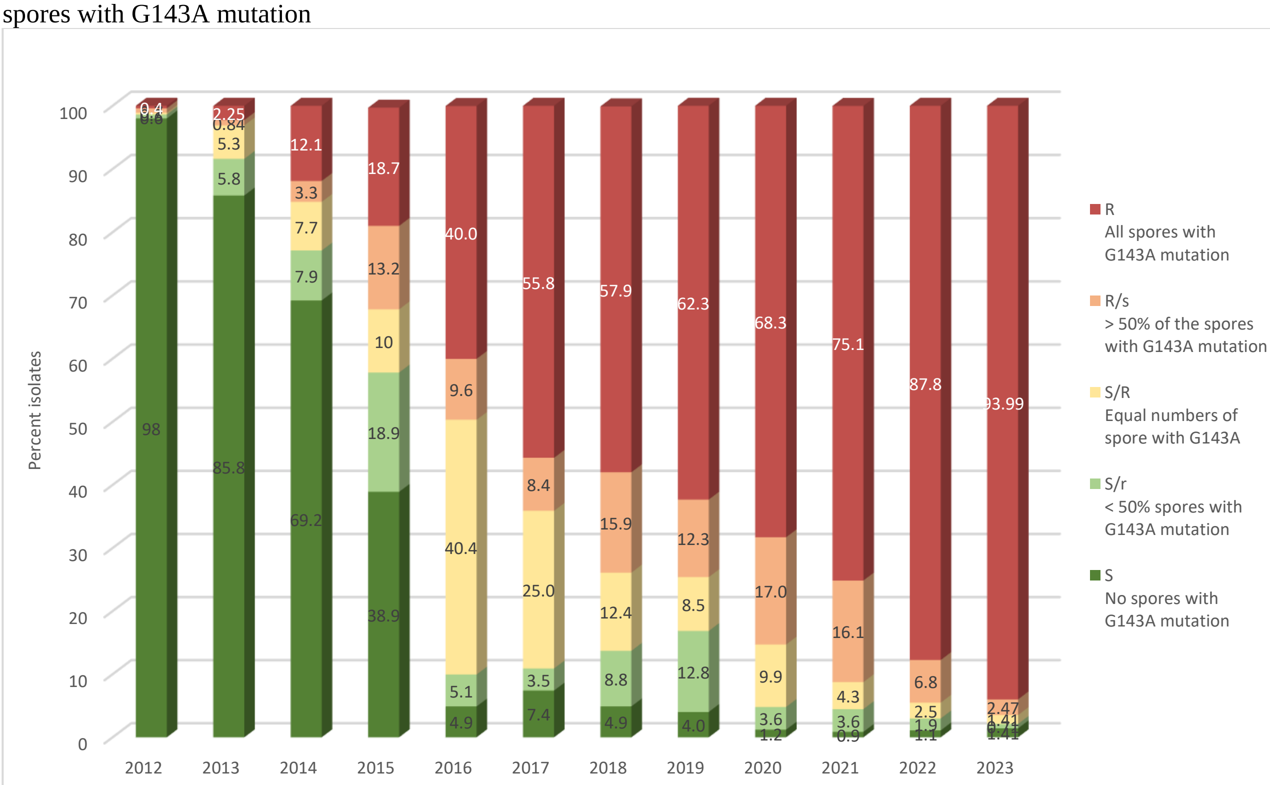


Figure 5. Profile of *C. beticola* isolates collected in ND and MN to Headline from 2012 to 2023 as expressed by the percentage of spores with G143A mutation



EARLY DETECTION OF CERCOSPORA BETICOLA ASYMPTOMATIC INFECTION IN COMMERCIAL SUGARBEET FIELDS IN 2023

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Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola*, (*Cb*) is the most important leaf spot disease of sugar beet and is endemic in sugarbeet fields in the Red River Valley (RRV). CLS severity varies yearly and causes serious economic losses if not managed. CLS is managed using a combination of crop rotation, cultural practices, resistant cultivars, and timely fungicide applications. *Cb* from the RRV has developed decreased sensitivity at varying levels to all fungicides used, including organotin compounds, strobilurin fungicides such as Priaxore and Headline, benzimidazoles such as Topsin, and triazole fungicides that include Proline, Inspire, and Provysol.

Timing of fungicide applications, especially the first application, is highly variable. For example, first applications can be based on calendar date, first appearance of CLS symptoms, or first observation CLS in the area. Subsequent fungicide applications are often based on daily infection values (DIVs) calculated from relative humidity and temperature in the region. As DIVs increase, disease favorability increases, and fungicide applications are recommended when a threshold is reached. Conditions typically indicative of CLS symptom development are high relative humidity and temperature.

Recent results from field surveys of asymptomatic leaf samples from commercial sugarbeet fields have shown that CLS infection is occurring earlier and at wider prevalence than previously thought. To investigate the occurrence, prevalence, and fungicide resistance profile of early CLS infection, we utilized molecular assays to detect known fungicide resistance mutations for detection of latent CLS infection and fungicide resistance mutations. Results of this work indicate that the latent phase of CLS infection occurs earlier than previously reported and opens numerous new avenues of research into the utility of early fungicide applications, molecular and genomic epidemiology, and pathogen basic biology.

OBJECTIVES

1) Detect the onset of CLS asymptomatic infection across the entire RRV growing region.

2) Determine fungicide resistance profiles for CLS asymptomatic samples.

METHODS AND MATERIALS

In 2021, 2022, and 2023, with financial support of the Sugarbeet Research and Extension Board of MN and ND, we tested samples collected for 5-6 weeks from 280 commercial sugarbeet fields in MN and ND. We asked the Agriculturalist staff from the region to collect five leaf samples from seven fields weekly to be mailed or dropped off to the USDA-ARS Sugarbeet and Potato Research Unit located in Fargo, ND.

Upon sample arrival, leaves are hole punched for a total of 10 leaf disks from each of the five leaves submitted per field location. These leaf punches are batch processed as a single sample for DNA extraction using a KingFisher^{TM} Flex Purification System (ThermoFisher: 5400630) with the sbeadex^{TM} plant nucleic acid purification kit (LGC: NAP41620) after freeze drying samples. Sample DNA is then subjected to qPCR assays designed to detect the G143A mutation associated with Strobilurin fungicide resistance (Bolton et al. 2013), The E170 and L144F mutations associated with Triazole fungicide resistance (Spanner et al. 2021, Shrestha et al. 2022), and the E198A mutation associated with Benzimidazole fungicide resistance. A probe designed to detect the wild type at the G143A locus is also incorporated to ensure that *C. beticola* DNA is detected in either of the two forms this mutation is present as. Results from each weekly sample set and assay batches are compiled into weekly reports and distributed back to the regional sugar cooperatives.

RESULTS AND DISCUSSION

Detection of latent CLS infection steadily rose as the sampling season progressed (Figure 1). In each of 2021, 2022, and 2023 the frequency of latent CLS detected in submitted samples approached 100% during the first week of July, corresponding to row closure events.

Assays to detect the G143A fungicide resistance mutations showed that during the initial detection of latent infection, samples primarily contain the sensitive allele for Strobilurin fungicides but as the weeks progress, detection of resistant mutations rises. This may be due to management practices used in sugarbeet cultivation such as in-furrow fungicide treatments using strobilurin fungicides, but this hypothesis has yet to be examined. Another potential cause of the rise of resistance detection is observation that strobilurin resistant isolates produce lower spore numbers and need higher temperatures to sporulate in laboratory experiments. This would create a natural lag in resistance detection due to the delay in spore production and subsequent infection due to environmental conditions in the early growing season (**Figure 2**).

Fungicide resistance mutations for triazole fungicides show similar patterns to strobilurin fungicides, beginning at low frequency and trending upwards as the latent infection progresses. As of yet we do not know if there are fitness penalties associated with triazole fungicide resistance in terms of spore production but results from radial growth assays show that triazole resistant isolates grow faster than their sensitive counterparts. This increase in growth may be the reason we see increased sample detection as the latent infection progresses as the resistant isolates out pace sensitive isolates growth in the sugarbeet host. Additional experiments are necessary to confirm this observation (**Figure 3**).

Last, benzimidazole resistance mutation detection during the latent infection progression steadily increased as was observed with triazole fungicides though additional work needs to be done to better understand the affects of this resistance mutation on the fitness of the pathogen (**Figure 4**).

SUMMARY

Across three sampling years, a consistent pattern of latent CLS progression has been observed, leading to near 100% prevalence of CLS detection just prior to or at sugarbeet row closure. These results have implications for the initial timing of fungicide applications for CLS management. Control of primary infection is important to mitigate the exponential increase in inoculum levels that can occur when CLS symptoms begin to arise. Comparative examination of early season fungicide resistance profiles and late season fungicide sensitivity assays show that the prevalence of fungicide resistance is higher at the end of the year than the beginning of CLS infection. This makes sense as isolates collected at the end of the year have undergone significant selection though fungicide applications. These results indicate that fungicide chemistries previously considered ineffective due to widespread resistance may have utility if deployed properly in the growing season.

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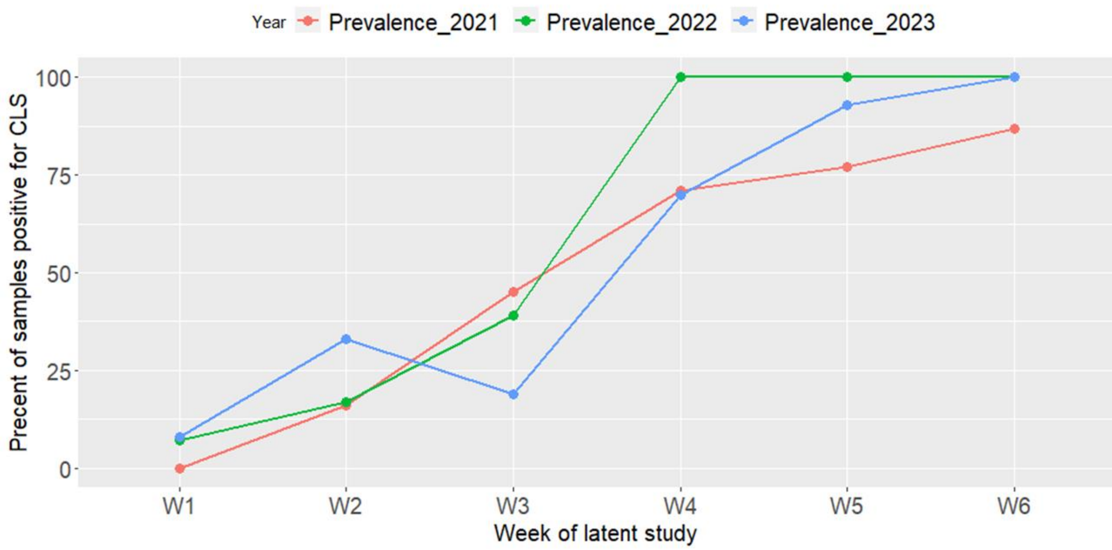

Figure 1: Prevalence of latent CLS detection in years 2021, 2022, and 2023 across sampling weeks. Sampling week 5 (W5) corresponds to the first week in July.

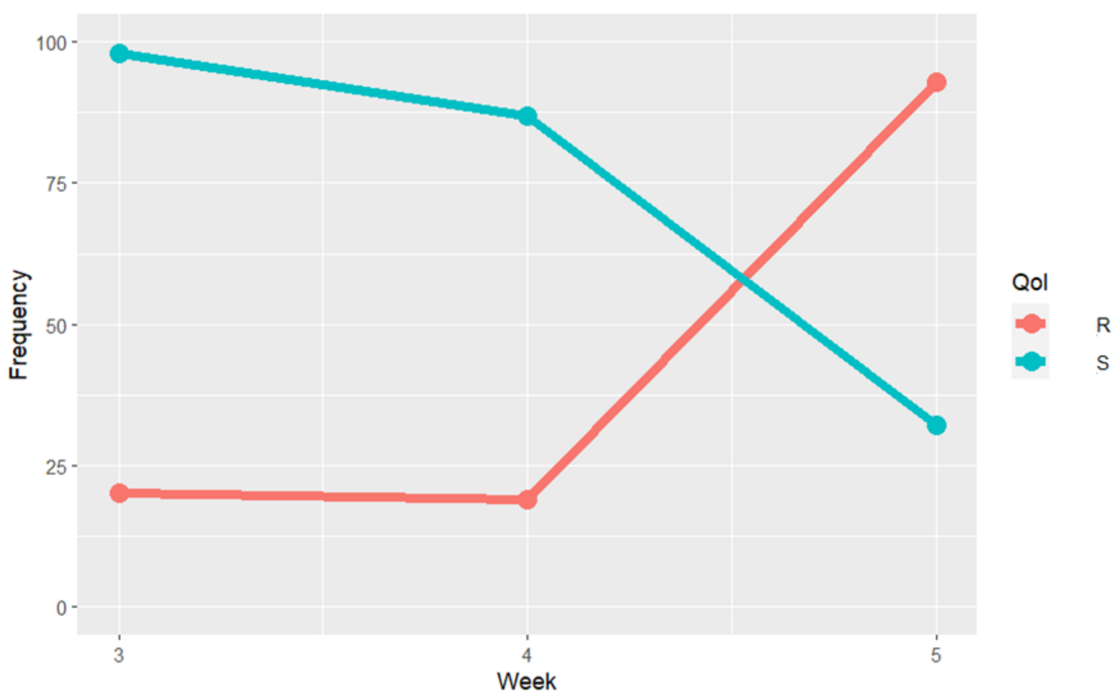

Figure 2: Strobilurin resistance and sensitivity mutation prevalence in CLS latent infection samples during weeks 3, 4, and 5 of the 2023 Latent CLS survey. Week 5 corresponds to the first week of July 2023. The blue line denotes the prevalence of the G143A strobilurin sensitivity allele and the red line denotes the prevalence of the G143A strobilurin resistance allele.

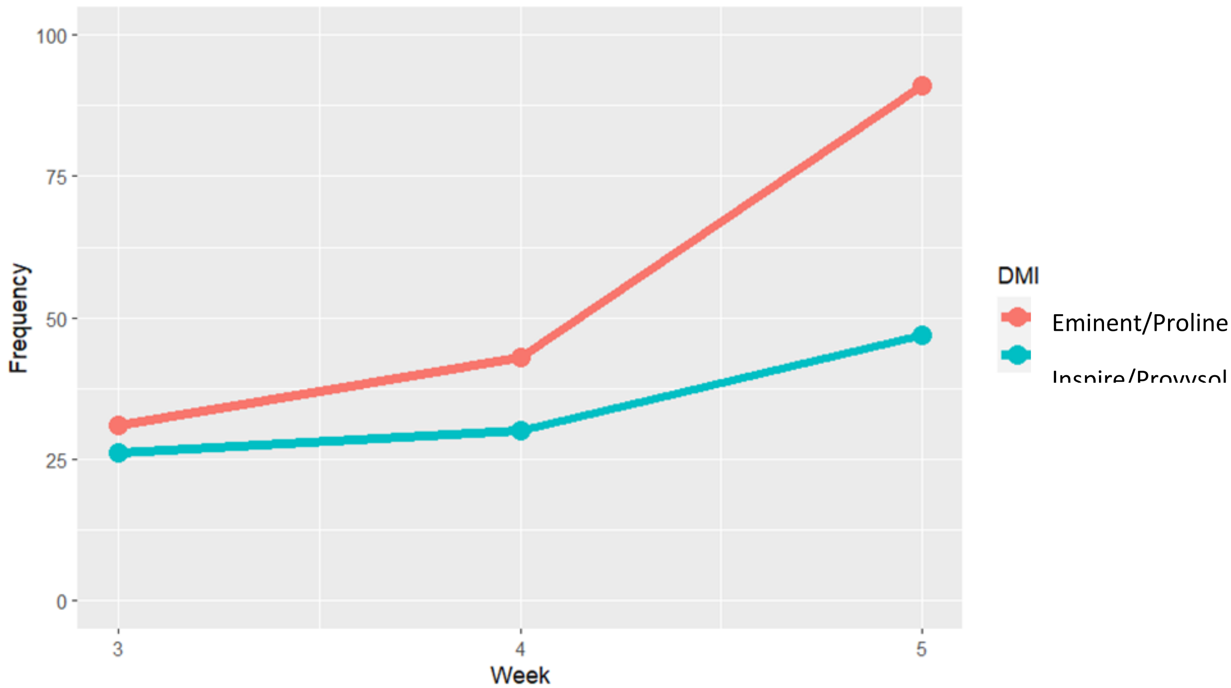

Figure 3: Triazole resistance mutation prevalence in CLS latent infection samples during weeks 3, 4, and 5 of the 2023 Latent CLS survey. Week 5 corresponds to the first week of July 2023. The red line denotes the prevalence of the E170 triazole resistance allele associated with resistance for the triazoles Tetraconazole and Prothioconazole and the blue line denotes the prevalence of the L144F triazole resistance prevalence for the triazoles Difenoconazole and Mefentrifluconazole.

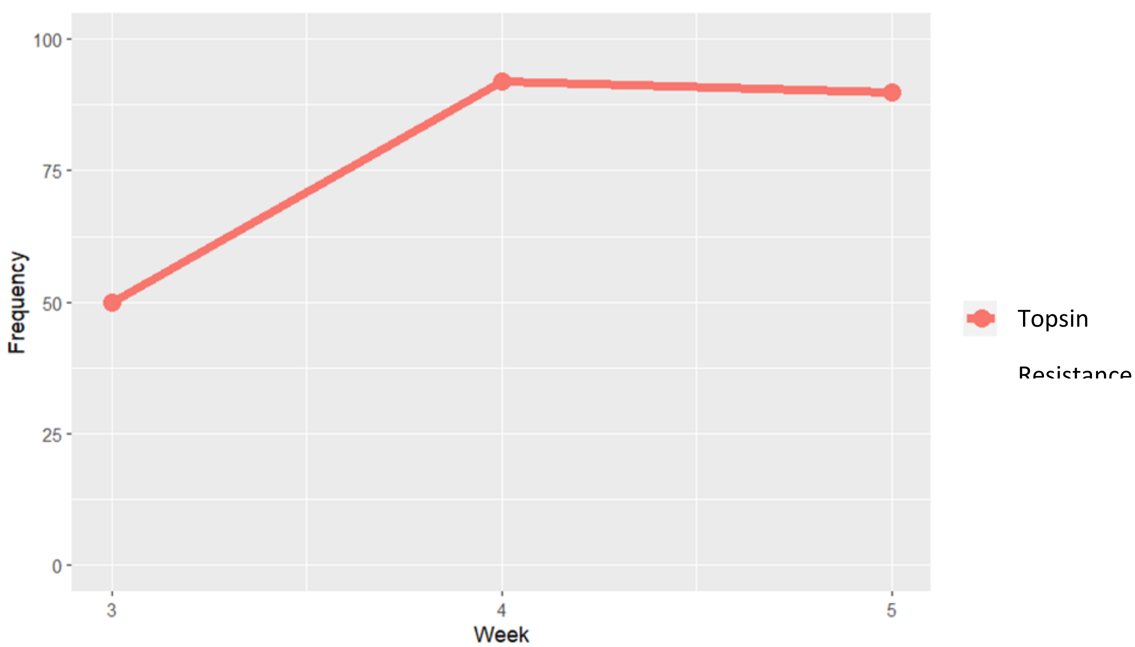

Figure 3: Benzimidazole resistance mutation prevalence in CLS latent infection samples during weeks 3, 4, and 5 of the 2023 Latent CLS survey. Week 5 corresponds to the first week of July 2023. The red line denotes the prevalence of the E198A benzimidazole resistance mutation.

EVALUATION OF AT-PLANTING FUNGICIDE TREATMENTS FOR CONTROL OF *RHIZOCTONIA SOLANI* ON SUGARBEET, 2023

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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 of sugarbeet in Minnesota and North Dakota for over the past decade (Brantner and Windels 2009, 2011; Crane et al. 2013; Brantner 2015; Brantner and Chanda 2017, 2019; Lien et al. 2022). Disease can occur throughout the growing season and reduce plant stand, root yield, and quality especially when warm and wet soil conditions favor infection. Disease management options include rotating with non-host crops (small grains), 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 use multiple control options to reduce Rhizoctonia crown and root rot (Windels et al. 2009, Chanda et al. 2016).

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 on a Hegne-Fargo silty clay soil with an organic matter content of 5.2%. Field plots were fertilized for optimal yield and quality. A moderately susceptible variety (Crystal 793RR) with a 2-year average Rhizoctonia rating of 4.5 (Brantner and Moomjian 2023) 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) (mixed in 3 gal water) mixed with starter fertilizer (3 gallons 10-34-0) were applied down the drip tube in 6 gallons total volume/A. The nontreated control did not include any seed or in-furrow fungicide treatment that would suppress or control *Rhizoctonia*. Prior to planting, soil was infested with *R. solani* AG 2-2-infested (a mixture of four isolates) whole barley (50 kg/ha) by hand-broadcasting in plots and incorporating with an 11-ft Rau seedbed finisher. The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 12 at 4.5-inch seed spacing.

Counter 20G (7.5 lb/A) was applied at planting for control of sugarbeet root maggot. For the control of weeds, ethofumesate (6 pt/A) was applied before planting using a spray boom mounted to the front of the Rau seedbed finisher to incorporate the product parallel with the direction of rows, glyphosate (3 lb ae/gal; 32 fl oz/A) plus clopyralid (1.8 fl/A) was applied on May 23, and Sequence (glyphosate + S-metolachlor, 2.5 pt/A) with additional glyphosate (4.5 lb ae/gal; 8 fl oz/A) was applied on June 07. For postemergence control of sugarbeet root maggot, Asana XL + Exponent (9.6 fl + 8 fl oz/A) was applied on June 08. Cercospora leaf spot was controlled by applying Inspire XT + Manzate Pro-Stick (7 fl oz + 2 lbs/A) on July 13, SuperTin 4L + Topsin 4.5FL (8 + 10 fl oz/A) on July 26, Proline 480 SC + Manzate Pro-Stick (5.7 fl oz + 2 lbs/A) on Aug 17, and SuperTin 4L + Priaxor Xemium (8 + 6.7 fl oz/A) on Aug 30.

Plant stands were evaluated beginning May 23 (11 days after planting [DAP]) through June 30 (49 DAP) by counting the number of plants in the center two rows of each plot. On Sept 12, plots were defoliated and the center two rows of each plot were harvested mechanically and weighed for root yield. Data was also collected for root rot severity and number of harvested roots immediately following harvest. Twenty roots per plot were arbitrarily selected, and root surfaces were rated for the severity of Rhizoctonia crown and root rot (RCRR) using a 0 to 10 scale with a 10% incremental increase per each unit of rating (i.e., 0=0%, 5 = 41-50%, 10=91-100%). Each rating was mid-point transformed to percent severity for statistical analysis. Ten representative roots from each plot were analyzed for sugar quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. Statistical analysis was conducted in SAS (version 9.4; SAS Institute, Cary, NC). A mixed-model analysis of variance was performed using the GLIMMIX procedure, with treatments defined as the fixed factor and replication as the random factor. Treatment means were separated based on the least square means test at the 0.05 significance level using the LSMEANS statement. The CONTRAST statement was used to compare the means of seed treatments vs. in-furrow treatments.

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.

Application[Z]	Product[Y]	Active ingredient (FRAC Group)	Rate[X]
Nontreated	-	-	-
Seed	Kabina ST	Penthiopyrad (7)	14 g a.i./unit seed
Seed	Systiva	Fluxapyroxad (7)	5 g a.i./unit seed
Seed	Vibrance	Sedaxane (7)	1.5 g a.i./unit seed
Seed	Zeltera	Inpyrfluxam (7)	0.1 g a.i./unit seed
Seed	Metlock Suite + Zeltera	Metconazole (3) + Tolclofos-methyl (14) Inpyrfluxam (7)	0.21 g a.i + 0.5 g a.i./unit seed 0.05 g a.i/unit seed
In-furrow	AZteroid FC3.3	Azoxystrobin (11)	5.7 fl oz product/A
In-furrow	Quadris	Azoxystrobin (11)	9.5 fl oz product/A
In-furrow	Headline SC	Pyraclostrobin (11)	9.0 fl oz product/A
In-furrow	Elatus WG	Azoxystrobin (11) + Benzovindiflupyr (7)	7.1 oz product/A
In-furrow	Proline 480 SC	Prothioconazole (3)	5.7 fl oz product/A
In-furrow	Propulse	Fluopyram (7) + Prothioconazole (3)	13.6 fl oz product/A
In-furrow	Priaxor	Fluxapyroxad (7) + Pyraclostrobin (11)	6.7 fl oz product/A

[Z] All treatments received 3 gal 10-34-0 applied down the drip tube in a total volume of 6 gal/A; In-furrow fungicides were mixed in 3 gal water prior to mixing with 3 gal 10-34-0.

[Y] Standard rates of Allegiance + Thiram and 45 g/unit Tachigaren were on all seeds.

[X] 5.7 fl oz AZteroid FC3.3 and 9.5 fl oz Quadris contain 67 and 70 g azoxystrobin, respectively; 9.0 fl oz Headline EC contain 67 g pryaclostrobin; 7.1 oz Elatus WG contains 60 g azoxystrobin and 30 g benzovindiflupyr; 5.7 fl oz Proline 480 SC contains 81 g prothioconazole; 13.6 fl oz Propulse contains 80 g each of fluopyram and prothioconazole; 6.7 fl oz Priaxor contains 33 g fluxapyroxad and 66 g pyraclostrobin

RESULTS AND DISCUSSION

The Northwest Research and Outreach Center, Crookston, MN, recorded a total rainfall of 1.71 and 0.87 in. for April and May, which was less than the 30-year average of 1.32 and 2.81 in., respectively. Warm conditions and adequate soil moisture at planting allowed for the rapid emergence of sugarbeet seedlings and generally high plant populations of 215 plants per 100 ft. of row averaged across all treatments in this trial on May 23 (11 DAP).

There were no significant differences among at-planting treatments for plant stands at any evaluation date or by the time of harvest (Table 2). However, based on the contrast analysis, in-furrow treatments had a statistically lower number of plants compared to the seed treatments on May 31 (19 DAP) (Table 2). Generally, seed treatments had a slightly higher number of plants throughout the first 7 weeks after planting (Fig. 1). Optimum soil moisture at planting typically does not result in seedling injury associated with in-furrow products as seen in previous years (Chanda and Brantner 2016, 2017; Lien et al. 2020, Lien et al. 2023). However, it is not unusual for stands to be lower for in-furrow fungicides compared to seed treatments under drier soil conditions (Brantner and Chanda 2018, 2020; Chanda and Brantner 2019; Lien et al. 2022).

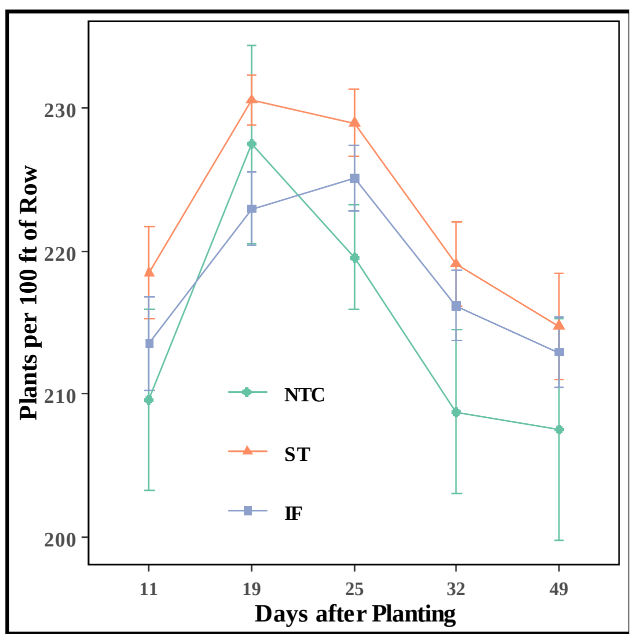

Figure 1. Emergence and stand establishment in 2023 comparing the averages of seed treatments and in-furrow fungicide treatments compared to the nontreated control in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2 in Crookston, MN.

Warmer temperatures in May and June likely contributed to a favorable environment for Rhizoctonia establishment early on; however, lower-than-average rainfall later in the season was unfavorable for disease development and resulted in moderately low disease pressure throughout the season in 2023. There were no significant differences ($P > 0.05$) among treatments for severity and incidence of Rhizoctonia crown and root rot (RCRR), sucrose percentage, root yield, or recoverable sucrose. However, based on the contrast analysis, in-furrow treatments had statistically lower plant loss, lower incidence and severity of RCRR, and higher yield and recoverable sucrose per acre compared to seed treatments (Table 3 and Fig. 2B).

Table 2. Effects of at-planting (seed treatment or in-furrow) fungicide treatments on emergence and stand establishment in a *Rhizoctonia*-infested field trial planted on May 12, 2023 at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Treatment and rate (Application type)[z]	Plants per 100 ft row [y,x] May 23 11 DAP	May 31 19 DAP	June 6 25 DAP	June 13 32 DAP	June 30 49 DAP
Nontreated Control	210	228	220	209	208
§Headline SC (9 fl oz)	212	225	225	215	213
§Priaxor (6.7 fl oz)	209	218	223	214	217
§Proline (5.7 fl oz)	218	219	228	220	215
§Propulse (13.6 fl oz)	220	222	223	212	203
¥Kabina ST (14 g)	216	232	223	209	204
¥Systiva XS (5 g)	205	227	226	215	210
¥Vibrance (1.5 g)	230	233	235	231	229
¥Zeltera (0.1 g)	220	232	227	219	218
¥Metlock Suite (0.21 + 0.5) + Zeltera (0.05 g)	222	230	234	221	213
§Quadris (9.5 fl oz)	207	224	219	211	206
§Elatus WG (7.1 oz)	221	235	235	229	226
§AZteroid FC[3.3] (5.7 fl oz)	208	218	224	212	210
LSD	-	-	-	-	-
P-value	0.5511	0.4246	0.5847	0.2568	0.3137
Contrast analysis of Seed Treatments vs. In-furrow Treatments [w]					
Mean of In-furrow treatments	214	223	225	216	213
Mean of Seed treatments	218	231	229	219	215
P-value	0.2063	**0.0366**	0.2946	0.5679	0.9709

z Treatments were applied as seed treatment (grams per unit of seed) or in-furrow application (rate per acre)
y Plant stands based on the number of plants in the center two rows of each plot
x Means followed by the same letter are not significantly based on LSMEANS test (*P*=0.05)
w Contrast analysis of seed versus in-furrow treatments does not include nontreated control
¥ Seed treatments applied by Germains Seed Technology, Fargo, ND
§ In-furrow fungicide application applied down a drip tube in 6 gallons total volume/A

Table 3. 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 and (Application rate)[z]	Plant Stand at Harvest[y]	Plant Loss (%)[x]	RCRR Severity (%)[w]	RCRR Incidence (%)[w]	Sugar (%)[t]	SLM (%)[t]	Sucrose (%)	Yield (tons/A)	Sucrose (lb/A)
§Elatus WG (7.1 oz)	185	22.4	8.2	36.2	20.1	1.0	19.1	27.9	10608
§Propulse (13.6 fl oz)	170	24.9	6.9	32.5	19.6	0.9	18.7	27.5	10256
§Proline (5.7 fl oz)	175	23.3	5.8	26.2	19.6	1.0	18.6	27.1	9991
§Priaxor (6.7 fl oz)	184	18.2	4.6	31.2	19.5	1.0	18.5	27.0	9962
§AZteroid FC[3.3] (5.7 fl oz)	175	23.2	4.5	21.2	19.1	1.1	18.0	27.5	9891
§Quadris (9.5 fl oz)	172	24.2	7.4	32.5	19.8	1.1	18.7	26.3	9723
¥Kabina ST (14 g)	158	32.0	11.3	41.2	19.7	1.0	18.7	25.8	9608
¥Vibrance (1.5 g)	174	27.0	9.2	43.8	19.4	1.0	18.4	25.5	9388
¥Zeltera (0.1 g)	172	25.8	9.2	40.0	19.7	1.0	18.7	25.2	9364
Nontreated Control	157	31.0	8.6	33.8	19.0	1.0	18.0	26.0	9324
¥Metlock Suite (0.2 + 0.5 g) + Zeltera (0.05 g)	169	29.0	11.1	38.8	19.7	1.1	18.6	25.0	9180
¥Systiva XS (5 g)	167	27.6	8.6	31.2	20.0	1.0	19.0	23.7	9022
§Headline SC (9 fl oz)	161	29.3	6.5	32.5	19.4	1.1	18.3	24.8	8983
P-value	0.2831	0.1634	0.4536	0.7218	0.8514	0.6178	0.8521	0.5084	0.2508
[v] Contrast analysis of Seed Treatments vs. In-furrow Treatments									
Mean of In-furrow treatments	175	23.7	6.3	30.4	19.6	1.0	18.6	26.9	9916
Mean of Seed treatments	168	28.3	9.9	39.0	19.7	1.0	18.7	25.0	9312
P-value	0.1274	**0.0148**	**0.0073**	**0.0480**	0.6257	0.3268	0.6043	**0.0338**	**0.0411**

z Treatments were applied as seed treatment (grams per unit of seed) or in-furrow application (rate per acre)
y Plant stands are equivalent to number of plants per 100 ft of row
x Plant loss percent equals 100 * (Maximum number of live plants – number of harvested roots) / (Maximum number of live plants)
w Ratings and incidence Rhizoctonia crown and root rot are described in text
v Contrast analysis of seed versus in-furrow treatments does not include nontreated control
¥ Seed treatments applied by Germains Seed Technology, Fargo, ND
§ In-furrow fungicide application applied down a drip tube in 6 gallons total volume/A

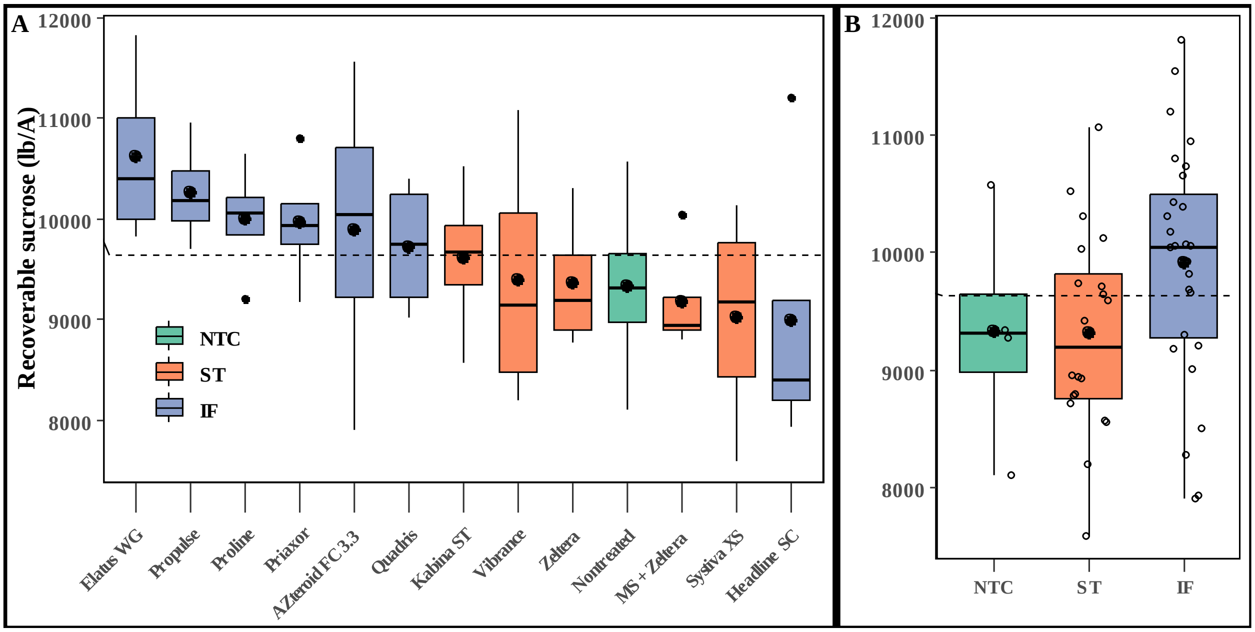

Figure 2. Effect of at-planting treatments on recoverable sucrose (lbs/A) in sugarbeets (A) and averages of seed treatments (ST) and in-furrow fungicide treatments (IF) compared to the nontreated control (NTC) (B) in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2 in Crookston, MN. Boxplots display the distribution of data for each treatment based (minimum, first quartile, median, third quartile, and maximum); hollow dots represent each data point; filled dots represent treatment means. The dashed horizontal line represents the mean of all treatments in this trial.

ACKNOWLEDGEMENTS

We thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for funding this research; BASF, Bayer, Mitsui Chemicals Agro, Inc., Syngenta, Valent, and Vive Crop Protection for providing products; Crystal Beet Seed for providing seed; Germains Seed Technology for treating seed; the University of Minnesota Northwest Research and Outreach Center, Crookston for providing land, equipment and other facilities; Jeff Nielsen for plot maintenance; James Deleon, Zahra Pagiri, Stephanie Melby, and Kenan McQueen for technical assistance; American Crystal Sugar Company, East Grand Forks, MN for sugarbeet quality analysis.

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EVALUATION OF POSTEMERGENCE FUNGICIDES AND APPLICATION METHOD ON SUGAR BEET FOR CONTROL OF RHIZOCTONIA CROWN AND ROOT ROT, 2023

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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 of sugarbeet in Minnesota and North Dakota for over the past decade (Brantner and Windels 2009, 2011; Crane et al. 2013; Brantner 2015; Brantner and Chanda 2017, 2019; Lien et al. 2022). Disease can occur throughout the growing season and reduce plant stand, root yield, and quality, especially when warm and wet soil conditions favor infection. Disease management options include rotating with non-host crops (small grains), planting early when soil temperatures are cool, improving soil drainage, planting partially resistant varieties, and applying fungicides as seed treatments, in-furrow (IF), and/or postemergence (Chanda et al. 2016). Postemergence applications of Quadris can result in the reduction of root rot and increased yield and recoverable sucrose (Chanda et al., 2017, 2018, 2019, 2020). However, limited trials have been conducted to compare currently labeled fungicides for postemergence management of RCRR, and it is unclear if efficacy is reduced when fungicides are applied as a broadcast application compared to a 7-in. band.

OBJECTIVES

A field trial was established to evaluate various postemergence fungicide treatments as a 7-in. band or broadcast application 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 on a Hegne-Fargo silty clay soil with an organic matter content of 5.2%. The preceding crop was soybeans, and field plots were fertilized in the fall for optimal yield and quality. A moderately susceptible variety (Crystal 793RR) with a 2-year average Rhizoctonia rating of 4.5 (Brantner and Moomjian 2023) was used. All seeds were treated with standard rates of Allegiance, Thiram, Tachigaren (45g/unit), and Kabina (14g/unit). Treatments were arranged in a randomized complete block design with four replicates. The trial was sown in six-row plots (22-in. row spacing, 30-ft rows) with a 4.5-in. seed spacing on May 11. Paralign starter fertilizer (5-15-3 + 0.8% Zn) was applied in-furrow at a rate of 2 gal/A with a total application volume of 6 gal/A across all treatments.

Counter 20G (7.5 lb/A) was applied at planting for control of sugarbeet root maggot. For the control of weeds, ethofumesate (6 pt/A) was applied before planting with a spray boom mounted to the front of the Rau seedbed finisher to incorporate the product parallel with the direction of rows, glyphosate (3 lb ae/gal; 32 fl oz/A) plus clopyralid (1.8 fl/A) was applied on May 23, and Sequence (glyphosate + S-metolachlor, 2.5 pt/A) with additional glyphosate (4.5 lb ae/gal; 8 fl oz/A) was applied on June 07. For postemergence control of sugarbeet root maggot, Asana XL + Exponent (9.6 fl + 8 fl oz/A) was applied on June 08. Cercospora leaf spot was controlled by applying Inspire XT + Manzate Pro-Stick (7 fl oz + 2 lbs/A) on July 13, SuperTin 4L + Topsin 4.5FL (8 + 10 fl oz/A) on July 26, Proline 480 SC + Manzate Pro-Stick (5.7 fl oz + 2 lbs/A) on Aug 17, and SuperTin 4L + Priaxor Xemium (8 + 6.7 fl oz/A) on Aug 30.

On the morning of June 21 (10-leaf stage), fungicide treatments (see table) were applied to the center four rows within plots. Each fungicide was evaluated in two separate treatments: a 7-in. band and a broadcast application, using Teejet 8002 or 11002 nozzles, respectively, each with an application volume of 10 gal/A at 30 psi. Following the appropriate re-entry intervals, the center four rows within each plot were inoculated in the afternoon of June 21; the inoculum consisted of 20 g per row of ground barley infested with *R. solani* AG 2-2. A tractor-mounted Gandy delivery system spread the inoculum over the sugar beet crowns.

Plant stands were evaluated on June 14 (34 DAP) and June 27 (47 DAP) by counting the number of live plants in the center two rows of each plot. Data were collected for disease severity, the number of harvested roots, and yield at harvest. On Sept 13, plots were defoliated, and the center two rows of each plot were harvested mechanically and weighed for root yield. Twenty roots per plot were arbitrarily selected and were rated for the severity of Rhizoctonia crown and root rot (RCRR) on the root surface using a 0 to 10 scale with a 10% incremental increase per each unit of rating (i.e., 0=0%, 5 = 41-50%, 10=91-100%). Each rating was mid-point transformed to percent severity for statistical analysis. Ten representative roots from each plot were analyzed for sugar quality at the

American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. Statistical analysis was conducted in SAS (version 9.4; SAS Institute, Cary, NC). A mixed-model analysis of variance was performed using the GLIMMIX procedure, with treatments defined as the fixed factor and replication as the random factor. Treatment means were separated based on the least square means test at the 0.05 significance level using the LSMEANS statement. The CONTRAST statement was used to compare the means of the 7-in. Band vs. the Broadcast application method.

RESULTS AND DISCUSSION

Following fungicide applications and inoculation of *R. solani*, the site received 0.55 in. of rain and provided conditions that favored the establishment of the Rhizoctonia inoculum. However, lower-than-average rainfall for the remainder of the growing season was unfavorable for disease development which resulted in low to moderate disease pressure. There were significant ($P < 0.05$) differences among treatments for the severity and incidence of Rhizoctonia root rot (RCRR) where all fungicide treatments resulted in lower disease than the nontreated control (Table 1). There were no significant differences in the number of harvested roots, plant loss, root yield, sugar percentage, or recoverable sucrose. However, there were numerical differences in which the nontreated control resulted in the greatest plant loss as well as the lowest root yield and recoverable sucrose while AZterknot and Quadris applied at 14.5 fl oz per acre resulted in the greatest recoverable sucrose (Table 1 and Fig. 1A). There were no significant differences for any of the parameters evaluated when comparing the means of the band applications vs. the broadcast applications according to the contrast analysis (Table 1). Despite disease severity and incidence being slightly higher for the broadcast applications than the band applications, recoverable sucrose was slightly higher for broadcast applications (Fig. 1B). Moreover, data reported by Lien and Chanda (2023) shows that 7-in band applications resulted in slightly lower disease severity and higher recoverable sucrose, although differences were not significant.

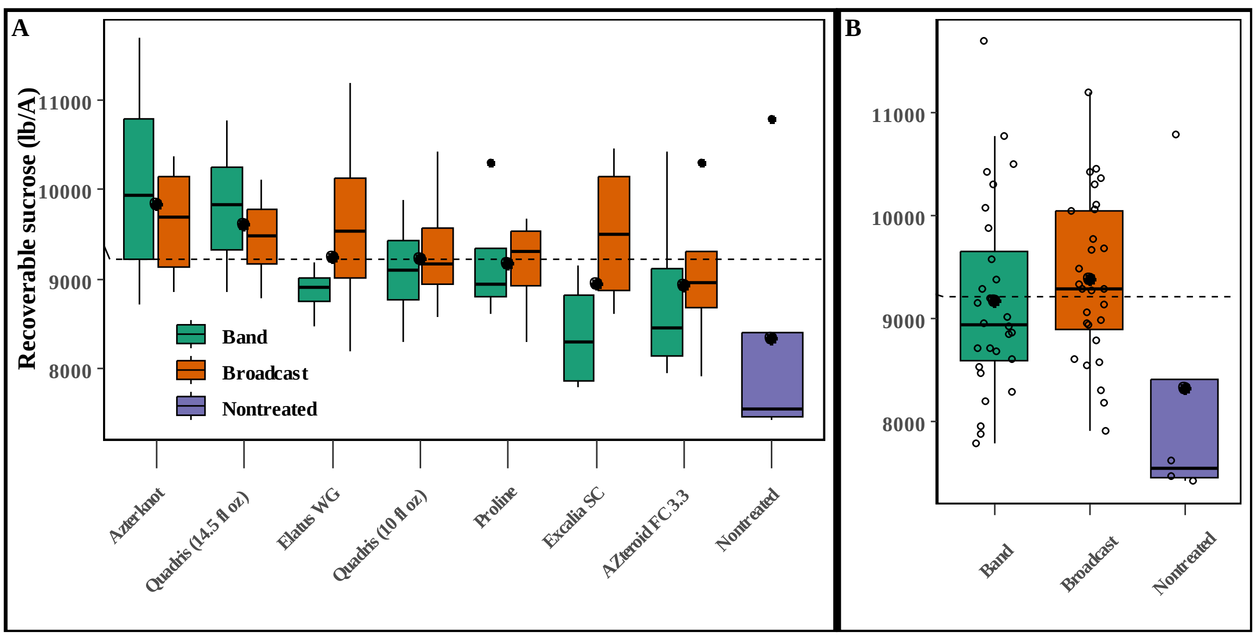

Figure 1. Effect of postemergence fungicide treatments on recoverable sucrose (lbs/A) in sugarbeets (A) and averages of 7-in. band applications and broadcast applications compared to the nontreated control (B) in a sugarbeet field trial inoculated with *Rhizoctonia solani* AG 2-2 in Crookston, MN. Boxplots display the distribution of data for each treatment (minimum, first quartile, median, third quartile, and maximum); hollow dots represent each data point; filled dots represent treatment means. The dashed horizontal line represents the mean of all treatments in this trial.

Table 1. Effects of postemergence fungicide treatments applied as either a 7-in band or broadcast application on Rhizoctonia crown and root rot and sugarbeet yield and quality in a field trial inoculated with *Rhizoctonia solani* at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Treatment and (rate/acre) [z]	Plant Stand at Harvest[y]	Plant Loss (%)[x]	RCRR Severity (%)[w,v]	RCRR Incidence (%)[u]	Sugar (%)	SLM (%)[t]	Yield (tons/A)	Sucrose (lb/A)[s]
Nontreated	153	20.0	12.6 a	56.2 a	19.7	1.29	22.7	8327
Elatus WG (7.1 oz) [r]	176	11.5	0.1 b	1.2 c	20.1	1.32	23.7	8870
Elatus WG (7.1 oz) [q]	192	8.5	1.4 b	7.5 bc	20.1	1.24	25.5	9612
Excalia SC (0.64 fl oz) [r]	173	12.7	0.9 b	8.8 bc	19.7	1.42	23.0	8386
Excalia SC (2 fl oz) [q]	183	6.5	0.2 b	3.8 bc	20.0	1.36	25.5	9516
Quadris (10 fl oz) [r]	173	11.6	1.0 b	7.5 bc	20.1	1.29	24.2	9100
Quadris (10 fl oz) [q]	185	9.2	2.1 b	12.5 b	20.3	1.20	24.4	9335
Quadris (14.5 fl oz) [r]	190	7.6	1.2 b	6.2 bc	20.8	1.16	24.9	9742
Quadris (14.5 fl oz) [q]	189	8.0	0.9 b	10.0 bc	21.1	1.25	23.9	9463
AZteroid FC$^{3.3}$ (9.2 fl oz) [r]	167	12.0	0.5 b	6.2 bc	19.9	1.20	23.6	8819
AZteroid FC$^{3.3}$ (9.2 fl oz) [q]	183	7.7	1.2 b	8.8 bc	19.5	1.31	24.9	9036
AZterknot (16.6 fl oz) [r]	195	5.8	0.5 b	7.5 bc	20.0	1.31	27.0	10074
AZterknot (16.6 fl oz) [q]	183	7.6	0.5 b	6.2 bc	20.0	1.37	25.8	9579
Proline 480 SC (5.7 fl oz) [r]	188	12.1	0.3 b	6.2 bc	20.7	1.25	23.6	9198
Proline 480 SC (5.7 fl oz) [q]	189	9.8	0.4 b	7.5 bc	20.6	1.29	23.7	9153
P- value	0.2083	0.0886	**<0.0001**	**<0.0001**	0.1404	0.4277	0.6584	0.3455
Contrast analysis of 7-in. Band Treatments vs. Broadcast Treatments								
7-in. Band	180	10.4	0.6	6.2	20.2	1.29	24.3	9170
Broadcast	186	8.2	1.0	8.0	20.2	1.29	24.8	9385
P- value	0.2625	0.1227	0.5942	0.3523	0.8699	0.8122	0.4580	0.3770

[z] The active ingredient and FRAC group of each treatment follows: Excalia SC is inpyrfluxam (7), Quadris and AZteroid FC$^{3.3}$ is azoxystrobin (11), Proline 480 SC is prothioconazole (3), AZterknot is azoxystrobin (11) + Extract of *Reynoutria sachalinensis* (P 05), and Elatus WG is azoxystrobin (11) + benzovindiflupyr (7)

[y] Plants stands are equal to number of roots per 100 ft of row

[x] Plant loss percent equals 100 * (Maximum number of live plants – number of harvested roots) / (Maximum number of live plants)

[w] Means within a column followed by a common letter are not significantly different by LSMEANS test at the 0.05 level of significance

[v] Percent severity of Rhizoctonia crown and root rot based on a 0 to 10 scale with a 10% incremental increase per each unit of rating (i.e., 0=0%, 5 = 41-50%, 10=91-100%). Each rating was mid-point transformed to percent severity for statistical analysis.

[u] Percent incidence of rated roots with > 0% of rot on the root surface

[t] Percent sugar loss to molasses (SLM)

[s] Recoverable sucrose per acre; equal to yield*(percent sugar – percent SLM) *20))

[r] 7-inch band application

[q] Broadcast application

ACKNOWLEDGEMENTS

We thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for funding this research; Mitsui Chemicals Agro, Inc., Bayer, Syngenta, Valent, and Vive Crop Protection for providing products; Crystal Beet Seed for providing seed; Germains Seed Technology for treating seed; the University of Minnesota Northwest Research and Outreach Center, Crookston for providing land, equipment and other facilities; Jeff Neilsen for plot maintenance; James Deleon, Zahra Pagiri, Stephanie Melby, and Kenan McQueen, for technical assistance; American Crystal Sugar Company, East Grand Forks, MN for sugarbeet quality analysis.

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EVALUATING RHIZOMANIA RESISTANCE-BREAKING STRAINS OF *BEET NECROTIC YELLOW VEIN VIRUS* USING HIGH-THROUGHPUT SEQUENCING

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Rhizomania, caused by *Beet necrotic yellow vein virus* (BNYVV), is an economically important disease of sugarbeet that impacts sugarbeet productivity and growers' economy. BNYVV is a multipartite RNA virus that belongs to the family *Benyvirus* (Tamada and Baba, 1973), and is transmitted by *Polymyxa betae* a soilborne parasite of sugarbeet (D'Alonzo et al., 2012). In the USA, the disease was first identified in the early 1980s and within a few years had spread to all sugarbeet production areas (Duffus, 1984; Wisler et al. 1997). The disease is managed through resistance genes, *Rz1* and other sources of resistance, that were introduced to the commercial cultivars. In a few years, the *Rz1*-mediated resistance has been compromised with the appearance of resistance-breaking strains of BNYVV. The appearance of rhizomania disease started as blinkers and later spreading to large diseased area in fields planted with *Rz1* resistance carrying cultivars (Scholten et al. 1996; Liu et al. 2005; Rush and Acosta-Leal, 2007). Further research indicated that the ability for BNYVV overcoming the *Rz1*-mediated resistance was mapped to BNYVV RNA 3, to a highly variable 'tetrad' amino acid of the p25 gene (Koenig et al. 2009). A recent survey on the distribution and prevalence of BNYVV strains and p25 mapping in North Dakota and Minnesota area revealed no correlation between the p25 tetrad signature and the ability to compromise *Rz1*-mediated resistance (Weiland et al., 2019).

Rhizomania disease is managed by host resistance introduced into commercial cultivars used for sugar beet production. On the other hand, rhizomania disease is being observed in sugar beet production fields indicating the appearance of resistance-breaking variants of BNYVV. Identification of the resistance-breaking strains of BNYVV is important for developing new disease management strategies for the future. Next-generation high-throughput sequencing (HTS) is a powerful technology that can provide the sequence information of known and unknown viruses. To evaluate the rhizomania-resistance breaking, soil samples from rhizomania suspicious sugarbeet production fields will be obtained, and viruses in the soil will be recovered using soil-baiting assay. Rhizomania resistance-breaking will be evaluated by growing seeds of different sugarbeet varieties that includes susceptible, *Rz1*, and *Rz1* plus *Rz2* in the field soil under laboratory conditions. Then, by applying, HTS analysis to the sugarbeet grown in rhizomania-infested soil samples, the sequence information of BNYVV present in the roots of sugarbeet plants grown in rhizomania-infested soil will be identified. Identification of the nucleotide changes and the associated amino acids will allow the characterization of the resistance-breaking strains of BNYVV.

Materials and Methods

Survey of rhizomania disease was conducted in coordination with agriculturists and cooperatives of Minnesota and North Dakota sugarbeet growing areas: American Crystal Sugar Company, Minn-Dak Farmers' Cooperative, and Southern Minnesota Beet Sugar Cooperative. Soil samples from around the roots of sugarbeet plants those are suspicious for rhizomania disease were collected from multiple fields on North Dakota and Minnesota. The sugarbeet seeds with different genotypes were kindly provided by the seed company, SESVanderhave. The soil-baiting assay was carried out using susceptible sugarbeet seeds were planted into Sunshine Mix with sand of 1:1 ratio along slow-release fertilizer with (Sungro Horticulture, MA). Plants were grown in a greenhouse under standardized conditions at 24°C/18°C day/night with 8 hours of supplemental light per day, and water was added directly as needed. Six weeks after planting in infested soil, plants were harvested and root sample consisting of 3 plants was taken from each pot. Roots were washed gently in a tray containing water taking care to retain fine root hairs, damp dried on paper towel, and stored for ELISA testing on BNYVV (Torrance et al.,1988) or stored at -80°C until used for RNA extraction and library construction to accomplish high-throughput sequencing. We have an established bioinformatic pipeline to carry out the downstream sequencing data analysis.

Results and Discussion

A survey was conducted for rhizomania disease prevalence in the sugarbeet growing area of Minnesota, North Dakota, and South Dakota in cooperation with agriculturists. Sugar beet samples with rhizomania symptoms and the corresponding soil samples were obtained from multiple sugar beet fields of Minnesota, North Dakota, and South Dakota. Hairy roots from beet samples were carefully collected and washed gently to remove tare attached to it. After damp drying, a portion of it was ground in ELISA extraction buffer in a volume of 600 uL and loaded 150 uL in one well of ELISA plate in three replicates. Each ELISA plate was included with positive and negative controls to confirm the assay reagents in the diagnosis. Out of 143 beet samples, 85 tested positive (59%) based on ELISA analysis (Table 1). Each beet sample was tested in three replicates and an average was used for plotting analysis. The beet samples that are positive for BNYVV could be due to lack of the trait or appearance of resistance-breaking variants of BNYVV.

Table 1. Detection of BNYVV using ELISA in sugar beet obtained from fields. In the table symbol ++ refers to highly positive for BNYVV, + symbol stands for moderately positive for BNYVV, and – symbol denotes negative for BNYVV in the beet samples.

Sample	Location	Beet	++	+	-
1	SD	10	0	0	10
2	ND	7	4	2	1
3	ND	7	5	1	1
4	ND	7	0	0	7
5	ND	4	3	0	1
6	ND	5	3	1	1
7	ND	8	5	2	1
8	ND	7	4	3	0
9	MN	9	1	5	3
10	MN	9	0	0	9
11	MN	5	1	1	3
12	MN	4	0	1	3
13	MN	9	3	3	3
14	ND	9	1	5	3
15	MN	6	2	3	1
16	MN	5	3	1	1
17	MN	10	5	1	4
18	MN	7	4	3	0
19	MN	6	4	0	2
20	MN	9	4	1	4
		143	52	33	58
			Rhizomania positive	85	58

The obtained rhizomania suspicious soil samples were used in soil-baiting assay to recover the BNYVV from rhizomania-infested soil by growing different sugar beet cultivars representing susceptible, *Rz1*, and *Rz1Rz2* sugar beet genotypes. BNYVV detection in the roots of bait plants was accomplished using ELISA. For each sugar beet cultivar three replicates were used for ELISA analysis, and the average value was used for plotting. Positive and negative controls were included in each ELISA plate diagnosis. Twenty-five soil samples were obtained from various locations of Minnesota, North Dakota, and South Dakota sugarbeet production fields. Soil-baiting analysis is ongoing and expected to be completed end of February 2024. Once, completed the results will be communicated to the cooperatives depending on the locations from where the samples were obtained. Based on the ELISA analysis and sugarbeet genotype comparison, a subset of the samples will be subjected to next generation high-throughput sequencing analysis to identify the molecular changes at the nucleotide levels on the BNYVV genome to understand rhizomania resistance breaking variants of BNYVV. In summary, evaluation of rhizomania resistance breaking in field soil samples will provide important information to growers to make informed decisions on disease management strategies.

SUGARBEET PLANT PATHOLOGY LABORATORY: SUMMARY OF 2022 and 2023 FIELD SAMPLE DIAGNOSTICS

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The plant pathology laboratory at the University of Minnesota, Northwest Research and Outreach Center in Crookston receives sugarbeet samples for diagnosis every growing season. These samples have problems caused mostly by plant pathogens, insects, or abiotic causes such as chemical injury (usually herbicide) or nutrient deficiencies. This report summarizes the results of samples received during the 2022 and 2023 growing seasons.

It is important to note that the number of samples received of a particular disease may not always accurately reflect the prevalence of the diseases observed during the growing season. Agricultural staff and crop consultants may be more comfortable self-diagnosing certain diseases, or they may go unnoticed if aboveground symptoms are not observed. However, similarities and differences between 2022 and 2023 were observed. Additionally, some samples had multiple pathogens/problems, so numbers add up to more than 100%.

In 2022, sugarbeet samples were received from 45 fields (224 individual roots and 87 leaves), and diagnostic results are summarized in Figure 1A. Of those fields, 33.3% had *Rhizoctonia solani*, 8.9% *Aphanomyces cochlioides,* 17.8% *Fusarium* spp., 6.7% possible chemical injury, 6.7% possible environmental causes, and 6.7% had no recovery of pathogens and/or other causes. There were no fields in 2022 where both *A. cochlioides* and *R. solani* were isolated from samples. Rainfall in April and May was much greater than the 5-year average, and June, July, and August were below average. Samples infected by *A. cochlioides* were received beginning in early June through July, with a majority of the samples received in early June (Fig. 1B). The number of samples infected by *A. cochlioides* were likely associated with the periods of excessive rainfall received early in 2022 (Fig. 3B). Samples infected by *R. solani* were received later in June through August with most samples being received in August (Fig. 1B.) The beginning of June was slightly cooler than average, but temperatures returned to average or slightly above average for the rest of June, July, and August. Despite frequent rainfall events early in the growing season, samples infected by *R. solani* were not received until temperatures increased near or above 65°F (Fig. 4). *Fusarium* spp. were recovered from samples beginning in late June through September (Fig. 1B). Additionally, leaf samples were evaluated mainly in August, of which, *Alternaria* and *Stemphylium* were recovered from 20.0% and 6.7% of samples, respectively.

In 2023, samples were received from 50 sugarbeet fields (326 individual roots and 47 leaves), and diagnostic results are summarized in Figure 2A. Of those fields, 34.0% had *R. solani*, 16.0% *Fusarium* spp., 14.0% possible chemical injury, 30.0% possible environmental causes, and 4.0% had no recovery of pathogens and/or other causes. No Aphanomyces samples were received, possibly due to low rainfall received in April and May (compared to the 5-year average), creating conditions unfavorable for the development of *A. cochlioides*. Samples infected by *R. solani* were received beginning in early June through September, peaking in early July (Fig. 2B). Compared to the 5-year average, temperatures in May and June were warmer, which likely contributed to the number of samples infected by *R. solani*, despite lower-than-average rainfall. *Fusarium* spp. were recovered from samples beginning in late June through September, also peaking in early July (Fig. 2B). The drought conditions in the later part of 2022 and 2023 resulted in several samples with severe nutrient deficiencies due to the immobilization of nutrients. Additionally, the dry conditions experienced in 2022 likely contributed to the limited breakdown of soil-residual herbicides applied prior to sugarbeet production in 2023.

R. solani continues to be the most prevalent pathogen in field samples from Minnesota and North Dakota. In recent years, *Fusarium*-infected samples have been increasing. Between the years of 2014 through 2018, only 9 field samples had been confirmed to be infected by pathogenic *Fusarium* spp., whereas, from 2019 through 2023, there were 35 *Fusarium*-infected samples. As fields and areas with a history of pathogens are documented, cultural practices, varietal selection, and the use of effective fungicides, when possible, should continue to be used to reduce losses, levels of pathogen inoculum, and the spread of pathogens into clean fields. An integrated approach should take advantage of multiple control methods to reduce the incidence and severity of disease in the field. However, control methods for *Fusarium* spp. are limited to the use of sugarbeet varieties with partial resistance and cultural practices that limit the spread of infested soils. Currently, no effective fungicides are available to growers to control *Fusarium* spp.

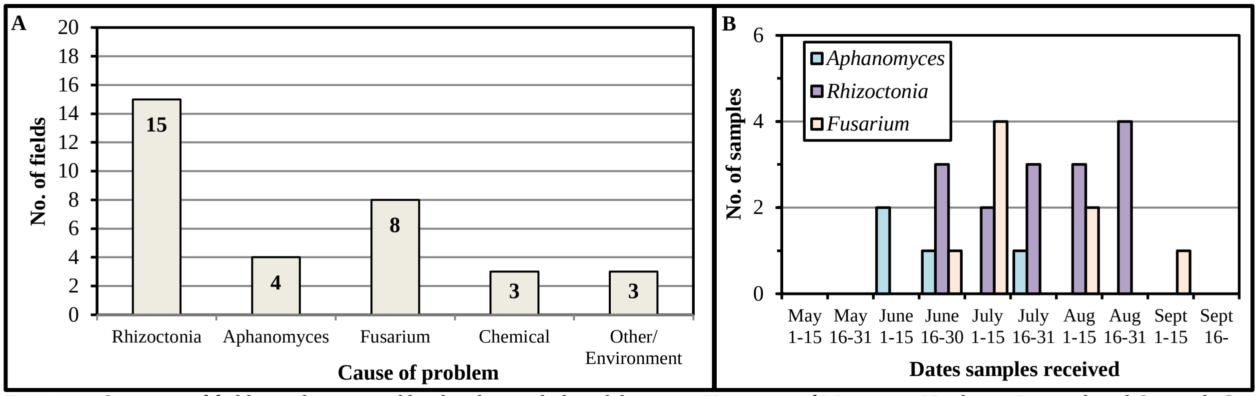

Fig. 1. Summary of field samples received by the plant pathology laboratory, University of Minnesota, Northwest Research and Outreach Center, Crookston in 2022. Results are reported by **A.**) diagnoses and **B.**) dates samples were received for *Rhizoctonia*, *Aphanomyces*, and *Fusarium*, the three most common root pathogens.

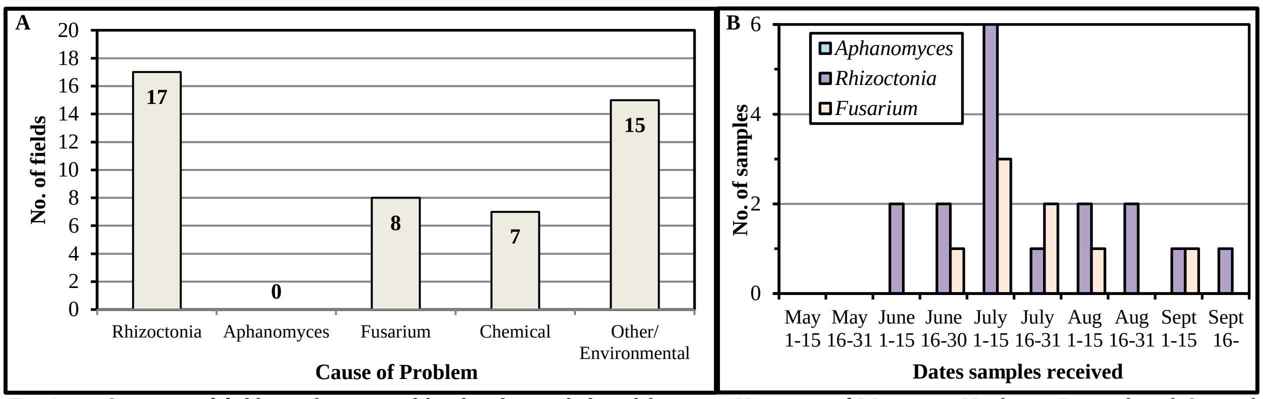

Fig. 2. Summary of field samples received by the plant pathology laboratory, University of Minnesota, Northwest Research and Outreach Center, Crookston in 2023. Results are reported by **A.**) diagnoses and **B.**) dates samples were received for *Rhizoctonia*, *Aphanomyces*, and *Fusarium*, the three most common root pathogens.

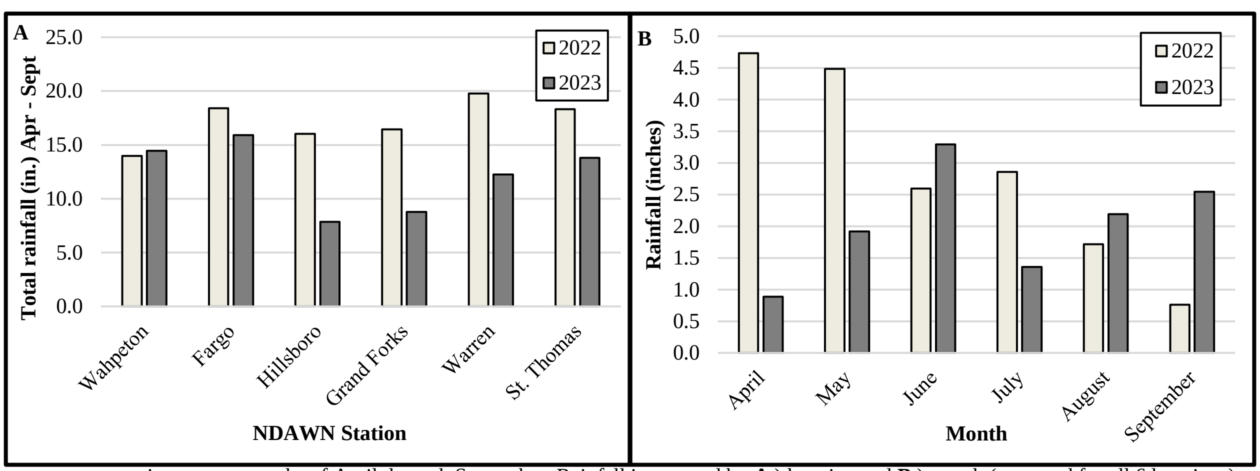

Fig. 3. Total rainfall recorded by the North Dakota Agricultural Weather Network (NDAWN) at six locations in the Red River Valley (Wahpeton, Fargo, Hillsboro, Grand Forks, Warren, MN and St. Thomas). Rainfall is reported in inches for the 2022 and 2023 growing season months of April through September. Rainfall is reported by **A.**) location and **B.**) month (averaged for all 6 locations).

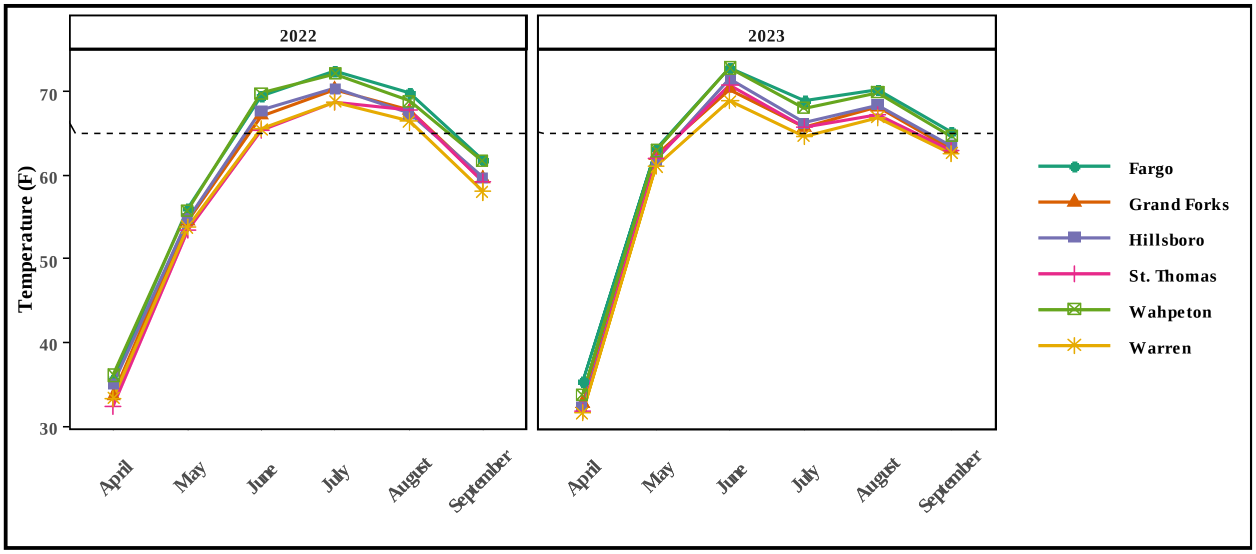

Fig. 4. Average monthly air temperatures recorded by the North Dakota Agricultural Weather Network (NDAWN) at six locations in the Red River Valley (Wahpeton, Fargo, Hillsboro, Grand Forks, Warren, MN and St. Thomas). Temperature is reported in Fahrenheit for the 2022 and 2023 growing season months of April through September. The dotted line represents 65°F.

ACKNOWLEDGEMENTS

We thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for funding this diagnostic service; agricultural staff of American Crystal Sugar Company, Minn-Dak Farmers Cooperative, Southern Minnesota Beet Sugar Cooperative, and crop consultants for submitting samples; student workers James Deleon, Zarah Pagiri, and Stephanie Melby for technical assistance.

SUGARBEET VARIETIES/QUALITY TESTING

NOTES

RESULTS OF AMERICAN CRYSTAL SUGAR COMPANY'S 2023 CODED OFFICIAL VARIETY TRIALS

Jason Brantner, Official Trial Manager and Alec Deschene, Beet Seed Analyst

American Crystal Sugar Company, Moorhead, Minnesota

American Crystal Sugar Company's 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 averages 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 2023 American Crystal Sugar Company (ACSC) OVTs and describes the procedures and cultural practices utilized in the trials.

Table	Information in the table
1	ACSC approved varieties for 2024
2	Multi-year performance of approved varieties (all locations combined)
3	Performance of approved varieties under Aphanomyces disease pressure (2020 data only)
4	2017-2019 Conventional variety combined trials
5	Multi-year disease ratings for approved varieties against multiple diseases
6	Multi-year root aphid ratings
7	Official trial sites, cooperators, planting and harvest dates, soil types, and disease notes
8	Seed treatments applied to seed used in the OVTs
9-20	2023 Combined and individual yield trial site results
21-24	Variety approval tables for ACSC market
25	Aphanomyces disease nursery ratings
26	Cercospora disease nursery ratings
27	Rhizoctonia disease nursery ratings
28	Fusarium disease nursery ratings
29	Herbicides and fungicides applied to official trials

Procedures and cultural practices

All official trials utilize seed identified by code numbers which prevents ACSC personnel from knowing variety names when conducting trials. All entries were assigned code numbers by KayJay Ag Services. The seed then was sent to ACSC Technical Services Center at Moorhead for official testing.

Sugarbeet official variety yield trials and disease nurseries were conducted across the ACSC growing region of the Red River Valley with additional disease nurseries conducted by third party cooperators. The 2023 official coded variety performance trials included 13 yield trials and 10 disease nurseries planted at a total of 18 sites by ACSC personnel. Seven additional disease/insect nurseries were planted by third party cooperators.

Results from the Official Variety Trial sites were excellent overall. Planting dates were around ten days later than typical but stands in the trials were good at most locations. Eleven sites were used for variety approval calculations. The Averill, MN site was abandoned due to very poor stand establishment from soil crusting. Results from Humboldt were not used in approval numbers due to harvest loss. Rhizoctonia crown and root rot was minimal in 2023. Revenue calculations in 2023 are based on a hypothetical $50.09 payment (5-year rolling average) assuming 17.5% sugar and 1.5% SLM, not considering hauling or production costs.

Aphanomyces root rot ratings are from the naturally infested nursery at Shakopee, MN (KWS). The Red River Valley sites were too dry to develop Aphanomyces disease pressure. As a result, there are no yield results under Aphanomyces conditions for 2023. Cercospora leafspot ratings are from inoculated nurseries at Foxhome and Randolph (KWS), MN and Saginaw, MI (BSDF) as well as a non-inoculated nursery at East Grand Forks, MN. Cercospora ratings from all four sites were highly correlated, but ratings from Randolph were not included in approval numbers as hail damage put an end to the plot in late July before severity of disease could increase. Rhizoctonia crown and root rot ratings are from inoculated nurseries at Crookston, MN and Saginaw, MI (BSDF). Fusarium ratings are from naturally infested sites at Moorhead and Sabin, MN. Root aphid ratings are from a greenhouse assay at Shakopee, MN (KWS). The Longmont, CO (Magno) root aphid nursery had high rainfall and soil moisture resulting in little to no root aphid pressure.

2023 harvest conditions were challenging at some locations, but roots dug well at most locations. Soil moisture levels were dry throughout most of the growing season and at the beginning of harvest, but widespread rainfall in late September made conditions more difficult at later harvested sites. Wet, heavy soil conditions at Humboldt would not allow the lifter to dig deep enough to get smaller roots present at that site leading to harvest loss.

The 2023 data have been combined with previous years' data for several tables. Bolter data is presented as the number of bolters observed at a location for each variety. Results from 2023 for the yield trials from individual sites are included in this report and available on the internet at www.crystalsugar.com/agronomy/crystal-beet-seed/official-coded-trials/.

Conventional trials were not planted in the 2023 OVT trials. Conventional varieties tested in 2017-2019 that were approved for 2020-2023 sales are permitted to continue in 2024 sales.

Yield trials were planted to stand at 4.5 inches. Starter fertilizer (10-34-0, 3 GPA) and AZteroid fungicide (5.7 fl oz/A) were applied in-furrow (6 GPA total volume) in all yield trials. Counter 20G (8.9 lb/A) was applied in a band after planting at all yield trial sites. Plots were planted perpendicular to the cooperators' normal farming operations, where possible. Plot row lengths for all official trials were maintained at 46 feet with about 40 feet harvested (25 feet harvested at Climax due to removal of gaps from a planter malfunction). 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 an Aphanomyces seed treatment, insecticide and a Rhizoctonia seed treatment fungicide. Emergence counts were taken on 24 feet of each plot. Multiple seedlings were counted as a single plant if they emerged less than one inch apart. The stands in all yield trials were refined by removing doubles (multiple seedlings less than 1.5 inch apart) by hand but were not further reduced.

Roundup Powermax 3 with Class Act (surfactant) and full rates of fungicides were applied by ACSC technical staff using a pickup sprayer driven down the alleys. Two applications of Roundup (25 and 21 oz/A, respectively) were made at the 2-4 and 6-10 leaf stages in 10 GPA using 50-60 psi. A third application of Roundup (20 oz/A) was made at Reynolds, ND and Foxhome, MN at row closure. Hand weeding was used where necessary. In addition to AZteroid at planting (see above), all yield trials were treated with Quadris in a band during the 6-10 leaf stage (10 oz/A) for Rhizoctonia control. Treatments used for Cercospora control in 2023 included Inspire XT/Manzate Max, Agri Tin/T-Methyl, Proline/Manzate Max, Manzate Max, and Priaxor/Agri Tin. Cercospora fungicides were applied in 20 GPA using 75-80 psi.

Roundup Ready (RR) entries with commercial seed available were planted in four-row plots with six replicates. The RR experimental entries were planted in two-row plots with four replicates.

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 custom six- row harvester with increased cleaning capacity. All harvested beets of each plot were used for yield determination while one sample (approximately 20 lbs) was obtained from each plot for sugar and impurity analysis. Quality analysis was performed at the ACSC Technical Services Quality Lab in Moorhead, MN.

Varieties were planted in nurseries in Minnesota, Michigan, and Colorado to evaluate varieties for disease and insect susceptibility. ACSC adjusts the Aphanomyces, Cercospora, Rhizoctonia, and Fusarium nursery data each year to provide a consistent target for variety approval criteria.

Acknowledgements

Thanks to the sugarbeet seed companies for their participation in the official variety testing program and to the grower-cooperators. Thanks are extended to the dedicated Technical Services staff (Jon Hickel, Earl Hodson, Nick Weller, Gary Hamann, Luke Mitchell, and Barry McRaith) for official trial planting, plot care, data collection, and harvest. Thanks to Nick Moritz and the Quality Lab at the Technical Services Center for quality sample analysis. Thanks to Dr. Mohamed Khan and Peter Hakk for Cercospora inoculation at Foxhome, MN, Maureen Aubol and the Northwest Research and Outreach Center for hosting a Rhizoctonia nursery, Randy Nelson for RRV disease ratings, USDA staff in Michigan for Cercospora and Rhizoctonia nursery data, Magno Seed staff for running Aphanomyces and root aphid nurseries, KWS staff for Aphanomyces and Cercospora nursery data, and KayJay Ag Services for sampling and coding all variety entries.

Table 1. Varieties Meeting ACSC Approval Criteria for the 2024 Sugarbeet Crop

Roundup Ready ®	Full Market	Aph Spec	Rhc Spec	High Rzm
BTS 8018	Yes	Yes		Hi Rzm
BTS 8034	Yes	Yes		Hi Rzm
BTS 8156	Yes	Yes		Hi Rzm
BTS 8205	New	New	New	Hi Rzm
BTS 8226	New	New	New	Hi Rzm
BTS 8242	New			Hi Rzm
BTS 8270	New	New		Hi Rzm
BTS 8927	Yes	Yes		Hi Rzm
Crystal 022	Yes	Yes	Yes	Hi Rzm
Crystal 130	Yes	Yes		Hi Rzm
Crystal 137	Yes	Yes		Hi Rzm
Crystal 138	Yes	Yes	Yes	Hi Rzm
Crystal 260	New	New	New	Hi Rzm
Crystal 262	New	New	New	Hi Rzm
Crystal 269	New	New		Hi Rzm
Crystal 793	Yes	Yes		Hi Rzm
Crystal 912	Yes	Yes	Yes	Hi Rzm
Crystal 913	Yes	Yes		Hi Rzm
Hilleshög HIL2317	Yes	Yes+		Hi Rzm
Hilleshög HIL2366	Yes			Rzm
Hilleshög HIL2368	Yes		Yes	Hi Rzm
Hilleshög HIL2386	Yes		New	Hi Rzm
Hilleshög HIL2389	Yes	Yes		Hi Rzm
Hilleshög HIL2441	No	New	New	Hi Rzm
Hilleshög HIL2442	New		New	Hi Rzm
Hilleshög HIL2487 (MA942)	New	New		Hi Rzm
Hilleshög HIL9920	Yes	Yes+		Hi Rzm
Maribo MA717	Yes			Hi Rzm
Maribo MA902	Yes		Yes	Hi Rzm
Maribo MA943	New			Hi Rzm
SV 203	Yes	Yes+		Hi Rzm
SV 265	Yes			Hi Rzm
SV 285	Yes	Yes+		Hi Rzm
SX 1815	Yes			Hi Rzm
SX 1818	Yes			Hi Rzm
SX 1898	Yes	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

Created 11/03/2023

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

Roundup Ready ® is a registered trademark of Bayer Group.
Roundup Ready ® sugarbeets are subject to the ACSC RRSB Bolter Destruction Policy
++ 2nd Year of not meeting Specialty Approval of previously approved Specialty variety. According to Approval Policy, may be sold as Specialty in 2024
+ 1st Year of not meeting Specialty Approval of previously approved Specialty variety. According to Approval Policy, may be sold as Specialty in 2024

Table 2. Performance Data of RR Varieties During 2022 & 2023 Growing Seasons (All Locations Combined) Approved for Sale to ACSC Growers in 2024 +++

Variety	Yrs Com	Rev/Ton ++ 23	Rev/Ton ++ 2 Yr	Rev/Ton ++ 2Y%	Rev/Acre ++ 23	Rev/Acre ++ 2 Yr	Rev/Acre ++ 2Y%	Rec/Ton 23	Rec/Ton 2 Yr	Rec/Acre 23	Rec/Acre 2 Yr	Yield 23	Yield 2 Yr	Sugar 23	Sugar 2 Yr	Molasses 23	Molasses 2 Yr	Emergence + 23	Emergence + 2 Yr	Bolters ^ 23	Bolters ^ 2 Yr	Cerc. * 23	Cerc. * 2 Yr	Aphan. * 23	Aphan. * 2 Yr	Rhizoc. * 23	Rhizoc. * 2 Yr	Fusarium * 23	Fusarium * 2 Yr	Rzm *
Number of locations →		11	20		11	20		11	20	11	20	11	20	11	20	11	20	11	20	11	20	3	6	1	4	2	5	2	4	
Previous Approved																														
BTS 8018	2	58.94	54.16	101	1960	1704	107	348	339	11617	10637	33.4	31.5	18.43	17.99	1.01	1.06	78	77	0	0	2.4	2.2	3.9	4.0	4.1	4.0	3.2	3.1	Hi
BTS 8034	2	55.87	50.61	94	1896	1629	102	339	327	11505	10487	34.1	32.0	18.02	17.52	1.10	1.19	81	79	0	0	2.5	2.4	3.8	3.8	4.1	4.3	2.7	2.4	Hi
BTS 8156	1	58.84	53.96	100	1890	1650	104	348	338	11205	10308	32.3	30.5	18.44	18.01	1.04	1.12	76	79	0	0	2.5	2.5	4.0	4.1	3.9	4.1	2.8	2.6	Hi
BTS 8927	3	60.55	56.51	105	1948	1700	107	354	346	11392	10396	32.3	30.1	18.65	18.31	0.97	1.00	82	80	2	1	4.4	4.4	3.3	3.6	4.0	4.1	3.1	3.1	Hi
Crystal 022	2	61.98	57.27	107	1975	1712	108	358	349	11433	10405	32.0	29.8	18.88	18.46	0.97	1.03	79	76	0	1	5.0	4.8	3.7	3.8	3.8	4.0	3.4	3.3	Hi
Crystal 130	1	60.48	55.48	103	2009	1722	108	353	343	11772	10620	33.4	31.0	18.64	18.18	0.98	1.04	79	77	1	1	2.6	2.4	4.0	3.8	3.7	3.9	3.5	3.4	Hi
Crystal 137	1	59.31	53.76	100	1922	1656	104	350	337	11339	10360	32.5	30.6	18.52	17.99	1.04	1.13	80	77	1	1	2.6	2.6	4.2	4.2	4.0	4.1	2.8	2.6	Hi
Crystal 138	NC	59.25	54.91	102	1983	1727	108	349	341	11687	10688	33.4	31.3	18.51	18.11	1.03	1.06	74	74	0	0	4.8	4.8	4.1	4.0	3.8	3.8	3.8	3.5	Hi
Crystal 793	5	59.26	54.62	102	1981	1729	109	349	340	11693	10733	33.5	31.5	18.48	18.05	1.01	1.05	80	78	0	0	4.2	4.2	4.3	4.1	4.3	4.5	3.4	3.2	Hi
Crystal 912	2	56.40	50.50	94	2025	1729	109	340	326	12240	11144	36.0	34.1	18.03	17.43	1.02	1.11	82	79	1	1	5.0	4.9	3.4	3.4	3.5	3.4	3.8	3.7	Hi
Crystal 913	3	59.42	54.48	101	2042	1750	110	350	340	12043	10873	34.5	32.0	18.49	18.04	1.00	1.07	82	78	0	0	3.9	3.8	4.0	3.9	4.2	4.2	3.4	3.3	Hi
Hilleshög HIL2317	3	58.66	53.75	100	1862	1617	102	348	337	11050	10118	31.9	30.0	18.38	17.89	1.01	1.04	69	72	2	1	4.8	5.0	5.2	4.6	4.4	4.6	5.8	5.7	Hi
Hilleshög HIL2366	2	54.24	50.42	94	1751	1551	97	333	326	10784	10024	32.4	30.7	17.67	17.38	1.00	1.06	79	78	0	0	5.0	5.0	4.7	4.5	4.0	4.0	5.1	4.9	Hi
Hilleshög HIL2368	1	59.17	54.36	101	1737	1445	91	349	339	10270	8983	29.5	26.6	18.47	18.03	1.01	1.07	69	62	0	0	4.4	4.5	5.0	4.8	3.5	3.5	4.3	4.3	Hi
Hilleshög HIL2386	1	57.18	52.35	97	1836	1630	102	343	333	11036	10359	32.3	31.2	18.18	17.72	1.04	1.08	80	78	0	1	4.2	4.4	4.2	4.3	3.9	3.7	4.0	3.9	Hi
Hilleshög HIL2389	1	59.20	54.03	101	1948	1677	105	349	338	11520	10475	33.1	31.0	18.46	17.97	0.99	1.06	80	78	0	0	4.5	4.6	5.4	4.6	4.5	4.2	5.5	4.9	Hi
Hilleshög HIL9920	5	58.62	53.39	99	1878	1631	102	347	336	11132	10237	32.1	30.5	18.40	17.87	1.04	1.08	76	77	0	0	5.1	5.0	5.5	4.9	4.4	4.5	6.0	5.8	Hi
Maribo MA717	5	57.26	51.83	96	1871	1634	103	343	331	11241	10423	32.9	31.5	18.14	17.61	0.99	1.07	79	77	0	0	5.0	5.0	4.6	4.5	4.1	4.0	4.5	4.7	Hi
Maribo MA902	3	56.06	51.61	96	1730	1520	95	339	330	10491	9723	31.0	29.5	17.96	17.57	1.01	1.06	79	81	1	1	4.7	4.8	5.8	5.2	3.9	3.7	4.4	4.3	Hi
SV 203	2	59.64	53.53	100	1972	1634	103	351	336	11599	10217	33.1	30.3	18.52	17.90	0.99	1.09	80	72	0	0	4.8	4.8	7.1	5.7	4.3	4.2	5.2	5.4	Hi
SV 265	6	57.15	51.70	96	1859	1590	100	343	330	11161	10138	32.6	30.7	18.12	17.57	0.99	1.05	82	79	1	1	4.7	4.6	7.5	5.9	3.9	3.9	5.9	6.0	Hi
SV 285	3	58.25	52.92	98	1909	1593	100	346	334	11357	10015	32.9	29.9	18.33	17.82	1.02	1.10	82	74	0	0	4.8	4.8	7.4	5.9	4.3	4.4	5.8	5.6	Hi
SX 1815	1	59.71	54.53	101	1996	1699	107	351	340	11742	10554	33.5	31.0	18.52	18.03	0.98	1.04	81	79	0	0	4.7	4.9	6.2	5.2	4.4	4.2	5.6	5.5	Hi
SX 1818	1	57.89	52.56	98	1958	1659	104	345	333	11698	10490	34.0	31.5	18.26	17.74	1.01	1.08	78	74	0	0	4.5	4.6	7.1	6.0	4.1	4.1	4.6	4.6	Hi
SX 1898	3	58.17	52.56	98	1927	1612	101	346	333	11474	10174	33.2	30.5	18.32	17.76	1.02	1.10	81	73	0	0	4.9	4.8	6.7	5.5	4.1	4.1	5.5	5.4	Hi
Newly Approved																														
BTS 8205	NC	59.77	54.06	101	1981	1703	107	351	338	11640	10623	33.2	31.4	18.61	18.02	1.06	1.12	77	77	0	1	4.7	4.5	3.7	3.7	3.8	3.8	3.1	3.0	Hi
BTS 8226	NC	61.07	57.38	107	1945	1733	109	355	349	11318	10520	31.9	30.1	18.70	18.44	0.93	0.98	74	75	0	0	2.3	2.2	3.7	3.8	3.8	3.8	3.9	3.7	Hi
BTS 8242	NC	61.38	57.15	106	1940	1690	106	356	348	11269	10295	31.7	29.6	18.83	18.47	1.02	1.06	77	77	0	0	4.5	4.4	4.2	4.4	4.1	4.0	4.0	3.7	Hi
BTS 8270	NC	60.15	55.52	103	1966	1719	108	352	343	11519	10601	32.8	30.9	18.65	18.23	1.03	1.08	79	76	0	0	2.4	2.2	3.9	3.9	3.7	4.0	3.5	3.3	Hi
Crystal 260	NC	58.82	54.90	102	1962	1725	108	348	341	11630	10693	33.5	31.4	18.41	18.09	1.00	1.05	78	78	0	0	2.1	2.1	3.8	3.9	3.5	3.6	3.4	3.2	Hi
Crystal 262	NC	58.10	53.26	99	1932	1697	107	346	335	11510	10680	33.3	31.8	18.28	17.82	0.99	1.05	76	75	0	0	4.4	4.4	4.6	4.0	3.3	3.3	3.8	3.5	Hi
Crystal 269	NC	61.98	56.47	105	1932	1699	107	358	346	11185	10417	31.3	30.2	19.01	18.44	1.11	1.14	69	69	0	0	4.4	4.5	3.6	3.6	3.9	4.1	4.1	3.7	Hi
Hilleshög HIL2441**	NC	58.61	53.76	100	1797	1554	98	347	337	10668	9752	30.8	29.0	18.48	17.99	1.11	1.13	75	74	1	1	3.8	3.9	4.2	4.0	3.9	3.8	4.1	4.1	Hi
Hilleshög HIL2442	NC	59.05	54.69	102	1761	1536	97	349	340	10433	9570	30.0	28.2	18.58	18.17	1.15	1.16	71	70	0	0	4.1	4.2	4.7	4.8	3.9	3.8	4.4	4.6	Hi
Hilleshög HIL2487 (MA942)	NC	58.44	53.94	100	1794	1552	97	347	338	10641	9692	30.7	28.7	18.35	17.94	1.00	1.05	77	76	0	0	4.7	4.7	4.1	4.1	4.3	4.2	4.7	4.9	Hi
Maribo MA943	NC	59.63	54.17	101	1810	1572	99	351	338	10650	9812	30.4	29.0	18.61	18.04	1.08	1.11	65	67	0	0	4.4	4.4	4.8	4.5	4.2	4.1	4.5	4.4	Hi
Benchmark var. mean		59.23	53.73		1860	1592		349	337	10997	9971	31.6	29.6	18.54	17.99	1.07	1.14	75	74											

+++ 2023 Sites include Casselton, Perley, Halstad, Reynolds, Climax, Grand Forks, Scandia, East Grand Forks, Stephen, St. Thomas, and Bathgate

Created 10/30/2023

+++ 2022 Sites include Casselton, Averill, Ada, Grand Forks, Scandia, Alvarado, St. Thomas, Hallock, Bathgate

++ 2023 Revenue estimate based on a $50.09 beet payment (5-yr ave) at 17.5% crop with a 1.5% loss to molasses and 2022 Revenue estimate based on a $46.80 beet payment. Revenue does not consider hauling or production costs.

+ Emergence is % of planted seeds producing a 4 leaf beet.

^ Number of bolters observed across locations.

** Does not meet Full Market Approval. Meets Aphanomyces and/or Rhizoctonia Specialty Approval .

* 2023 Aphanomyces ratings from Shakopee MN (res.<4.2, susc>4.8). Cercospora ratings from Saginaw MI, Foxhome MN, and East Grand Forks, MN (res.<4.4, susc>5.0). Fusarium ratings from Moorhead MN and Sabin MN (res.<3.0, susc>5.0). Rhizoctonia ratings from Crookston MN and Saginaw MI (res.<3.8, susc>5). Hi may perform better under severe Rhizomania.

* 2022 Aphanomyces ratings from Shakopee MN, Glyndon MN, and Perley MN (res.<4.2, susc>4.8). Cercospora ratings from Randolph MN, Foxhome MN, and Saginaw MI (res.<4.4, susc>5.0). Fusarium ratings from Moorhead MN and Sabin MN (res.<3.0, susc>5.0). Rhizoctonia ratings from Crookston MN, Moorhead MN, and Saginaw MI (res.<3.8, susc>5).

Table 3. Performance Data of RR 2023 Approved Varieties Under Aphanomyces Conditions (Relative to Susceptible Check) +++

Variety	Yrs Com	Aph Spc +	Rev/Ton++ 2023^	Rev/Ton++ 2022^	Rev/Ton++ 2020	Rev/Ton++ %Mn	Rev/Acre++ 2023^	Rev/Acre++ 2022^	Rev/Acre++ 2020	Rev/Acre++ %Mn	Rec/Ton 2023^	Rec/Ton 2022^	Rec/Ton 2020	Rec/Acre 2023^	Rec/Acre 2022^	Rec/Acre 2020	Sugar 2023^	Sugar 2022^	Sugar 2020	Yield 2023^	Yield 2022^	Yield 2020	Cerc. * 23	Cerc. * 2Yr	Aphan. * 23	Aphan. * 2 Yr	Rhizoc. * 23	Rhizoc. * 2Yr	Fusarium * 23	Fusarium * 2Yr
Number of locations →			0	0	3		0	0	3		0	0	3	0	0	3	0	0	3	0	0	3	3	6	1	4	2	5	2	3
Previous Approved																														
BTS 8018	2	Yes	--	--	40.59	107	--	--	982	119	--	--	303.9	--	--	7256	--	--	16.22	--	--	23.62	2.42	2.23	3.95	3.97	4.06	4.00	3.20	3.09
BTS 8034	2	Yes	--	--	35.57	94	--	--	887	108	--	--	286.7	--	--	7046	--	--	15.53	--	--	24.32	2.54	2.41	3.80	3.84	4.09	4.29	2.72	2.44
BTS 8156	1	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.53	2.48	3.97	4.09	3.93	4.08	2.80	2.55
BTS 8927	3	Yes	--	--	43.12	114	--	--	985	120	--	--	312.6	--	--	7070	--	--	16.58	--	--	22.44	4.38	4.40	3.26	3.63	3.98	4.06	3.08	3.10
Crystal 022	2	Yes	--	--	44.07	116	--	--	1047	127	--	--	315.8	--	--	7422	--	--	16.80	--	--	23.24	4.97	4.79	3.66	3.84	3.85	3.98	3.43	3.32
Crystal 130	1	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.60	2.35	4.00	3.78	3.69	3.88	3.55	3.38
Crystal 137	1	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.65	2.61	4.21	4.23	4.01	4.09	2.78	2.57
Crystal 138	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.77	4.82	4.06	3.97	3.81	3.81	3.76	3.46
Crystal 793	5	Yes	--	--	37.97	100	--	--	886	108	--	--	294.9	--	--	6732	--	--	15.80	--	--	22.43	4.20	4.15	4.31	4.07	4.35	4.54	3.40	3.22
Crystal 912	2	Yes	--	--	35.21	93	--	--	886	108	--	--	285.5	--	--	7041	--	--	15.44	--	--	24.35	5.00	4.91	3.41	3.43	3.50	3.39	3.82	3.74
Crystal 913	3	Yes	--	--	39.55	104	--	--	951	116	--	--	300.2	--	--	7129	--	--	16.06	--	--	23.53	3.91	3.82	4.05	3.92	4.19	4.21	3.37	3.25
Hilleshög HIL2317	3	No	--	--	36.66	97	--	--	741	90	--	--	290.5	--	--	5836	--	--	15.50	--	--	20.04	4.84	4.99	5.22	4.56	4.44	4.57	5.83	5.74
Hilleshög HIL2366	2	No	--	--	37.57	99	--	--	729	89	--	--	293.5	--	--	5656	--	--	15.66	--	--	19.18	5.02	5.01	4.68	4.50	3.99	3.95	5.07	4.95
Hilleshög HIL2368	1	No	--	--	40.99	108	--	--	693	84	--	--	305.2	--	--	5136	--	--	16.25	--	--	16.78	4.41	4.48	5.02	4.83	3.55	3.51	4.26	4.29
Hilleshög HIL2386	1	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.23	4.39	4.21	4.26	3.91	3.71	3.99	3.86
Hilleshög HIL2389	1	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.51	4.60	5.42	4.60	4.45	4.19	5.50	4.92
Hilleshög HIL9920	5	No	--	--	35.57	94	--	--	706	86	--	--	286.5	--	--	5606	--	--	15.37	--	--	19.33	5.15	5.04	5.49	4.91	4.42	4.50	6.03	5.84
Maribo MA717	5	No	--	--	34.86	92	--	--	731	89	--	--	284.0	--	--	5834	--	--	15.24	--	--	20.22	5.04	5.05	4.61	4.50	4.10	4.01	4.53	4.70
Maribo MA902	3	No	--	--	37.28	98	--	--	652	79	--	--	292.5	--	--	5126	--	--	15.61	--	--	17.57	4.66	4.80	5.77	5.18	3.87	3.72	4.37	4.33
SV 203	2	No	--	--	37.75	100	--	--	829	101	--	--	294.1	--	--	6380	--	--	15.78	--	--	21.48	4.78	4.76	7.15	5.70	4.25	4.22	5.20	5.38
SV 265	6	No	--	--	37.96	100	--	--	839	102	--	--	294.9	--	--	6388	--	--	15.77	--	--	21.30	4.65	4.56	7.47	5.89	3.86	3.91	5.92	6.00
SV 285	3	No	--	--	38.37	101	--	--	822	100	--	--	296.3	--	--	6301	--	--	15.89	--	--	21.15	4.83	4.78	7.39	5.87	4.28	4.40	5.82	5.65
SX 1815	1	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.74	4.91	6.15	5.22	4.35	4.24	5.60	5.46
SX 1818	1	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.53	4.63	7.09	5.95	4.06	4.11	4.59	4.56
SX 1898	3	No	--	--	37.53	99	--	--	855	104	--	--	293.4	--	--	6643	--	--	15.74	--	--	22.57	4.88	4.80	6.70	5.47	4.15	4.13	5.47	5.42
Newly Approved																														
BTS 8205	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.69	4.48	3.67	3.68	3.77	3.80	3.10	2.97
BTS 8226	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.33	2.17	3.72	3.76	3.78	3.76	3.85	3.66
BTS 8242	NC	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.48	4.41	4.25	4.36	4.07	4.04	3.95	3.69
BTS 8270	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.43	2.20	3.90	3.88	3.67	4.00	3.46	3.26
Crystal 260	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.15	2.10	3.84	3.86	3.46	3.58	3.38	3.22
Crystal 262	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.36	4.39	4.61	4.01	3.31	3.35	3.83	3.55
Crystal 269	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.38	4.49	3.62	3.55	3.90	4.05	4.11	3.74
Hilleshög HIL2441**	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.85	3.93	4.18	4.05	3.89	3.75	4.11	4.05
Hilleshög HIL2442	NC	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.10	4.24	4.73	4.78	3.90	3.80	4.43	4.55
Hilleshög HIL2487 (MA942)	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.74	4.65	4.06	4.13	4.29	4.24	4.72	4.86
Maribo MA943	NC	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.44	4.36	4.80	4.50	4.18	4.11	4.55	4.36
AP SUS RR#5 (2020)					30.80	81			590	72			269.8			4984			14.75			18.00								
Mean of Aph Specialty Varieties					39.44	104			946	115			299.9			7100			16.06			23.42								
Trial mean (includes AP SUS RR#5)					37.86	100			823	100			294.5			6310			15.78			21.20								

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

++ 2023 Revenue estimate based on a $50.09 beet payment (5-yr ave) at 17.5% crop with a 1.5% loss to molasses, 2022 Revenue estimate based on a $46.80 beet payment and 2020 Revenue estimate based on $45.12 beet payment. Revenue does not consider hauling or production costs.

+ Yes indicates varieties that have met the current Aphanomyces Specialty requirement for 2023 with a 2yr rating ≤ 4.2 or previously met Aphanomyces Specialty requirement maintaining a 3 year rating ≤ 4.5

^ Lack of uniform Aphanomyces pressure at any of the OVT sites prevented collection of Aphanomyces Yield Data for 2023 and 2022

%Mn=Percent of 2020 trial mean (including susceptable check AP SUS RR#5)

** Does not meet Full Market Approval. Meets Aphanomyces and/or Rhizoctonia Specialty Approval.

* 2023 Aphanomyces ratings from Shakopee MN (res.<4.2, susc>4.8). Cercospora ratings from Saginaw MI, Foxhome MN, and East Grand Forks, MN (res.<4.4, susc>5.0). Fusarium ratings from Moorhead MN and Sabin MN (res.<3.0, susc>5.0).
Rhizoctonia ratings from Crookston MN and Saginaw MI (res.<3.8, susc>5). Hi may perform better under severe Rhizomania.

* 2022 Aphanomyces ratings from Shakopee MN, Glyndon MN, and Perley MN (res.<4.2, susc>4.8). Cercospora ratings from Randolph MN, Foxhome MN, and Saginaw MI (res.<4.4, susc>5.0). Fusarium ratings from Moorhead MN and Sabin MN (res.<3.0, susc>5.0).
Rhizoctonia ratings from Crookston MN, Moorhead MN, and Saginaw MI (res.<3.8, susc>5).

Table 4. Performance Data of Conventional Varieties During 2017, 2018, 2019 Growing Seasons (All Locations Combined) +++

Variety	Yrs	Rev/Ton ++					Rev/Acre ++					Rec/Ton		Rec/Acre		Sugar		Yield		Molasses		Emergence +		Bolters ^		Cerc. *		Aphan. *		Rhizoc. *		Fusarium *		Rzm *
	Com	19	2 Yr	2Y%	3Yr	3Y%	19	2 Yr	2Y%	3Yr	3Yr%	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	
Number of locations →		3	8		14		3	8		14		3	8	3	8	3	8	3	8	3	8	3	8	3	8	3	6	2	3	3	6	2	4	
Crystal 620	NC	41.74	47.24	97	49.48	99	1394	1631	118	1656	104	311	326	10403	11312	16.59	17.38	33.7	34.9	1.07	1.06	54	67	0	0	3.95	4.13	4.7	4.2	5.1	4.6	2.5	3.0	Hi
Crystal R761	10	38.62	43.53	89	46.06	92	1375	1582	115	1618	101	299	313	10742	11457	16.18	16.86	36.0	36.7	1.21	1.19	61	72	0	0	4.98	4.85	4.4	4.3	4.9	4.6	3.0	3.6	Hi
Crystal 840	NC	39.30	45.48	93	30.32	60	1288	1585	115	NA	--	302	320	9916	11173	16.23	17.10	33.1	35.1	1.15	1.10	52	65	0	0	4.18	4.25	4.0	3.9	4.7	4.4	2.7	3.1	Hi
Hilleshög HM3035Rz	13	43.77	49.17	101	50.89	101	1294	1379	100	1405	88	318	333	9439	9422	16.91	17.65	29.9	28.5	1.02	1.00	72	71	0	0	4.42	4.32	5.1	5.2	4.4	4.2	4.1	4.3	Rzm
Seedex 8869 Cnv	NC	40.88	45.47	93	48.33	96	1374	1617	117	1658	104	307	320	10388	11418	16.40	17.00	33.9	35.8	1.02	1.00	64	74	0	1	4.52	4.59	4.8	4.8	5.1	4.9	3.5	3.7	Hi
SV 48777	NC	45.18	50.25	103	52.63	105	1452	1634	118	1656	104	323	337	10342	10954	17.08	17.78	31.8	32.5	0.94	0.93	63	73	0	0	4.10	4.33	4.9	5.0	5.0	4.7	4.3	4.4	Hi
Crystal 950	NC	41.21	--	--	--	--	1430	--	--	--	--	309	--	10719	--	16.49	--	34.7	--	1.06	--	62	--	0	--	4.72	--	4.8	--	4.8	--	2.9	--	Hi
Benchmark var. mean		44.35	48.87		50.20		1427	1381		1595		320	332	10330	10887	17.07	17.68	32.4	33.0	1.08	1.09	66	75											

+++ 2019 Sites include Grand Forks, Scandia, and Bathgate

Created 11/06/2023

+++ 2018 Sites include Casselton, Ada, Grand Forks, Scandia, and St. Thomas

+++ 2017 Sites incllude Casselton, Hendrum, Grand Forks, Scandia, St. Thomas, and Humboldt

++ 2019 Revenue estimate is based on a $44.38 beet payment (5-yr ave) at 17.5% sugar and 1.5% loss to molasses. 2018 Revenue estimate is based on a $46.40 beet payment and 2017 Revenue estimate is based on a $48.49 beet payment.

+ Emergence is % of planted seeds producing a 4 leaf beet.

^ Number of bolters observed across locations.

* 2019 Aphanomyces ratings from Shakopee MN (res<4.4, susc>5.0). Cercospora ratings from Randolph MN, Foxhome MN & Saginaw MI (res<4.5, susc>5.0). Fusarium ratings from Moorhead MN (res<3.0, susc>5.0). Rhizoctonia from Moorhead MN, Crookston MN, and Saginaw MI (res<3.8, susc>5). Hi may perform better under severe Rzm.

* 2018 Aphanomyces ratings from Shakopee MN and Georgetown MN (res<4.4, susc>5.0). Cercospora ratings from Randolph MN, Foxhome MN & Saginaw MI (res<4.5, susc>5.0). Fusarium ratings from Moorhead MN (res<3.0, susc>5.0). Rhizoctonia from Moorhead MN and Saginaw MI (res<3.8, susc>5).

Table 5. ACSC Official Trial Disease Nurseries 2021-2023 (Varieties tested in 2023) Cercospora, Aphanomyces, Rhizoctonia & Fusarium

		< 4.5 Cercospora > 5.0					< 4.2 Aphanomyces > 4.8					< 3.82 Rhizoctonia > 5.0					< 3.0 Fusarium > 5.0					High Rzm
		23	22	21	2 Yr	3 Yr	23	22	21	2 Yr	3 Yr	23	22	21	2 Yr	3 Yr	23	22	21	2 Yr	3 Yr	
Code	Description	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	
	Previously Approved																					
550	BTS 8018	2.42	2.03	2.31	2.23	2.25	3.95	4.00	4.52	3.97	4.16	4.06	3.93	3.83	4.00	3.94	3.20	2.98	3.22	3.09	3.13	Hi Rzm
558	BTS 8034	2.54	2.28	2.56	2.41	2.46	3.80	3.89	3.24	3.84	3.64	4.09	4.49	3.88	4.29	4.15	2.72	2.16	2.71	2.44	2.53	Hi Rzm
538	BTS 8156	2.53	2.43	2.48	2.48	2.48	3.97	4.21	3.64	4.09	3.94	3.93	4.24	3.81	4.08	3.99	2.80	2.30	2.72	2.55	2.61	Hi Rzm
528	BTS 8927	4.38	4.42	4.48	4.40	4.43	3.26	4.00	4.51	3.63	3.93	3.98	4.13	3.68	4.06	3.93	3.08	3.11	4.00	3.10	3.40	Hi Rzm
521	Crystal 022	4.97	4.60	4.97	4.79	4.85	3.66	4.03	4.79	3.84	4.16	3.85	4.10	3.53	3.98	3.83	3.43	3.22	3.50	3.32	3.38	Hi Rzm
510	Crystal 130	2.60	2.10	2.38	2.35	2.36	4.00	3.57	4.23	3.78	3.93	3.69	4.08	3.57	3.88	3.78	3.55	3.22	3.22	3.38	3.33	Hi Rzm
552	Crystal 137	2.65	2.57	2.53	2.61	2.58	4.21	4.25	3.13	4.23	3.86	4.01	4.18	3.53	4.09	3.91	2.78	2.35	2.25	2.57	2.46	Hi Rzm
502	Crystal 138	4.77	4.87	4.74	4.82	4.79	4.06	3.87	4.19	3.97	4.04	3.81	3.81	3.52	3.81	3.71	3.76	3.16	3.75	3.46	3.55	Hi Rzm
509	Crystal 793	4.20	4.10	4.13	4.15	4.15	4.31	3.82	3.74	4.07	3.96	4.35	4.73	4.36	4.54	4.48	3.40	3.03	2.80	3.22	3.08	Hi Rzm
547	Crystal 912	5.00	4.81	5.13	4.91	4.98	3.41	3.44	3.95	3.43	3.60	3.50	3.28	3.77	3.39	3.52	3.82	3.66	4.11	3.74	3.86	Hi Rzm
549	Crystal 913	3.91	3.73	4.10	3.82	3.92	4.05	3.79	4.39	3.92	4.08	4.19	4.23	3.94	4.21	4.12	3.37	3.13	3.68	3.25	3.39	Hi Rzm
553	Hilleshög HIL2317	4.84	5.13	4.57	4.99	4.85	5.22	3.91	5.01	4.56	4.71	4.44	4.71	4.76	4.57	4.64	5.83	5.65	6.06	5.74	5.85	Hi Rzm
520	Hilleshög HIL2366	5.02	5.00	5.01	5.01	5.01	4.68	4.32	5.81	4.50	4.94	3.99	3.92	3.98	3.95	3.96	5.07	4.83	4.65	4.95	4.85	Hi Rzm
511	Hilleshög HIL2368	4.41	4.56	4.66	4.48	4.54	5.02	4.63	5.25	4.83	4.97	3.55	3.46	2.92	3.51	3.31	4.26	4.33	4.44	4.29	4.34	Hi Rzm
542	Hilleshög HIL2386	4.23	4.54	4.30	4.39	4.36	4.21	4.31	5.98	4.26	4.83	3.91	3.51	4.20	3.71	3.87	3.99	3.73	4.26	3.86	3.99	Hi Rzm
522	Hilleshög HIL2389	4.51	4.69	4.85	4.60	4.68	5.42	3.78	3.86	4.60	4.35	4.45	3.92	3.99	4.19	4.12	5.50	4.34	4.75	4.92	4.86	Hi Rzm
507	Hilleshög HIL9920	5.15	4.92	4.75	5.04	4.94	5.49	4.33	4.65	4.91	4.82	4.42	4.58	4.70	4.50	4.57	6.03	5.66	5.45	5.84	5.71	Hi Rzm
504	Maribo MA717	5.04	5.05	4.68	5.05	4.92	4.61	4.39	6.75	4.50	5.25	4.10	3.92	4.31	4.01	4.11	4.53	4.87	5.11	4.70	4.84	Hi Rzm
539	Maribo MA902	4.66	4.95	4.63	4.80	4.75	5.77	4.59	6.96	5.18	5.77	3.87	3.57	3.80	3.72	3.75	4.37	4.30	4.50	4.33	4.39	Hi Rzm
543	SV 203	4.78	4.74	4.75	4.76	4.76	7.15	4.24	4.35	5.70	5.25	4.25	4.19	4.34	4.22	4.26	5.20	5.55	5.99	5.38	5.58	Hi Rzm
503	SV 265	4.65	4.46	4.30	4.56	4.47	7.47	4.30	4.95	5.89	5.58	3.86	3.96	4.17	3.91	4.00	5.92	6.08	5.65	6.00	5.89	Hi Rzm
515	SV 285	4.83	4.72	4.78	4.78	4.78	7.39	4.35	4.48	5.87	5.41	4.28	4.53	4.26	4.40	4.36	5.82	5.47	6.26	5.65	5.85	Hi Rzm
554	SX 1815	4.74	5.07	4.78	4.91	4.86	6.15	4.28	4.19	5.22	4.88	4.35	4.12	4.40	4.24	4.29	5.60	5.32	4.82	5.46	5.25	Hi Rzm
530	SX 1818	4.53	4.72	4.86	4.63	4.71	7.09	4.82	5.56	5.95	5.82	4.06	4.16	4.41	4.11	4.21	4.59	4.54	5.26	4.56	4.80	Hi Rzm
537	SX 1898	4.88	4.72	4.76	4.80	4.79	6.70	4.25	4.97	5.47	5.31	4.15	4.12	4.34	4.13	4.20	5.47	5.38	5.67	5.42	5.51	Hi Rzm
Newly Approved																						
540	BTS 8205	4.69	4.27	--	4.48	--	3.67	3.69	--	3.68	--	3.77	3.82	--	3.80	--	3.10	2.85	--	2.97	--	Hi Rzm
527	BTS 8226	2.33	2.00	--	2.17	--	3.72	3.79	--	3.76	--	3.78	3.74	--	3.76	--	3.85	3.47	--	3.66	--	Hi Rzm
561	BTS 8242	4.48	4.35	--	4.41	--	4.25	4.47	--	4.36	--	4.07	4.00	--	4.04	--	3.95	3.42	--	3.69	--	Hi Rzm
533	BTS 8270	2.43	1.97	--	2.20	--	3.90	3.87	--	3.88	--	3.67	4.33	--	4.00	--	3.46	3.06	--	3.26	--	Hi Rzm
529	Crystal 260	2.15	2.05	--	2.10	--	3.84	3.89	--	3.86	--	3.46	3.70	--	3.58	--	3.38	3.06	--	3.22	--	Hi Rzm
555	Crystal 262	4.36	4.43	--	4.39	--	4.61	3.42	--	4.01	--	3.31	3.38	--	3.35	--	3.83	3.27	--	3.55	--	Hi Rzm
557	Crystal 269	4.38	4.60	--	4.49	--	3.62	3.48	--	3.55	--	3.90	4.20	--	4.05	--	4.11	3.36	--	3.74	--	Hi Rzm
541	Hilleshög HIL2441**	3.85	4.01	--	3.93	--	4.18	3.91	--	4.05	--	3.89	3.62	--	3.75	--	4.11	4.00	--	4.05	--	Hi Rzm
526	Hilleshög HIL2442	4.10	4.39	--	4.24	--	4.73	4.83	--	4.78	--	3.90	3.70	--	3.80	--	4.43	4.68	--	4.55	--	Hi Rzm
536	Hilleshög HIL2487 (MA942)	4.74	4.57	--	4.65	--	4.06	4.20	--	4.13	--	4.29	4.18	--	4.24	--	4.72	5.01	--	4.86	--	Hi Rzm
562	Maribo MA943	4.44	4.28	--	4.36	--	4.80	4.21	--	4.50	--	4.18	4.04	--	4.11	--	4.55	4.18	--	4.36	--	Hi Rzm

** Does not meet full market approval. Meets Aphanomyces and/or Rhizoctonia Specialty approval.

Green font ratings indicate specialty or good resistance.

Red font ratings indicate level of concern for some fields.

-- indicates data not available

Created 11/02/2023

Table 6. Root Aphid Ratings for RR Varieties During 2021-2023 Growing Seasons (All Locations Combined)

Approved for Sale to ACSC Growers in 2024

Shakopee, MN X (1=Exc - 4=Poor)									**Longmont, CO** Y (% Infested Plants)		
Code	**Variety**										
713	BTS 8018	1.00	1.00	1.16	1.08	1.05	67.94	--	--	--	--
703	BTS 8034	1.32	1.00	1.28	1.14	1.20	68.72	--	--	--	--
725	BTS 8156	--	1.00	1.20	1.10	--	--	--	--	--	--
720	BTS 8205	--	--	1.12	--	--	--	--	--	--	--
731	BTS 8217	--	--	1.04	--	--	--	--	--	--	--
718	BTS 8226	--	--	1.00	--	--	--	--	--	--	--
726	BTS 8242	--	--	1.20	--	--	--	--	--	--	--
712	BTS 8270	--	--	1.08	--	--	--	--	--	--	--
728	BTS 8927	1.16	1.04	1.12	1.08	1.11	76.97	--	--	--	--
722	Crystal 022	1.00	1.00	1.04	1.02	1.01	68.23	--	--	--	--
724	Crystal 130	--	1.13	1.00	1.06	--	--	--	--	--	--
733	Crystal 137	--	1.12	1.00	1.06	--	--	--	--	--	--
734	Crystal 138	--	1.00	1.04	1.02	--	--	--	--	--	--
710	Crystal 260	--	--	1.12	--	--	--	--	--	--	--
737	Crystal 262	--	--	1.04	--	--	--	--	--	--	--
723	Crystal 269	--	--	1.04	--	--	--	--	--	--	--
721	Crystal 793	1.08	1.04	1.08	1.06	1.07	84.86	--	--	--	--
727	Crystal 912	1.24	1.00	1.04	1.02	1.09	64.72	--	--	--	--
736	Crystal 913	1.12	1.04	1.24	1.14	1.13	62.18	--	--	--	--
704	Hilleshög HIL2317	3.41	3.48	3.32	3.40	3.40	76.15	--	--	--	--
715	Hilleshög HIL2366	3.72	3.36	3.48	3.42	3.52	73.41	--	--	--	--
714	Hilleshög HIL2368	3.54	3.44	3.32	3.38	3.43	73.23	--	--	--	--
709	Hilleshög HIL2386	--	3.32	3.44	3.38	--	--	--	--	--	--
717	Hilleshög HIL2389	--	2.00	2.04	2.02	--	--	--	--	--	--
730	Hilleshög HIL2441	--	--	2.24	--	--	--	--	--	--	--
729	Hilleshög HIL2442	--	--	3.16	--	--	--	--	--	--	--
706	Hilleshög HIL2487 (MAR942)	--	--	3.24	--	--	--	--	--	--	--
701	Hilleshög HIL9920	3.58	3.48	3.24	3.36	3.43	74.56	--	--	--	--
702	Maribo MA717	3.68	3.56	3.40	3.48	3.55	68.33	--	--	--	--
735	Maribo MA902	3.75	3.36	3.32	3.34	3.48	73.70	--	--	--	--
708	Maribo MA943	--	--	2.96	--	--	--	--	--	--	--
732	SV 203	2.32	2.00	2.20	2.10	2.17	70.81	--	--	--	--
705	SV 265	3.65	3.36	3.16	3.26	3.39	70.81	--	--	--	--
711	SV 285	2.28	2.24	1.80	2.02	2.11	66.81	--	--	--	--
719	SX 1815	--	2.40	2.36	2.38	--	--	--	--	--	--
716	SX 1818	--	2.00	2.08	2.04	--	--	--	--	--	--
707	SX 1898	2.21	2.32	2.20	2.26	2.24	54.21	--	--	--	--
738	Root Aphid Res CK#3	1.36	1.00	1.08	1.04	1.15	70.65	--	--	--	--
739	Root Aphid Susc CK#4	3.48	3.48	3.52	3.50	3.49	71.31	--	--	--	--
740	Root Aphid Susc CK#6	--	3.48	3.20	3.34	--	--	--	--	--	--

Created 1/25/2024

X Greenhouse assay based on a 1-4 rating scale (1 = no aphids, 4 = very susceptible), Shakopee, MN, KWS
Y Field trial based on incidence (% infested plants), Longmont, CO, Magno Seed, LLC
* No data available due to low emergence
** No data available due to wet conditions and low root aphid levels

Table 7. Planting & Harvest Dates, Previous Crop and Disease Levels for 2023 ACSC Official Trial Sites +

Yield Trials 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	5/5	9/12	Wheat	Medium/Light	N	L	N	N	N	N	Planting errors, some gappy stands from crusting
Averill MN	Mhd/Hlb	Tang Farms	5/18	Abandon	Wheat	Medium/Light	N	N	N	N	N	N	Abandoned due to very poor stand
West of Perley MN (ND)	Mhd/Hlb	TD Hoff Partnership	5/22	9/8 & 9/11	Soybean	Heavy	L	M-V	N	N	N	N	Some cutworm and Rhizoctonia damage
Halstad MN	Mhd/Hlb	Peter Steen	5/15	10/12	Wheat	Medium	N	N	L	N	N	L-M	Excellent overall
Reynolds ND	Mhd/Hlb	Hong Farms	5/13	9/13	Wheat	Medium/Light	N	N	N	N	N	L	Some gappy stands
Climax MN	EGF/Crk	Knutson Farms	5/4	9/14	Wheat	Medium/Light	N	L	N	N	N	N	Planter gaps near ends of plots removed prior to harvest
Grand Forks ND	EGF/Crk	Drees Farming Association	5/12	9/18	Wheat	Medium/Light	N	N	N	N	L	N	Moisture stress across trial area
Scandia MN	EGF/Crk	Deboer Farms	5/14	10/9	Wheat	Medium	N	N	N	N	N	N	Hail damage even across trial area
East Grand Forks MN	EGF/Crk	Mark Holy	5/15	9/15	Fallow	Medium	N	N	N	N	N	N	On fallow ground, some light late Cercospora
Stephen MN	Dtn	Jensen Farms	5/11	10/3	Wheat	Medium/Heavy	N	N	N	N	N	N	
St Thomas ND	Dtn	Baldwin Farms	5/16	9/27	Wheat	Medium/Light	N	N	N	N	L	N	~7 inches of rainfall June 24-25
Humboldt MN	Dtn	Prosser/Kuznia Beets	5/10	9/30	Wheat	Heavy	N	L	N	N	N	N	Abandoned due to harvest loss
Bathgate ND	Dtn	Shady Bend Farm	5/16	9/29	Wheat	Medium	N	N	N	N	N	N	

Disease Trials 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	5/23	Multiple	Wheat	Medium/Heavy	N	N	N	M-V	N	N	Moderate Fusarium
Sabin Fus-S MN	Fus Nurs	Krabbenhoft & Sons Farm	5/17	Multiple	Wheat	Medium/Light	N	N	N	V	L	N	Heavy Fusarium pressure
Mhd Rhc-E MN	Rhc Nurs	Jon Hickel	5/23	Abandon	Soybean	Heavy	N	L	N	L-M	N	N	Abandoned due to lack of Rhizoctonia severity
Mhd Rhc-W MN	Rhc Nurs	Jon Hickel	5/23	Abandon	Soybean	Heavy	N	L	N	L-M	N	N	Abandoned due to interference from Fusarium
NWROC MN	Rhc Nurs	Maureen Aubol	5/17	8/7	Soybean	Medium/Heavy	N	M	N	N	N	N	Nice range of Rhizoctonia symptoms
Saginaw MI	Rhc Nurs	Linda Hanson	5/10	8/29-9/1	--	--	N	V	N	N	N	N	Severe Rhizoctonia pressure
Shakopee MN	Aphanomyces	Patrick O'Boyle	5/10	8/29	--	--	M-V	L	N	N	N	N	Nice range of moderate Aphanomyces symptoms
Glyndon MN	Aphanomyces	Ryan Brady	5/23	Abandon	--	Light	N-L	L	N	M	N	N	Lack of soil moisture to develop Aphanomyces
West of Perley MN (ND)	Aphanomyces	TD Hoff Partnership	5/22	Abandon	Soybean	Heavy	L	M-V	N	N	N	N	Lack of soil moisture to develop Aphanomyces
Climax MN	Aphanomyces	Knutson Farms	5/17	Abandon	Wheat	Medium/Light	N	N	N	N	N	N	Lack of soil moisture to develop Aphanomyces
Longmont CO	Root Aphids	Ryan Brady	--	Abandon	--	--	--	--	--	--	--	--	Lack of root aphid pressure from excess soil moisture
Foxhome MN	Cercospora	NDSU/Kevin Etzler	5/18	Multiple	Wheat	Medium	N	N	N	N	N	N	Moderate to severe Cercospora pressure
Saginaw MI	Cercospora	Linda Hanson	4/27	Multiple	--	--	N	N	N	N	N	N	Very nice Cercospora pressure
Randolph MN	Cercospora	Patrick O'Boyle	5/3	Multiple	--	--	N	N	N	N	N	N	Five ratings through July 20 and hail damage in late July; not used for approval numbers
Averill MN	Cercospora	Tang Farms	5/18	Abandon	Wheat	Medium/Light	N	N	N	N	N	N	Abandoned due to very poor stand
East Grand Forks MN	Cercospora	Mark Holy	5/15	Multiple	Fallow	Medium	N	N	N	N	N	N	Non-inoculated trial, used for approval numbers

+ 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)

Created 10/27/2023

Table 8. Seed Treatments Used on Varieties in Official Variety Trials in 2023

Description	Years in Trial	Years Comm.	Fungicide Seed Treatment (Damping-off)	Fungicide Seed Treatment (Rhizoctonia)	Fungicide Seed Treatment (Aphanomyces)	Insecticide (Springtails & Maggots)	Priming (Emergence)
ACSC Commercial							
BTS 8018	4	2	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8034	4	2	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8156	3	1	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8927	5	3	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
Crystal 022	4	2	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 130	3	1	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 137	3	1	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 793	7	5	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 912	5	2	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 913	5	3	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Hilleshög HIL2317	5	3	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2366	4	2	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2368	4	1	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2386	3	1	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2389	3	1	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL9920	7	5	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Maribo MA717	7	5	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Maribo MA902	5	3	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
SV 203	4	2	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
SV 265	8	6	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
SV 285	6	3	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
SX 1815	3	1	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
SX 1818	3	1	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
SX 1898	5	3	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
BTS 8337 (Check)	11	9	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 578RR (Check)	9	6	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
BTS 8815 (Check)	6	4	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 803 (Check)	6	3	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
BTS 8927 (Check)	5	3	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Xbeet ®
AP CK MOD SUS RR#5	8	6	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
AP CK MOD SUS RR#6	9	7	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
RA CK SUS RR#7	9	6	Apron XL Maxim	Vibrance	Tach 45	--	Xbeet ®
ACSC Experimental							
BTS 8205	2	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8217	2	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8226	2	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8242	2	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8270	2	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8303	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8311	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8328	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8341	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8349	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8359	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8365	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
Crystal 138	3	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 260	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 262	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 269	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 360	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 361	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 363	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 364	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 367	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 368	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 369	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Crystal 371	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
Hilleshög HIL2441	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2442	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2477	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2478	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2479	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2480	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Hilleshög HIL2487 (MA942)	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Maribo MA943	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Maribo MA945	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
Maribo MA946	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	Xbeet ®
SV 231	1	NC	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
SV 232	1	NC	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
SX 1835	1	NC	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
SX 1836	1	NC	Apron XL Maxim	Zeltera	Int Sol	NipsIt	Xbeet ®
BTS 8337 (Check)	11	9	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 578RR (Check)	9	6	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
BTS 8815 (Check)	6	4	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 803 (Check)	6	3	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
BTS 8927 (Check)	5	3	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Xbeet ®
AP CK MOD SUS RR#5	8	6	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
AP CK MOD SUS RR#6	9	7	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
RA CK SUS RR#7	9	6	Apron XL Maxim	Vibrance	Tach 45	--	Xbeet ®
AP CK MOD RES RR#7	5	2	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®
AP CK MOD SUS RR#8	4	2	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Xbeet ®

Created 11/01/2023

Table 9. 2023 Performance of Varieties - ACSC RR Official Trials 11 sites

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T + %Bnch	Rev/A + $	Rev/A + %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	348.4	100	11617	106	58.94	100	1960	105	33.43	18.43	1.01	17.42	124	1485	342	0	77.8
BTS 8034	101	338.6	97	11505	105	55.87	94	1896	102	34.05	18.02	1.10	16.92	161	1652	353	0	81.1
BTS 8156	114	348.1	100	11205	102	58.84	99	1890	102	32.29	18.44	1.04	17.40	134	1610	332	0	76.1
BTS 8927	109	353.5	101	11392	104	60.55	102	1948	105	32.31	18.65	0.97	17.68	125	1423	329	2	81.8
Crystal 022	121	358.1	103	11433	104	61.98	105	1975	106	31.99	18.88	0.97	17.91	111	1443	329	0	78.5
Crystal 130	113	353.3	101	11772	107	60.48	102	2009	108	33.44	18.64	0.98	17.66	120	1486	319	1	79.5
Crystal 137	122	349.6	100	11339	103	59.31	100	1922	103	32.48	18.52	1.04	17.48	129	1621	328	1	80.3
Crystal 793	118	349.4	100	11693	106	59.26	100	1981	106	33.49	18.48	1.01	17.47	126	1502	336	0	80.2
Crystal 912	116	340.3	97	12240	111	56.40	95	2025	109	36.04	18.03	1.02	17.01	144	1429	356	1	81.6
Crystal 913	106	349.9	100	12043	110	59.42	100	2042	110	34.46	18.49	1.00	17.49	129	1477	334	0	81.6
Hilleshög HIL2317	120	347.5	99	11050	100	58.66	99	1862	100	31.88	18.38	1.01	17.37	150	1568	309	2	69.1
Hilleshög HIL2366	111	333.3	95	10784	98	54.24	92	1751	94	32.44	17.67	1.00	16.67	156	1459	334	0	79.5
Hilleshög HIL2368	119	349.1	100	10270	93	59.17	100	1737	93	29.50	18.47	1.01	17.46	138	1474	344	0	69.5
Hilleshög HIL2386	112	342.7	98	11036	100	57.18	97	1836	99	32.30	18.18	1.04	17.14	138	1511	355	0	79.5
Hilleshög HIL2389	105	349.2	100	11520	105	59.20	100	1948	105	33.08	18.46	0.99	17.47	122	1532	320	0	80.2
Hilleshög HIL9920	115	347.4	99	11132	101	58.62	99	1878	101	32.07	18.40	1.04	17.36	149	1602	323	0	76.3
Maribo MA717	110	343.0	98	11241	102	57.26	97	1871	101	32.88	18.14	0.99	17.15	139	1506	319	0	78.9
Maribo MA902	124	339.1	97	10491	95	56.06	95	1730	93	31.02	17.96	1.01	16.95	157	1473	333	1	79.1
SV 203	123	350.6	100	11599	105	59.64	101	1972	106	33.11	18.52	0.99	17.53	118	1526	320	0	80.4
SV 265	107	342.7	98	11161	101	57.15	96	1859	100	32.63	18.12	0.99	17.13	129	1530	315	1	81.9
SV 285	108	346.2	99	11357	103	58.25	98	1909	103	32.86	18.33	1.02	17.31	129	1583	325	0	82.1
SX 1815	104	350.9	100	11742	107	59.71	101	1996	107	33.51	18.52	0.98	17.54	112	1520	316	0	80.8
SX 1818	103	345.0	99	11698	106	57.89	98	1958	105	34.01	18.26	1.01	17.25	116	1575	324	0	77.8
SX 1898	102	345.9	99	11474	104	58.17	98	1927	104	33.21	18.32	1.02	17.30	128	1566	332	0	80.6
BTS 8337 (CommBench)	125	358.3	103	10624	97	62.04	105	1837	99	29.70	19.00	1.08	17.92	135	1630	356	0	76.2
Crystal 578RR (CommBench)	126	342.4	98	11075	101	57.06	96	1838	99	32.49	18.20	1.08	17.12	149	1620	351	0	78.3
BTS 8815 (CommBench)	127	343.9	98	10378	94	57.55	97	1733	93	30.25	18.29	1.10	17.19	153	1689	346	0	64.9
Crystal 803 (CommBench)	128	352.6	101	11912	108	60.25	102	2033	109	33.83	18.67	1.03	17.64	122	1529	352	4	81.9
BTS 8927 (1stYearBench)	129	358.1	103	11258	102	61.97	105	1948	105	31.43	18.88	0.97	17.91	120	1430	330	0	77.8
AP CK MOD SUS RR#5	130	343.0	98	11140	101	57.27	97	1857	100	32.54	18.23	1.08	17.15	147	1606	355	1	74.1
AP CK MOD SUS RR#6	131	355.2	102	11250	102	61.06	103	1931	104	31.73	18.77	1.01	17.76	114	1497	343	0	81.8
RA CK SUS RR#7	132	339.5	97	10286	94	56.16	95	1694	91	30.46	17.98	1.01	16.97	159	1494	327	0	78.4
Experimental Trial (Comm status)																		
BTS 8205	205	351.1	101	11640	106	59.77	101	1981	106	33.18	18.61	1.06	17.55	113	1537	362	0	77.1
BTS 8217	233	347.7	100	11418	104	58.72	99	1924	103	32.93	18.41	1.01	17.39	125	1581	312	0	74.4
BTS 8226	208	355.3	102	11318	103	61.07	103	1945	105	31.88	18.70	0.93	17.77	113	1392	305	0	74.3
BTS 8242	211	356.3	102	11269	102	61.38	104	1940	104	31.70	18.83	1.02	17.81	112	1485	345	0	76.7
BTS 8270	232	352.3	101	11519	105	60.15	102	1966	106	32.75	18.65	1.03	17.62	116	1528	343	0	78.8
BTS 8303	218	355.3	102	10942	99	61.06	103	1879	101	30.81	18.80	1.04	17.76	126	1603	327	0	72.4
BTS 8311	213	364.3	104	10652	97	63.90	108	1866	100	29.30	19.17	0.95	18.22	107	1452	305	0	72.1
BTS 8328	224	356.1	102	11389	104	61.32	104	1961	105	32.04	18.86	1.05	17.81	123	1576	345	0	73.2
BTS 8341	215	348.2	100	8299	75	58.87	99	1407	76	23.74	18.54	1.13	17.41	132	1581	394	0	71.0
BTS 8349	223	336.4	96	11159	101	55.22	93	1827	98	33.29	17.89	1.06	16.82	161	1604	331	0	78.4
BTS 8359	219	350.9	100	11524	105	59.72	101	1957	105	32.93	18.59	1.04	17.55	119	1549	347	0	72.3
BTS 8365	206	362.2	104	11342	103	63.25	107	1980	106	31.34	19.07	0.95	18.12	109	1442	305	0	76.2
Crystal 138	238	349.4	100	11687	106	59.25	100	1983	107	33.42	18.51	1.03	17.47	122	1497	347	0	74.4
Crystal 260	230	348.0	100	11630	106	58.82	99	1962	105	33.50	18.41	1.00	17.40	121	1511	322	0	77.9
Crystal 262	227	345.7	99	11510	105	58.10	98	1932	104	33.32	18.28	0.99	17.28	134	1423	332	0	76.3
Crystal 269	229	358.1	103	11185	102	61.98	105	1932	104	31.32	19.01	1.11	17.91	130	1614	367	0	69.3
Crystal 360	203	351.2	101	11555	105	59.82	101	1963	106	33.02	18.57	1.01	17.56	113	1517	333	0	78.0
Crystal 361	201	357.9	102	11644	106	61.91	105	2012	108	32.60	18.87	0.97	17.90	120	1415	326	0	75.5
Crystal 363	222	358.1	103	11072	101	61.96	105	1918	103	30.90	18.93	1.02	17.91	114	1543	333	0	72.7
Crystal 364	214	342.5	98	12032	109	57.10	96	2000	108	35.25	18.21	1.09	17.12	161	1633	336	0	78.7
Crystal 367	220	342.2	98	11168	102	57.01	96	1860	100	32.68	18.18	1.06	17.11	134	1652	330	0	78.9
Crystal 368	217	350.4	100	11209	102	59.54	101	1906	102	32.00	18.62	1.12	17.51	124	1585	383	0	71.9
Crystal 369	231	354.6	102	11582	105	60.87	103	1984	107	32.76	18.83	1.10	17.74	140	1607	362	0	78.1
Crystal 371	226	360.6	103	10815	98	62.75	106	1883	101	29.93	19.01	0.97	18.04	112	1431	324	0	72.5
Hilleshög HIL2441	234	347.3	99	10668	97	58.61	99	1797	97	30.78	18.48	1.11	17.37	135	1551	387	1	74.6
Hilleshög HIL2442	204	348.8	100	10433	95	59.05	100	1761	95	30.02	18.58	1.15	17.44	128	1550	423	0	70.9
Hilleshög HIL2477	237	333.1	95	10453	95	54.19	91	1696	91	31.46	17.87	1.21	16.66	177	1635	425	0	71.3
Hilleshög HIL2478	209	334.6	96	11182	102	54.65	92	1821	98	33.52	17.85	1.12	16.73	172	1610	360	0	73.6
Hilleshög HIL2479	210	353.0	101	10887	99	60.36	102	1861	100	30.87	18.67	1.03	17.64	142	1439	353	0	78.0
Hilleshög HIL2480	228	349.4	100	10767	98	59.24	100	1817	98	30.96	18.62	1.16	17.47	153	1557	411	0	79.9
Hilleshög HIL2487 (Maribo MA942)	225	346.8	99	10641	97	58.44	99	1794	96	30.70	18.35	1.00	17.34	120	1452	338	0	76.8
Maribo MA943	235	350.7	100	10650	97	59.63	101	1810	97	30.39	18.61	1.08	17.54	127	1530	371	0	64.6
Maribo MA945	202	339.4	97	11192	102	56.14	95	1848	99	33.03	18.02	1.04	16.97	131	1601	326	0	72.5
Maribo MA946	207	347.9	100	11055	101	58.77	99	1864	100	31.89	18.44	1.04	17.39	137	1496	350	0	75.5
SV 231	236	346.4	99	11683	106	58.32	98	1965	106	33.77	18.35	1.02	17.32	124	1568	321	0	76.7
SV 232	216	345.4	99	11223	102	58.01	98	1884	101	32.50	18.28	1.00	17.27	125	1568	307	0	72.0
SX 1835	212	347.3	99	11681	106	58.59	99	1968	106	33.71	18.45	1.09	17.36	128	1596	356	0	79.6
SX 1836	221	344.6	99	11262	102	57.75	98	1886	101	32.73	18.29	1.05	17.23	127	1583	339	0	74.3
BTS 8337 (CommBench)	239	356.0	102	10634	97	61.29	103	1828	98	29.93	18.89	1.10	17.80	134	1623	355	0	73.8
Crystal 578RR (CommBench)	240	346.1	99	11375	103	58.23	98	1907	102	32.99	18.36	1.05	17.30	145	1586	329	0	78.8
BTS 8815 (CommBench)	241	344.7	99	10184	93	57.79	98	1703	92	29.64	18.33	1.09	17.24	151	1649	339	0	61.0
Crystal 803 (CommBench)	242	350.5	100	11795	107	59.59	101	2003	108	33.71	18.58	1.05	17.53	123	1554	349	0	79.1
BTS 8927 (1stYearBench)	243	356.0	102	11017	100	61.27	103	1897	102	30.94	18.77	0.97	17.80	122	1427	319	0	77.3
AP CK MOD SUS RR#5	244	342.3	98	11144	101	57.05	96	1852	100	32.66	18.21	1.09	17.12	147	1607	352	0	71.8
AP CK MOD SUS RR#6	245	352.7	101	11228	102	60.27	102	1917	103	31.89	18.69	1.06	17.63	117	1514	367	0	80.0
RA CK SUS RR#7	246	344.5	99	10152	92	57.73	97	1700	91	29.49	18.25	1.02	17.22	143	1492	331	0	76.7
AP CK MOD RES RR#7	247	341.6	98	12165	111	56.81	96	2023	109	35.62	18.10	1.02	17.07	145	1427	348	0	73.2
AP CK MOD SUS RR#8	248	359.2	103	11369	103	62.30	105	1970	106	31.70	18.93	0.97	17.96	109	1444	320	0	77.8
Comm Benchmark Mean		349.3		10997		59.23		1860		31.57	18.54	1.07		140	1617	351		75.3
Comm Trial Mean		347.3		11272		58.61		1899		32.53	18.39	1.02		134	1533	334		78.4
Coeff. of Var. (%)		2.6		5.8		4.9		7.0		5.4	2.3	6.9		19.5	4.3	11.8		10.1
Mean LSD (0.05)		4.5		322		1.40		68		0.82	0.22	0.04		13	43	21		2.6
Mean LSD (0.01)		5.9		424		1.85		89		1.09	0.29	0.05		17	56	28		3.4
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from 11 sites

Created 10/23/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed across 11 locations.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 10. 2023 Performance of Varieties - ACSC RR Official Trials Casselton ND

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T + %Bnch	Rev/A + $	Rev/A + %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	347.8	100	8387	101	58.74	101	1415	102	24.20	18.69	1.30	17.39	153	1637	516	0	63.7
BTS 8034	101	336.6	97	8991	109	55.25	95	1475	106	26.75	18.25	1.43	16.82	209	1855	535	0	59.2
BTS 8156	114	346.5	100	9294	112	58.36	100	1568	113	26.76	18.64	1.31	17.33	161	1824	473	0	60.6
BTS 8927	109	350.8	101	8319	101	59.70	102	1415	102	23.76	18.79	1.25	17.54	182	1550	488	0	66.7
Crystal 022	121	358.1	103	8627	104	61.97	106	1494	107	24.00	19.15	1.24	17.91	141	1668	470	0	63.7
Crystal 130	113	359.3	104	8947	108	62.36	107	1553	112	24.93	19.13	1.16	17.97	144	1632	413	0	70.5
Crystal 137	122	346.3	100	8958	108	58.30	100	1512	109	25.79	18.63	1.32	17.31	169	1829	474	0	62.2
Crystal 793	118	350.8	101	8665	105	59.69	102	1473	106	24.75	18.75	1.22	17.53	161	1633	449	0	67.4
Crystal 912	116	336.7	97	9793	118	55.30	95	1607	115	29.13	18.23	1.40	16.83	202	1652	569	0	69.7
Crystal 913	106	346.5	100	8766	106	58.36	100	1476	106	25.29	18.63	1.30	17.33	178	1637	507	0	64.7
Hilleshög HIL2317	120	338.7	98	8053	97	55.92	96	1327	95	23.82	18.22	1.29	16.93	233	1748	449	0	45.4
Hilleshög HIL2366	111	334.5	97	8452	102	54.61	94	1382	99	25.21	18.09	1.37	16.72	209	1694	533	0	64.1
Hilleshög HIL2368	119	338.5	98	7477	90	55.86	96	1233	89	22.10	18.32	1.39	16.93	195	1716	551	0	47.4
Hilleshög HIL2386	112	346.6	100	9297	112	58.38	100	1567	113	26.84	18.59	1.26	17.33	179	1644	478	0	64.9
Hilleshög HIL2389	105	354.4	102	9642	117	60.82	104	1651	119	27.32	18.95	1.23	17.72	152	1750	434	0	66.3
Hilleshög HIL9920	115	343.0	99	8302	100	57.25	98	1385	99	24.18	18.56	1.41	17.15	210	1886	518	0	59.9
Maribo MA717	110	349.2	101	8793	106	59.21	101	1489	107	25.18	18.69	1.23	17.46	163	1660	454	0	68.8
Maribo MA902	124	337.9	97	7934	96	55.66	95	1306	94	23.45	18.14	1.25	16.89	200	1601	470	0	68.7
SV 203	123	345.5	100	8733	106	58.05	99	1467	105	25.26	18.60	1.32	17.28	158	1856	474	0	54.3
SV 265	107	333.8	96	7797	94	54.38	93	1271	91	23.36	18.07	1.38	16.69	201	1849	505	0	60.4
SV 285	108	338.8	98	8290	100	55.95	96	1367	98	24.51	18.34	1.40	16.94	189	1885	511	0	58.7
SX 1815	104	347.8	100	8764	106	58.77	101	1482	106	25.18	18.62	1.22	17.40	154	1760	426	0	63.1
SX 1818	103	338.6	98	8385	101	55.87	96	1385	99	24.72	18.27	1.34	16.93	161	1869	484	0	46.8
SX 1898	102	330.3	95	7992	97	53.29	91	1286	92	24.24	17.92	1.41	16.51	230	1884	506	0	62.9
BTS 8337 (CommBench)	125	356.7	103	7964	96	61.53	105	1373	99	22.36	19.14	1.30	17.84	190	1726	480	0	59.7
Crystal 578RR (CommBench)	126	340.1	98	8373	101	56.36	97	1386	100	24.66	18.35	1.34	17.01	201	1832	479	0	66.4
BTS 8815 (CommBench)	127	342.0	99	8012	97	56.95	98	1335	96	23.43	18.46	1.36	17.10	203	1903	473	0	47.7
Crystal 803 (CommBench)	128	347.6	100	8736	106	58.71	101	1476	106	25.12	18.62	1.24	17.38	170	1647	458	0	70.2
BTS 8927 (1stYearBench)	129	359.3	104	7950	96	62.35	107	1380	99	22.08	19.16	1.20	17.96	155	1561	457	0	64.1
AP CK MOD SUS RR#5	130	338.7	98	8626	104	55.93	96	1424	102	25.44	18.29	1.36	16.93	211	1803	495	0	62.0
AP CK MOD SUS RR#6	131	355.9	103	8893	108	61.30	105	1532	110	24.94	19.01	1.21	17.80	151	1652	442	0	68.3
RA CK SUS RR#7	132	346.0	100	8237	100	58.19	100	1381	99	23.90	18.53	1.23	17.30	195	1616	452	0	69.5
Experimental Trial (Comm status)																		
BTS 8205	205	339.3	98	8810	107	56.14	96	1468	105	25.73	18.27	1.36	16.91	127	1792	486	0	56.4
BTS 8217	233	343.1	99	8820	107	57.29	98	1478	106	25.50	18.42	1.29	17.13	148	1783	430	0	67.0
BTS 8226	208	347.8	100	8670	105	58.74	101	1476	106	24.53	18.53	1.18	17.34	152	1532	413	0	60.6
BTS 8242	211	347.8	100	8313	101	58.76	101	1412	101	23.76	18.65	1.30	17.36	139	1691	462	0	61.7
BTS 8270	232	346.7	100	8511	103	58.41	100	1425	102	24.60	18.64	1.33	17.31	130	1772	462	0	62.4
BTS 8303	218	346.0	100	8585	104	58.21	100	1439	103	24.65	18.57	1.29	17.28	143	1828	418	0	57.8
BTS 8311	213	359.7	104	7792	94	62.41	107	1350	97	21.60	19.12	1.16	17.96	123	1643	377	0	59.1
BTS 8328	224	344.8	99	8374	101	57.85	99	1413	101	24.12	18.54	1.31	17.23	140	1777	446	0	57.8
BTS 8341	215	342.3	99	5986	72	57.04	98	1000	72	17.32	18.57	1.48	17.09	164	1826	554	0	56.0
BTS 8349	223	329.3	95	8278	100	53.04	91	1333	96	25.21	17.85	1.41	16.43	195	1859	483	0	53.1
BTS 8359	219	347.7	100	9022	109	58.73	101	1525	110	25.90	18.63	1.24	17.39	134	1725	405	0	58.4
BTS 8365	206	354.2	102	7976	96	60.71	104	1369	98	22.49	18.89	1.19	17.70	140	1611	405	0	59.0
Crystal 138	238	333.9	96	8524	103	54.48	93	1372	99	25.64	18.11	1.45	16.67	179	1713	549	0	51.2
Crystal 260	230	347.2	100	9395	114	58.58	100	1574	113	27.17	18.62	1.30	17.32	143	1700	456	0	64.6
Crystal 262	227	339.1	98	8294	100	56.09	96	1360	98	24.56	18.17	1.24	16.93	156	1613	432	0	68.1
Crystal 269	229	337.4	97	8690	105	55.56	95	1423	102	25.87	18.29	1.44	16.85	155	1785	526	0	48.8
Crystal 360	203	355.3	102	8804	106	61.07	105	1521	109	24.65	18.92	1.23	17.70	115	1693	414	0	67.7
Crystal 361	201	344.0	99	8501	103	57.60	99	1425	102	24.61	18.42	1.23	17.19	136	1583	437	0	62.7
Crystal 363	222	340.9	98	7734	94	56.62	97	1273	91	22.73	18.35	1.33	17.02	148	1736	467	0	48.6
Crystal 364	214	334.9	97	9690	117	54.78	94	1594	114	28.77	18.06	1.33	16.73	199	1835	427	0	69.8
Crystal 367	220	338.1	98	8265	100	55.79	96	1363	98	24.50	18.19	1.30	16.89	146	1847	420	0	67.1
Crystal 368	217	343.5	99	8642	104	57.46	98	1451	104	25.03	18.45	1.29	17.16	116	1702	459	0	48.0
Crystal 369	231	349.4	101	9080	110	59.24	101	1549	111	25.77	18.69	1.28	17.42	160	1697	431	0	60.2
Crystal 371	226	354.9	102	8015	97	60.94	104	1374	99	22.53	18.96	1.25	17.71	129	1578	453	0	55.7
Hilleshög HIL2441	234	323.8	93	8115	98	51.36	88	1301	93	24.75	17.60	1.47	16.13	184	1759	548	0	52.2
Hilleshög HIL2442	204	336.6	97	8360	101	55.30	95	1379	99	24.71	18.27	1.49	16.78	169	1860	545	0	46.6
Hilleshög HIL2477	237	326.4	94	7867	95	52.19	89	1262	91	24.11	17.84	1.57	16.26	208	1906	580	0	53.8
Hilleshög HIL2478	209	320.2	92	8886	107	50.27	86	1394	100	27.69	17.46	1.50	15.96	233	1861	525	0	58.1
Hilleshög HIL2479	210	349.9	101	7841	95	59.42	102	1327	95	22.42	18.80	1.33	17.47	160	1647	489	0	70.0
Hilleshög HIL2480	228	337.0	97	7657	93	55.42	95	1265	91	22.75	18.32	1.52	16.80	185	1821	575	0	68.4
Hilleshög HIL2487 (Maribo MA942)	225	338.0	98	8551	103	55.74	95	1422	102	24.94	18.10	1.24	16.87	134	1587	442	0	56.7
Maribo MA943	235	333.3	96	7368	89	54.29	93	1199	86	21.98	18.06	1.43	16.64	175	1747	529	0	43.6
Maribo MA945	202	329.9	95	8783	106	53.22	91	1430	103	26.39	17.79	1.33	16.46	137	1839	443	0	52.1
Maribo MA946	207	344.1	99	8077	98	57.63	99	1362	98	23.24	18.50	1.31	17.19	148	1709	460	0	54.2
SV 231	236	349.0	101	9065	110	59.11	101	1542	111	25.69	18.67	1.25	17.43	137	1763	402	0	64.4
SV 232	216	341.5	99	9405	114	56.80	97	1557	112	27.54	18.36	1.32	17.04	170	1841	430	0	47.4
SX 1835	212	346.5	100	9133	110	58.35	100	1538	110	26.36	18.63	1.31	17.32	141	1795	443	0	76.3
SX 1836	221	337.6	97	9159	111	55.62	95	1523	109	26.82	18.22	1.36	16.86	150	1882	459	0	58.2
BTS 8337 (CommBench)	239	358.0	103	8267	100	61.89	106	1419	102	23.31	19.21	1.29	17.92	140	1733	445	0	59.6
Crystal 578RR (CommBench)	240	348.3	100	8625	104	58.89	101	1450	104	24.94	18.69	1.28	17.42	182	1783	408	0	71.4
BTS 8815 (CommBench)	241	334.7	97	7367	89	54.73	94	1208	87	21.91	18.12	1.40	16.72	201	1866	475	0	39.8
Crystal 803 (CommBench)	242	345.4	100	8826	107	58.04	99	1493	107	25.42	18.55	1.27	17.28	122	1772	425	0	64.9
BTS 8927 (1stYearBench)	243	353.4	102	8776	106	60.48	104	1493	107	24.77	18.84	1.18	17.66	143	1468	435	0	58.6
AP CK MOD SUS RR#5	244	328.8	95	8043	97	52.90	91	1277	92	24.49	17.88	1.45	16.43	223	1845	497	0	57.1
AP CK MOD SUS RR#6	245	343.2	99	8425	102	57.32	98	1410	101	24.42	18.48	1.32	17.16	132	1760	460	0	72.1
RA CK SUS RR#7	246	337.0	97	7151	86	55.44	95	1168	84	21.17	18.18	1.36	16.82	182	1734	482	0	66.9
AP CK MOD RES RR#7	247	329.0	95	9222	111	52.97	91	1495	107	27.80	17.68	1.25	16.43	153	1603	438	0	55.0
AP CK MOD SUS RR#8	248	354.4	102	8441	102	60.78	104	1457	105	23.75	18.88	1.19	17.69	120	1609	411	0	67.9
Comm Benchmark Mean		346.6		8271		58.39		1393		23.89	18.64	1.31		191	1777	472		61.0
Comm Trial Mean		345.1		8545		57.92		1434		24.77	18.56	1.30		182	1733	482		62.1
Coeff. of Var. (%)		2.5		7.3		4.7		8.1		7.2	2.1	7.3		17.0	4.1	11.3		17.3
Mean LSD (0.05)		7.8		543		2.44		101		1.55	0.35	0.09		28	63	49		9.0
Mean LSD (0.01)		10.3		715		3.22		133		2.04	0.45	0.11		37	83	64		11.8
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from Casselton ND

Created 10/18/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 11. 2023 Performance of Varieties - ACSC RR Official Trials West of Perley MN (ND)

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T + %Bnch	Rev/A + $	Rev/A + %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	335.2	99	7952	108	54.84	98	1296	106	23.80	18.02	1.26	16.76	182	1696	458	0	76.4
BTS 8034	101	337.6	100	8156	111	55.57	99	1342	110	24.21	18.16	1.28	16.88	194	1821	436	0	79.9
BTS 8156	114	341.7	101	8153	111	56.86	101	1355	111	23.88	18.36	1.27	17.09	202	1820	431	0	75.1
BTS 8927	109	343.9	101	8008	109	57.54	103	1339	110	23.31	18.39	1.20	17.19	175	1626	430	0	84.3
Crystal 022	121	359.0	106	8066	109	62.25	111	1400	115	22.47	19.12	1.17	17.95	135	1670	415	0	77.7
Crystal 130	113	343.9	101	8158	111	57.54	103	1363	112	23.77	18.43	1.23	17.20	163	1706	441	1	78.3
Crystal 137	122	334.4	99	7949	108	54.59	97	1297	107	23.78	17.94	1.22	16.72	181	1853	389	0	80.2
Crystal 793	118	335.3	99	8145	110	54.86	98	1328	109	24.37	17.98	1.21	16.77	162	1659	439	0	81.0
Crystal 912	116	326.9	96	9564	130	52.23	93	1527	125	29.27	17.53	1.18	16.35	205	1609	413	0	81.6
Crystal 913	106	339.1	100	8599	117	56.03	100	1418	116	25.42	18.12	1.17	16.95	155	1659	410	0	81.7
Hilleshög HIL2317	120	335.8	99	7514	102	55.01	98	1232	101	22.33	18.05	1.26	16.79	224	1833	407	1	66.5
Hilleshög HIL2366	111	325.2	96	7870	107	51.69	92	1250	103	24.24	17.40	1.14	16.26	183	1581	397	0	76.3
Hilleshög HIL2368	119	342.4	101	6815	92	57.08	102	1134	93	19.93	18.32	1.20	17.12	193	1654	418	0	64.3
Hilleshög HIL2386	112	331.1	98	7527	102	53.56	96	1214	100	22.77	17.74	1.19	16.55	180	1664	412	0	78.7
Hilleshög HIL2389	105	343.5	101	8083	110	57.43	102	1354	111	23.51	18.37	1.19	17.18	147	1779	397	0	71.6
Hilleshög HIL9920	115	333.8	98	7213	98	54.39	97	1175	96	21.58	17.90	1.22	16.68	195	1839	383	0	74.6
Maribo MA717	110	338.2	100	7972	108	55.77	99	1315	108	23.54	18.14	1.23	16.91	176	1745	428	0	74.2
Maribo MA902	124	327.1	96	6769	92	52.31	93	1079	89	20.77	17.54	1.19	16.35	228	1612	407	0	82.9
SV 203	123	344.3	101	8055	109	57.65	103	1347	111	23.45	18.47	1.26	17.21	173	1788	440	0	76.8
SV 265	107	337.8	100	7925	107	55.62	99	1307	107	23.44	18.06	1.17	16.89	154	1745	389	0	80.5
SV 285	108	335.7	99	7788	106	54.97	98	1275	105	23.21	17.97	1.19	16.78	163	1832	373	0	85.3
SX 1815	104	343.7	101	8069	109	57.48	102	1349	111	23.47	18.36	1.17	17.19	143	1749	394	0	82.6
SX 1818	103	337.6	100	8308	113	55.57	99	1368	112	24.59	18.06	1.19	16.87	145	1793	390	0	79.4
SX 1898	102	344.7	102	7820	106	57.80	103	1311	108	22.70	18.47	1.23	17.24	168	1841	407	0	82.6
BTS 8337 (CommBench)	125	347.8	103	6901	94	58.76	105	1165	96	19.83	18.62	1.23	17.39	151	1828	412	0	75.1
Crystal 578RR (CommBench)	126	337.9	100	7560	103	55.66	99	1240	102	22.49	18.16	1.27	16.89	197	1829	426	0	77.0
BTS 8815 (CommBench)	127	329.4	97	7131	97	53.01	95	1149	94	21.61	17.78	1.31	16.47	200	1932	429	0	63.3
Crystal 803 (CommBench)	128	341.8	101	7906	107	56.89	101	1317	108	23.14	18.36	1.27	17.09	160	1745	463	0	76.9
BTS 8927 (1stYearBench)	129	344.1	101	7520	102	57.59	103	1258	103	21.88	18.42	1.22	17.20	168	1657	442	0	74.4
AP CK MOD SUS RR#5	130	328.2	97	6997	95	52.63	94	1119	92	21.35	17.66	1.25	16.41	199	1762	430	0	73.6
AP CK MOD SUS RR#6	131	339.5	100	6935	94	56.15	100	1145	94	20.44	18.15	1.18	16.97	146	1736	398	0	83.0
RA CK SUS RR#7	132	335.5	99	7287	99	54.92	98	1190	98	21.78	17.99	1.22	16.77	218	1655	425	0	75.3
Experimental Trial (Comm status)																		
BTS 8205	205	348.1	103	8256	112	58.85	105	1397	115	23.72	18.69	1.29	17.41	186	1727	459	0	75.9
BTS 8217	233	338.8	100	8022	109	55.93	100	1322	109	23.75	18.19	1.24	16.95	196	1776	413	0	68.7
BTS 8226	208	347.2	102	7935	108	58.57	104	1338	110	22.87	18.50	1.15	17.35	168	1573	401	0	66.9
BTS 8242	211	356.3	105	8109	110	61.43	110	1396	115	22.80	19.03	1.21	17.82	165	1667	427	0	73.0
BTS 8270	232	344.0	101	8218	111	57.56	103	1374	113	23.94	18.44	1.23	17.21	173	1683	432	0	79.4
BTS 8303	218	344.3	101	8102	110	57.65	103	1355	111	23.62	18.56	1.33	17.24	177	1800	471	0	70.9
BTS 8311	213	364.9	108	8291	112	64.11	114	1460	120	22.68	19.32	1.07	18.25	153	1633	334	0	76.5
BTS 8328	224	352.4	104	8758	119	60.20	107	1496	123	24.85	18.90	1.30	17.61	187	1720	463	0	76.7
BTS 8341	215	339.2	100	5601	76	56.07	100	926	76	16.52	18.28	1.33	16.95	178	1805	472	0	68.7
BTS 8349	223	335.5	99	8444	115	54.92	98	1383	114	25.14	18.02	1.25	16.76	217	1872	388	0	72.2
BTS 8359	219	347.0	102	8405	114	58.51	104	1416	116	24.26	18.59	1.25	17.34	167	1683	448	0	59.7
BTS 8365	206	353.6	104	7929	108	60.56	108	1357	111	22.47	18.80	1.12	17.68	152	1622	373	0	73.1
Crystal 138	238	345.5	102	8528	116	58.03	103	1434	118	24.66	18.49	1.23	17.26	165	1610	453	0	71.5
Crystal 260	230	346.1	102	7847	106	58.23	104	1318	108	22.69	18.44	1.13	17.31	161	1649	371	0	73.1
Crystal 262	227	334.4	99	8125	110	54.55	97	1325	109	24.32	17.87	1.16	16.71	180	1587	406	0	70.3
Crystal 269	229	351.2	104	7743	105	59.83	107	1319	108	22.09	18.85	1.29	17.57	188	1769	446	0	70.3
Crystal 360	203	347.2	102	8418	114	58.59	104	1418	116	24.27	18.65	1.29	17.37	186	1746	457	0	78.6
Crystal 361	201	359.9	106	8270	112	62.56	112	1436	118	23.01	19.14	1.15	17.99	177	1552	410	0	75.1
Crystal 363	222	360.0	106	7503	102	62.58	112	1303	107	20.87	19.15	1.17	17.98	154	1737	381	0	68.5
Crystal 364	214	327.1	96	8759	119	52.30	93	1404	115	26.74	17.70	1.34	16.36	268	1749	459	0	71.4
Crystal 367	220	335.6	99	8191	111	54.93	98	1338	110	24.43	18.01	1.24	16.76	189	1800	403	0	75.1
Crystal 368	217	340.1	100	8155	111	56.34	100	1352	111	23.94	18.27	1.29	16.98	206	1747	446	0	69.8
Crystal 369	231	345.2	102	7743	105	57.95	103	1300	107	22.46	18.50	1.24	17.26	184	1723	426	0	72.6
Crystal 371	226	354.0	104	6982	95	60.73	108	1196	98	19.71	18.80	1.10	17.70	159	1600	362	0	67.6
Hilleshög HIL2441	234	347.4	102	7518	102	58.64	105	1267	104	21.66	18.61	1.23	17.38	195	1688	422	0	71.2
Hilleshög HIL2442	204	343.8	101	7124	97	57.51	103	1190	98	20.76	18.46	1.25	17.21	187	1709	447	0	65.9
Hilleshög HIL2477	237	328.0	97	6740	91	52.58	94	1081	89	20.56	17.84	1.44	16.40	278	1732	537	0	63.8
Hilleshög HIL2478	209	333.8	98	7530	102	54.38	97	1227	101	22.55	17.92	1.23	16.68	211	1720	414	0	71.7
Hilleshög HIL2479	210	343.4	101	7091	96	57.39	102	1186	97	20.65	18.34	1.17	17.17	203	1667	379	0	69.0
Hilleshög HIL2480	228	346.2	102	7947	108	58.25	104	1337	110	22.97	18.68	1.37	17.32	221	1711	513	0	72.5
Hilleshög HIL2487 (Maribo MA942)	225	339.5	100	6316	86	56.17	100	1038	85	18.74	18.15	1.19	16.96	204	1633	405	0	68.2
Maribo MA943	235	346.9	102	7830	106	58.49	104	1323	109	22.54	18.65	1.32	17.34	171	1688	490	0	65.4
Maribo MA945	202	334.9	99	7643	104	54.72	98	1249	103	22.82	17.85	1.11	16.74	179	1699	340	0	63.2
Maribo MA946	207	336.7	99	7932	108	55.27	99	1304	107	23.58	18.07	1.23	16.83	230	1600	434	0	74.1
SV 231	236	341.8	101	8217	111	56.90	101	1368	112	24.01	18.26	1.18	17.08	180	1732	380	0	72.3
SV 232	216	338.0	100	7995	108	55.70	99	1311	108	23.75	18.12	1.21	16.91	187	1845	374	0	64.5
SX 1835	212	338.1	100	8371	114	55.71	99	1380	113	24.75	18.22	1.33	16.89	197	1795	463	0	78.5
SX 1836	221	333.8	98	7510	102	54.37	97	1223	100	22.50	18.00	1.33	16.67	207	1814	453	0	72.2
BTS 8337 (CommBench)	239	341.1	101	6910	94	56.65	101	1147	94	20.28	18.41	1.36	17.05	201	1835	476	0	68.2
Crystal 578RR (CommBench)	240	340.7	100	7743	105	56.54	101	1281	105	22.81	18.28	1.23	17.05	204	1724	414	0	71.2
BTS 8815 (CommBench)	241	335.9	99	7293	99	55.02	98	1196	98	21.71	18.06	1.28	16.78	229	1772	417	0	57.6
Crystal 803 (CommBench)	242	339.3	100	7552	102	56.12	100	1247	102	22.27	18.17	1.21	16.96	182	1702	411	0	70.0
BTS 8927 (1stYearBench)	243	345.7	102	7787	106	58.09	104	1306	107	22.57	18.41	1.13	17.28	167	1635	372	0	72.8
AP CK MOD SUS RR#5	244	333.0	98	7036	95	54.11	96	1143	94	21.15	17.93	1.30	16.63	207	1735	456	0	63.5
AP CK MOD SUS RR#6	245	345.8	102	7130	97	58.14	104	1197	98	20.65	18.52	1.22	17.30	161	1624	451	0	74.6
RA CK SUS RR#7	246	348.4	103	6689	91	58.94	105	1127	93	19.30	18.57	1.16	17.41	207	1630	382	0	75.8
AP CK MOD RES RR#7	247	331.5	98	8508	115	53.66	96	1377	113	25.69	17.76	1.19	16.56	209	1608	411	0	69.9
AP CK MOD SUS RR#8	248	359.9	106	8399	114	62.56	112	1463	120	23.28	19.10	1.11	17.99	148	1652	359	0	78.5
Comm Benchmark Mean		339.2		7375		56.08		1218		21.77	18.23	1.27		177	1834	433		73.1
Comm Trial Mean		338.2		7772		55.76		1280		23.01	18.13	1.22		177	1741	416		77.2
Coeff. of Var. (%)		2.4		9.0		4.5		9.8		8.9	2.2	5.4		14.0	3.9	9.2		10.6
Mean LSD (0.05)		7.3		620		2.28		111		1.80	0.36	0.06		22	62	34		7.0
Mean LSD (0.01)		9.6		816		3.00		146		2.37	0.48	0.08		30	82	45		9.2
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from West of Perley MN (ND)

Created 10/18/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
\+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
\++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 12. 2023 Performance of Varieties - ACSC RR Official Trials Halstad MN

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T %Bnch	Rev/A + $	Rev/A %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	344.5	97	13869	106	57.74	95	2320	104	40.29	18.08	0.85	17.23	90	1414	250	0	79.4
BTS 8034	101	334.5	95	13717	105	54.61	90	2242	100	40.95	17.60	0.87	16.73	124	1530	223	0	83.7
BTS 8156	114	349.1	99	13418	103	59.18	98	2271	102	38.56	18.32	0.86	17.46	101	1462	242	0	82.3
BTS 8927	109	355.7	101	13468	103	61.23	101	2317	104	37.86	18.58	0.79	17.79	93	1313	232	0	84.1
Crystal 022	121	361.3	102	13393	102	62.98	104	2327	104	37.20	18.87	0.80	18.07	75	1321	242	0	81.7
Crystal 130	113	359.8	102	14080	108	62.51	103	2445	109	39.14	18.80	0.81	17.99	82	1376	236	0	79.7
Crystal 137	122	346.6	98	13141	101	58.38	96	2209	99	38.02	18.18	0.85	17.33	98	1486	232	0	83.3
Crystal 793	118	350.2	99	13768	105	59.50	98	2337	105	39.38	18.38	0.87	17.51	91	1393	271	0	85.4
Crystal 912	116	343.6	97	14245	109	57.46	95	2379	106	41.53	18.02	0.83	17.19	105	1316	259	0	88.7
Crystal 913	106	349.1	99	13914	106	59.15	98	2360	106	39.80	18.32	0.87	17.45	94	1408	267	0	84.1
Hilleshög HIL2317	120	350.4	99	12437	95	59.57	98	2113	94	35.51	18.29	0.77	17.52	97	1390	195	1	72.9
Hilleshög HIL2366	111	324.4	92	12065	92	51.44	85	1911	85	37.20	16.96	0.74	16.22	115	1254	198	0	83.6
Hilleshög HIL2368	119	340.7	96	11924	91	56.54	93	1977	88	35.08	17.79	0.75	17.04	97	1282	208	0	79.8
Hilleshög HIL2386	112	327.9	93	12289	94	52.55	87	1968	88	37.48	17.26	0.86	16.40	110	1387	261	0	81.4
Hilleshög HIL2389	105	336.2	95	12641	97	55.13	91	2074	93	37.56	17.55	0.74	16.81	101	1294	192	0	85.5
Hilleshög HIL9920	115	345.7	98	12516	96	58.10	96	2103	94	36.23	18.05	0.76	17.29	103	1355	194	0	81.5
Maribo MA717	110	327.0	92	12751	98	52.26	86	2035	91	39.02	17.12	0.77	16.35	105	1350	201	0	83.2
Maribo MA902	124	330.0	93	12195	93	53.21	88	1965	88	37.03	17.26	0.76	16.50	105	1303	202	0	84.4
SV 203	123	335.3	95	12529	96	54.86	91	2050	92	37.38	17.57	0.80	16.77	98	1359	225	0	87.5
SV 265	107	333.2	94	12333	94	54.19	90	2003	90	37.07	17.35	0.69	16.66	91	1226	177	0	85.7
SV 285	108	342.3	97	12722	97	57.03	94	2122	95	37.18	17.96	0.85	17.11	114	1427	240	0	89.8
SX 1815	104	347.4	98	13601	104	58.64	97	2298	103	39.11	18.13	0.76	17.37	78	1324	209	0	85.2
SX 1818	103	344.9	98	13266	102	57.84	96	2224	99	38.49	18.05	0.81	17.24	86	1341	241	0	86.7
SX 1898	102	342.1	97	13219	101	56.99	94	2201	98	38.63	17.91	0.80	17.11	74	1359	233	0	85.1
BTS 8337 (CommBench)	125	365.3	103	12805	98	64.22	106	2252	101	34.97	19.23	0.96	18.27	102	1534	301	0	83.2
Crystal 578RR (CommBench)	126	346.9	98	13415	103	58.46	97	2259	101	38.70	18.22	0.87	17.35	94	1418	264	0	81.7
BTS 8815 (CommBench)	127	345.2	98	12186	93	57.95	96	2047	92	35.34	18.12	0.86	17.26	106	1507	231	0	68.5
Crystal 803 (CommBench)	128	356.7	101	13862	106	61.52	102	2387	107	38.90	18.71	0.88	17.83	102	1391	276	1	83.9
BTS 8927 (1stYearBench)	129	358.2	101	13483	103	62.02	102	2335	104	37.56	18.71	0.80	17.91	84	1313	241	0	78.6
AP CK MOD SUS RR#5	130	349.1	99	13425	103	59.16	98	2277	102	38.41	18.30	0.85	17.45	93	1412	250	1	80.5
AP CK MOD SUS RR#6	131	352.1	100	12256	94	60.11	99	2093	94	34.80	18.52	0.91	17.61	96	1455	283	0	85.3
RA CK SUS RR#7	132	319.4	90	11599	89	49.91	82	1810	81	36.38	16.74	0.77	15.97	130	1315	200	0	82.8
Experimental Trial (Comm status)																		
BTS 8205	205	347.2	98	13124	100	58.56	97	2217	99	37.66	18.25	0.88	17.37	79	1396	281	0	85.3
BTS 8217	233	342.9	97	13667	105	57.20	94	2282	102	39.91	18.02	0.88	17.14	117	1460	254	0	80.2
BTS 8226	208	360.4	102	13478	103	62.68	104	2344	105	37.43	18.75	0.74	18.01	84	1275	201	0	84.1
BTS 8242	211	360.3	102	13082	100	62.66	104	2277	102	36.27	18.88	0.86	18.02	91	1427	256	0	82.1
BTS 8270	232	358.4	101	13123	100	62.04	102	2268	101	36.68	18.76	0.84	17.92	87	1400	249	0	85.6
BTS 8303	218	357.2	101	12992	99	61.69	102	2242	100	36.34	18.75	0.89	17.86	109	1508	247	0	77.7
BTS 8311	213	364.0	103	12443	95	63.81	105	2179	97	34.16	19.03	0.84	18.19	83	1360	257	0	77.3
BTS 8328	224	360.9	102	13304	102	62.85	104	2318	104	36.86	18.97	0.91	18.06	91	1491	279	0	80.4
BTS 8341	215	353.9	100	9970	76	60.65	100	1711	77	28.06	18.62	0.93	17.69	101	1452	297	0	77.1
BTS 8349	223	332.8	94	13241	101	54.04	89	2144	96	39.88	17.49	0.86	16.63	131	1401	247	0	82.6
BTS 8359	219	356.2	101	13186	101	61.37	101	2266	101	37.20	18.75	0.95	17.80	111	1498	298	0	82.7
BTS 8365	206	365.5	103	13197	101	64.27	106	2322	104	36.09	19.08	0.81	18.27	85	1332	241	0	83.7
Crystal 138	238	350.8	99	13381	102	59.68	99	2274	102	38.21	18.45	0.91	17.54	110	1414	289	0	86.5
Crystal 260	230	348.4	99	13499	103	58.94	97	2284	102	38.75	18.26	0.84	17.42	95	1402	243	0	82.0
Crystal 262	227	355.6	101	13400	103	61.18	101	2305	103	37.66	18.56	0.78	17.78	99	1248	233	0	83.0
Crystal 269	229	370.3	105	12715	97	65.78	109	2260	101	34.32	19.45	0.93	18.52	98	1508	288	0	80.7
Crystal 360	203	341.1	96	13320	102	56.64	94	2215	99	39.06	17.97	0.92	17.05	94	1419	301	0	83.3
Crystal 361	201	365.0	103	14044	107	64.13	106	2466	110	38.48	19.04	0.79	18.25	103	1329	220	0	83.5
Crystal 363	222	368.3	104	13014	100	65.17	108	2303	103	35.32	19.31	0.90	18.41	94	1458	275	0	83.2
Crystal 364	214	340.5	96	13338	102	56.44	93	2208	99	39.27	17.89	0.87	17.02	96	1503	244	0	81.0
Crystal 367	220	345.1	98	13801	106	57.89	96	2317	104	39.98	18.16	0.89	17.27	101	1548	246	0	85.9
Crystal 368	217	357.2	101	13479	103	61.69	102	2330	104	37.67	18.81	0.94	17.87	104	1486	298	0	80.5
Crystal 369	231	359.5	102	13612	104	62.39	103	2365	106	37.84	18.89	0.92	17.97	107	1493	278	0	87.1
Crystal 371	226	371.1	105	12686	97	66.04	109	2260	101	34.11	19.40	0.84	18.56	89	1355	256	0	78.9
Hilleshög HIL2441	234	348.1	98	11988	92	58.84	97	2025	91	34.43	18.36	0.96	17.40	108	1460	318	0	82.2
Hilleshög HIL2442	204	353.5	100	11796	90	60.51	100	2021	90	33.42	18.63	0.96	17.67	104	1404	332	0	81.5
Hilleshög HIL2477	237	344.8	98	12136	93	57.79	95	2032	91	35.22	18.18	0.95	17.23	126	1434	308	0	82.5
Hilleshög HIL2478	209	331.4	94	12730	97	53.60	89	2058	92	38.49	17.46	0.89	16.57	159	1419	257	0	82.8
Hilleshög HIL2479	210	356.5	101	12763	98	61.48	102	2200	98	35.80	18.62	0.79	17.83	123	1227	245	0	86.2
Hilleshög HIL2480	228	347.3	98	12416	95	58.58	97	2093	94	35.79	18.38	1.02	17.36	141	1478	343	0	89.4
Hilleshög HIL2487 (Maribo MA942)	225	345.6	98	12951	99	58.06	96	2176	97	37.48	18.10	0.82	17.28	89	1310	254	0	85.0
Maribo MA943	235	356.3	101	12609	96	61.41	101	2171	97	35.40	18.64	0.82	17.82	78	1329	256	0	77.1
Maribo MA945	202	343.8	97	12822	98	57.50	95	2145	96	37.33	18.07	0.88	17.19	113	1493	243	0	79.9
Maribo MA946	207	346.0	98	12576	96	58.16	96	2112	94	36.44	18.14	0.84	17.30	105	1334	256	0	83.3
SV 231	236	337.7	96	12967	99	55.59	92	2135	95	38.40	17.77	0.87	16.90	124	1465	244	0	80.9
SV 232	216	346.5	98	12908	99	58.34	96	2176	97	37.16	18.12	0.79	17.33	85	1356	224	0	84.8
SX 1835	212	344.8	98	12922	99	57.82	96	2165	97	37.51	18.17	0.93	17.24	101	1484	290	0	82.4
SX 1836	221	356.0	101	13101	100	61.29	101	2258	101	36.78	18.68	0.89	17.79	112	1458	263	0	83.3
BTS 8337 (CommBench)	239	359.8	102	12362	95	62.51	103	2145	96	34.37	18.90	0.91	17.99	101	1474	281	0	84.2
Crystal 578RR (CommBench)	240	348.6	99	13703	105	58.99	97	2321	104	39.31	18.29	0.86	17.43	100	1442	245	0	84.7
BTS 8815 (CommBench)	241	350.7	99	12412	95	59.66	99	2111	94	35.33	18.42	0.88	17.54	106	1528	240	0	71.1
Crystal 803 (CommBench)	242	355.0	100	13791	106	60.99	101	2368	106	38.91	18.67	0.92	17.75	108	1457	289	0	86.9
BTS 8927 (1stYearBench)	243	357.4	101	13422	103	61.74	102	2317	104	37.54	18.70	0.83	17.87	106	1349	250	0	85.2
AP CK MOD SUS RR#5	244	346.9	98	13134	101	58.46	97	2215	99	37.83	18.18	0.83	17.35	101	1434	228	0	77.4
AP CK MOD SUS RR#6	245	357.1	101	13012	100	61.65	102	2248	101	36.48	18.79	0.93	17.86	97	1419	313	0	85.0
RA CK SUS RR#7	246	348.0	98	13088	100	58.79	97	2212	99	37.52	18.21	0.81	17.40	111	1363	229	0	84.2
AP CK MOD RES RR#7	247	346.7	98	14762	113	58.40	96	2488	111	42.49	18.17	0.85	17.32	112	1304	268	0	85.0
AP CK MOD SUS RR#8	248	364.0	103	13227	101	63.80	105	2321	104	36.26	19.08	0.88	18.20	92	1420	270	0	80.3
Comm Benchmark Mean		353.5		13067		60.54		2236		36.98	18.57	0.89		101	1463	268		79.3
Comm Trial Mean		344.2		13017		57.64		2179		37.84	18.03	0.82		98	1376	234		82.8
Coeff. of Var. (%)		2.6		4.9		4.9		6.3		4.4	2.5	5.9		18.5	4.1	11.4		7.9
Mean LSD (0.05)		8.1		576		2.53		122		1.52	0.41	0.04		16	51	24		5.5
Mean LSD (0.01)		10.7		758		3.34		161		2.00	0.54	0.06		21	67	31		7.2
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from Halstad MN

Created 10/17/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 13. 2023 Performance of Varieties - ACSC RR Official Trials Reynolds ND

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T + %Bnch	Rev/A + $	Rev/A + %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	360.0	102	11340	105	62.56	103	1971	106	31.28	19.13	1.13	18.00	163	1574	400	0	66.2
BTS 8034	101	348.9	99	11587	107	59.09	98	1968	106	33.14	18.63	1.20	17.43	214	1746	385	0	72.8
BTS 8156	114	355.2	101	10531	97	61.07	101	1812	98	29.79	18.89	1.13	17.76	161	1732	357	0	66.5
BTS 8927	109	363.7	103	11204	103	63.72	105	1963	106	30.91	19.23	1.04	18.19	159	1478	356	0	70.4
Crystal 022	121	366.6	104	11125	103	64.63	107	1964	106	30.29	19.40	1.08	18.32	152	1508	381	0	61.6
Crystal 130	113	357.1	101	11595	107	61.66	102	2008	108	32.42	18.91	1.07	17.84	165	1536	360	0	68.1
Crystal 137	122	353.2	100	10981	101	60.44	100	1882	101	31.13	18.83	1.17	17.66	171	1752	383	0	66.0
Crystal 793	118	354.9	100	11496	106	60.96	101	1972	106	32.33	18.82	1.07	17.75	148	1570	360	0	66.2
Crystal 912	116	340.3	96	12189	112	56.42	93	2022	109	35.76	18.14	1.12	17.02	188	1552	386	0	69.0
Crystal 913	106	356.0	101	11864	109	61.33	101	2040	110	33.38	18.91	1.10	17.81	161	1558	381	0	70.9
Hilleshög HIL2317	120	350.2	99	10854	100	59.51	98	1847	100	30.92	18.57	1.07	17.50	192	1642	321	0	54.7
Hilleshög HIL2366	111	336.2	95	10517	97	55.13	91	1729	93	31.12	17.95	1.15	16.80	202	1567	402	0	65.5
Hilleshög HIL2368	119	356.6	101	9930	92	61.50	102	1711	92	27.87	18.94	1.11	17.83	162	1473	406	0	54.2
Hilleshög HIL2386	112	354.1	100	11061	102	60.74	100	1894	102	31.25	18.85	1.13	17.72	169	1550	407	0	66.8
Hilleshög HIL2389	105	360.2	102	11396	105	62.64	104	1982	107	31.62	19.15	1.14	18.01	156	1675	383	0	64.9
Hilleshög HIL9920	115	358.9	102	11291	104	62.22	103	1952	105	31.44	19.07	1.12	17.95	191	1674	355	0	61.1
Maribo MA717	110	349.4	99	11108	102	59.25	98	1883	102	31.67	18.54	1.08	17.46	181	1551	355	0	62.3
Maribo MA902	124	347.8	98	9708	90	58.76	97	1635	88	27.91	18.54	1.14	17.40	205	1560	393	0	60.1
SV 203	123	361.4	102	11645	107	62.99	104	2035	110	32.14	19.12	1.07	18.05	163	1601	340	0	67.0
SV 265	107	348.6	99	11490	106	59.02	98	1942	105	33.00	18.55	1.11	17.44	187	1697	339	0	71.2
SV 285	108	355.0	100	11369	105	61.00	101	1949	105	32.10	18.90	1.13	17.77	168	1721	360	0	70.0
SX 1815	104	364.3	103	11901	110	63.89	106	2088	113	32.70	19.26	1.05	18.21	130	1631	334	0	65.3
SX 1818	103	359.3	102	11622	107	62.35	103	2017	109	32.46	19.06	1.09	17.97	142	1676	348	0	59.7
SX 1898	102	353.3	100	11434	105	60.46	100	1958	106	32.31	18.81	1.15	17.66	180	1724	369	0	66.8
BTS 8337 (CommBench)	125	358.4	101	10215	94	62.06	103	1767	95	28.67	19.21	1.28	17.93	201	1740	455	0	63.8
Crystal 578RR (CommBench)	126	343.7	97	11094	102	57.49	95	1855	100	32.29	18.47	1.28	17.19	207	1811	432	0	63.8
BTS 8815 (CommBench)	127	346.8	98	9657	89	58.43	97	1625	88	27.86	18.59	1.25	17.34	208	1804	414	0	48.0
Crystal 803 (CommBench)	128	364.1	103	12389	114	63.84	106	2172	117	34.02	19.35	1.15	18.20	167	1649	395	0	73.5
BTS 8927 (1stYearBench)	129	363.7	103	11158	103	63.73	105	1951	105	30.67	19.31	1.12	18.19	155	1509	407	0	63.9
AP CK MOD SUS RR#5	130	350.4	99	10819	100	59.55	99	1839	99	31.02	18.71	1.20	17.51	212	1739	390	0	57.1
AP CK MOD SUS RR#6	131	363.6	103	11072	102	63.70	105	1940	105	30.63	19.27	1.09	18.18	139	1514	393	0	66.3
RA CK SUS RR#7	132	345.9	98	9902	91	58.17	96	1664	90	28.70	18.45	1.15	17.30	212	1542	403	0	68.8
Experimental Trial (Comm status)																		
BTS 8205	205	350.8	99	11495	106	59.67	99	1969	106	32.70	18.72	1.18	17.55	109	1660	367	0	60.9
BTS 8217	233	359.8	102	11023	102	62.49	103	1926	104	30.78	19.14	1.14	18.00	130	1683	329	0	60.2
BTS 8226	208	348.8	99	10018	92	59.08	98	1708	92	28.89	18.55	1.11	17.44	137	1504	346	0	54.6
BTS 8242	211	361.2	102	10926	101	62.91	104	1909	103	30.18	19.26	1.20	18.06	109	1591	402	0	58.8
BTS 8270	232	353.6	100	10906	101	60.59	100	1878	101	30.77	18.93	1.24	17.69	135	1593	424	0	66.3
BTS 8303	218	353.0	100	10112	93	60.35	100	1725	93	28.97	18.82	1.19	17.63	162	1743	331	0	50.0
BTS 8311	213	370.8	105	9974	92	65.87	109	1768	95	27.17	19.63	1.08	18.55	130	1486	337	0	52.4
BTS 8328	224	363.5	103	11002	102	63.60	105	1935	104	30.38	19.36	1.19	18.17	136	1652	367	0	54.3
BTS 8341	215	344.7	98	7883	73	57.80	96	1307	70	23.01	18.60	1.38	17.22	163	1731	472	0	48.9
BTS 8349	223	342.9	97	11286	104	57.27	95	1897	102	32.89	18.37	1.23	17.14	200	1760	345	0	66.1
BTS 8359	219	355.6	101	11298	104	61.20	101	1940	105	31.83	18.94	1.15	17.79	117	1608	360	0	54.4
BTS 8365	206	370.8	105	10911	101	65.90	109	1947	105	29.32	19.65	1.09	18.56	113	1540	332	0	58.8
Crystal 138	238	350.1	99	11124	103	59.48	98	1882	101	31.73	18.75	1.25	17.50	130	1604	422	0	53.2
Crystal 260	230	356.9	101	11373	105	61.59	102	1965	106	31.74	19.02	1.16	17.86	140	1590	364	0	64.4
Crystal 262	227	343.2	97	11095	102	57.35	95	1859	100	32.32	18.30	1.14	17.16	143	1556	358	0	55.2
Crystal 269	229	357.2	101	11077	102	61.67	102	1912	103	30.94	19.16	1.30	17.85	148	1742	418	0	48.8
Crystal 360	203	346.8	98	11343	105	58.44	97	1923	104	32.37	18.53	1.19	17.35	139	1613	373	0	59.9
Crystal 361	201	362.1	102	11412	105	63.17	104	1998	108	31.39	19.22	1.11	18.11	127	1481	358	0	63.5
Crystal 363	222	359.4	102	10915	101	62.34	103	1894	102	30.38	19.15	1.18	17.97	145	1632	361	0	51.0
Crystal 364	214	344.8	98	12310	114	57.83	96	2073	112	35.97	18.41	1.18	17.24	161	1700	336	0	62.9
Crystal 367	220	350.5	99	11275	104	59.59	99	1919	103	32.14	18.75	1.23	17.52	137	1770	365	0	65.0
Crystal 368	217	352.7	100	10187	94	60.28	100	1743	94	29.01	18.94	1.32	17.62	143	1736	431	0	48.5
Crystal 369	231	351.4	99	10641	98	59.87	99	1820	98	30.38	18.75	1.18	17.58	151	1595	364	0	57.7
Crystal 371	226	365.8	104	10267	95	64.37	106	1814	98	28.29	19.45	1.15	18.29	131	1519	383	0	57.5
Hilleshög HIL2441	234	346.4	98	10346	95	58.33	96	1760	95	29.68	18.56	1.24	17.32	146	1604	410	0	54.6
Hilleshög HIL2442	204	358.1	101	10850	100	61.97	102	1885	102	29.93	19.20	1.29	17.90	126	1623	452	0	50.1
Hilleshög HIL2477	237	339.0	96	10262	95	56.04	93	1705	92	30.42	18.32	1.39	16.93	196	1750	462	0	48.2
Hilleshög HIL2478	209	337.3	95	10971	101	55.51	92	1810	98	32.46	18.07	1.21	16.87	154	1725	356	0	60.4
Hilleshög HIL2479	210	366.8	104	11065	102	64.66	107	1955	105	29.96	19.50	1.15	18.34	140	1523	370	0	60.6
Hilleshög HIL2480	228	360.0	102	10060	93	62.53	103	1753	95	28.09	19.26	1.26	18.00	165	1662	406	0	59.9
Hilleshög HIL2487 (Maribo MA942)	225	352.7	100	10104	93	60.26	100	1732	93	28.94	18.79	1.15	17.64	122	1544	371	0	60.7
Maribo MA943	235	343.0	97	9167	85	57.28	95	1546	83	26.67	18.38	1.23	17.15	133	1638	400	0	38.7
Maribo MA945	202	341.4	97	11319	104	56.77	94	1891	102	33.31	18.21	1.14	17.07	137	1661	333	0	52.0
Maribo MA946	207	348.0	99	10768	99	58.83	97	1833	99	30.75	18.65	1.25	17.40	141	1581	423	0	58.2
SV 231	236	348.1	99	11268	104	58.86	97	1907	103	32.54	18.57	1.18	17.40	138	1732	335	0	57.0
SV 232	216	353.3	100	11142	103	60.44	100	1908	103	31.60	18.78	1.12	17.66	131	1647	316	0	55.3
SX 1835	212	357.4	101	11612	107	61.74	102	1997	108	32.50	19.06	1.19	17.87	118	1697	356	0	62.6
SX 1836	221	344.7	98	10785	100	57.82	96	1828	99	31.06	18.46	1.23	17.23	136	1725	375	0	50.8
BTS 8337 (CommBench)	239	357.8	101	10331	95	61.86	102	1786	96	28.96	19.21	1.33	17.88	151	1822	412	0	60.0
Crystal 578RR (CommBench)	240	346.5	98	11131	103	58.37	97	1881	101	32.12	18.60	1.27	17.33	165	1717	399	0	66.1
BTS 8815 (CommBench)	241	357.0	101	9605	89	61.62	102	1659	89	26.67	19.03	1.16	17.87	132	1765	323	0	43.1
Crystal 803 (CommBench)	242	351.7	100	12288	113	59.97	99	2093	113	35.09	18.78	1.20	17.58	118	1688	371	0	68.3
BTS 8927 (1stYearBench)	243	359.1	102	10288	95	62.26	103	1781	96	28.77	19.10	1.14	17.96	135	1549	358	0	57.2
AP CK MOD SUS RR#5	244	345.9	98	11176	103	58.17	96	1869	101	32.45	18.56	1.27	17.29	152	1756	395	0	53.5
AP CK MOD SUS RR#6	245	358.5	101	11418	105	62.09	103	1979	107	31.99	19.14	1.22	17.92	136	1585	407	0	64.0
RA CK SUS RR#7	246	345.9	98	10177	94	58.17	96	1723	93	29.43	18.48	1.19	17.30	167	1601	366	0	63.1
AP CK MOD RES RR#7	247	337.7	96	11807	109	55.63	92	1953	105	34.82	18.11	1.23	16.88	166	1587	403	0	55.1
AP CK MOD SUS RR#8	248	364.3	103	10909	101	63.84	106	1915	103	30.05	19.33	1.11	18.22	114	1480	367	0	57.4
Comm Benchmark Mean		353.3		10839		60.46		1855		30.71	18.91	1.24		196	1751	424		62.3
Comm Trial Mean		354.6		11111		60.88		1907		31.34	18.86	1.13		175	1627	380		64.8
Coeff. of Var. (%)		3.1		6.0		5.6		7.7		5.1	2.6	7.0		19.0	4.2	10.8		13.4
Mean LSD (0.05)		9.5		570		2.98		125		1.38	0.44	0.07		30	60	37		7.3
Mean LSD (0.01)		12.6		751		3.92		165		1.82	0.58	0.09		39	79	49		9.6
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from Reynolds ND

Created 10/19/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 14. 2023 Performance of Varieties - ACSC RR Official Trials Climax MN

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T + %Bnch	Rev/A + $	Rev/A + %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	352.1	102	11316	106	60.09	104	1932	108	32.13	18.60	0.99	17.61	81	1346	381	0	85.7
BTS 8034	101	338.9	98	11158	105	55.98	97	1842	103	32.95	18.09	1.14	16.95	108	1493	447	0	89.6
BTS 8156	114	346.2	100	10885	102	58.24	100	1830	102	31.44	18.45	1.14	17.31	99	1488	448	0	80.0
BTS 8927	109	342.1	99	10852	102	56.99	98	1809	101	31.70	18.17	1.06	17.11	103	1298	440	0	88.5
Crystal 022	121	350.9	102	10710	100	59.73	103	1824	102	30.51	18.53	0.99	17.54	88	1271	394	0	83.9
Crystal 130	113	349.8	101	11496	108	59.38	102	1954	109	32.83	18.46	0.98	17.48	88	1329	372	0	89.9
Crystal 137	122	346.0	100	11122	104	58.20	100	1871	105	32.16	18.45	1.15	17.30	107	1483	458	0	90.9
Crystal 793	118	338.5	98	10804	101	55.86	96	1780	100	31.99	18.00	1.07	16.93	97	1393	427	0	90.4
Crystal 912	116	338.4	98	11727	110	55.81	96	1932	108	34.70	17.99	1.07	16.92	91	1305	453	0	87.8
Crystal 913	106	345.1	100	11878	111	57.92	100	1992	111	34.45	18.25	0.99	17.26	89	1352	378	0	93.0
Hilleshög HIL2317	120	341.8	99	10619	100	56.88	98	1767	99	31.09	18.09	1.00	17.09	107	1377	373	0	78.1
Hilleshög HIL2366	111	325.3	94	10635	100	51.72	89	1696	95	32.59	17.26	1.00	16.26	106	1298	391	0	87.0
Hilleshög HIL2368	119	343.1	99	9807	92	57.30	99	1637	92	28.61	18.17	1.02	17.15	111	1294	408	0	73.7
Hilleshög HIL2386	112	345.8	100	11125	104	58.13	100	1869	105	32.20	18.36	1.07	17.29	94	1366	430	0	88.3
Hilleshög HIL2389	105	346.7	100	10958	103	58.41	101	1846	103	31.62	18.42	1.09	17.33	89	1441	434	0	90.1
Hilleshög HIL9920	115	341.7	99	10710	100	56.86	98	1783	100	31.31	18.14	1.05	17.09	94	1434	401	0	83.3
Maribo MA717	110	334.0	97	11194	105	54.45	94	1824	102	33.55	17.71	1.00	16.71	103	1337	385	0	84.4
Maribo MA902	124	338.2	98	10423	98	55.77	96	1720	96	30.77	17.93	1.02	16.91	100	1307	406	0	91.2
SV 203	123	344.8	100	11322	106	57.83	100	1897	106	32.85	18.32	1.08	17.24	92	1422	426	0	84.4
SV 265	107	340.8	99	10165	95	56.56	98	1685	94	29.87	18.11	1.07	17.04	94	1401	424	0	85.4
SV 285	108	344.7	100	11349	106	57.78	100	1903	106	32.93	18.30	1.07	17.23	93	1452	412	0	87.2
SX 1815	104	349.0	101	11579	109	59.14	102	1962	110	33.18	18.48	1.02	17.46	87	1408	388	0	90.1
SX 1818	103	352.3	102	11565	108	60.17	104	1975	111	32.82	18.61	0.99	17.62	86	1431	358	0	81.3
SX 1898	102	340.5	99	11091	104	56.47	97	1838	103	32.61	18.15	1.12	17.03	98	1433	454	0	87.2
BTS 8337 (CommBench)	125	358.5	104	10244	96	62.09	107	1774	99	28.58	19.05	1.13	17.92	87	1440	465	0	83.9
Crystal 578RR (CommBench)	126	331.8	96	10587	99	53.76	93	1712	96	31.96	17.73	1.13	16.60	122	1485	441	0	83.6
BTS 8815 (CommBench)	127	342.5	99	10465	98	57.09	98	1742	97	30.61	18.23	1.11	17.12	114	1472	425	0	69.8
Crystal 803 (CommBench)	128	348.8	101	11340	106	59.08	102	1920	107	32.51	18.56	1.12	17.44	82	1403	462	1	90.6
BTS 8927 (1stYearBench)	129	358.0	104	10536	99	61.93	107	1823	102	29.42	18.91	1.01	17.90	90	1335	396	0	89.6
AP CK MOD SUS RR#5	130	338.2	98	10709	100	55.77	96	1767	99	31.62	17.98	1.07	16.91	101	1418	414	0	80.2
AP CK MOD SUS RR#6	131	349.8	101	11199	105	59.38	102	1901	106	32.05	18.57	1.08	17.49	90	1418	430	0	90.4
RA CK SUS RR#7	132	340.2	98	10555	99	56.38	97	1750	98	31.01	18.01	1.00	17.01	100	1307	391	0	88.8
Experimental Trial (Comm status)																		
BTS 8205	205	348.1	101	12469	117	58.84	101	2108	118	35.90	18.54	1.14	17.41	86	1369	459	0	84.0
BTS 8217	233	342.3	99	11661	109	57.02	98	1942	109	34.08	18.27	1.16	17.11	96	1514	431	0	81.3
BTS 8226	208	354.1	103	10021	94	60.70	105	1720	96	28.27	18.70	0.99	17.71	86	1277	381	0	81.3
BTS 8242	211	350.0	101	10928	103	59.45	102	1857	104	31.21	18.61	1.11	17.51	88	1362	440	0	85.6
BTS 8270	232	353.1	102	11839	111	60.40	104	2027	113	33.55	18.74	1.08	17.67	84	1349	429	0	88.7
BTS 8303	218	351.4	102	11014	103	59.87	103	1877	105	31.41	18.67	1.11	17.57	92	1436	443	0	87.1
BTS 8311	213	354.9	103	10719	101	60.94	105	1840	103	30.31	18.81	1.06	17.76	86	1368	398	0	83.6
BTS 8328	224	346.4	100	11549	108	58.30	101	1949	109	33.30	18.45	1.13	17.33	84	1322	459	0	83.6
BTS 8341	215	340.7	99	8306	78	56.54	97	1381	77	24.31	18.30	1.26	17.03	108	1401	534	0	82.8
BTS 8349	223	326.4	94	9621	90	52.08	90	1537	86	29.52	17.42	1.10	16.32	124	1435	408	0	86.7
BTS 8359	219	350.0	101	11035	104	59.43	102	1872	105	31.63	18.53	1.03	17.51	89	1341	383	0	87.9
BTS 8365	206	355.3	103	11251	106	61.06	105	1937	108	31.74	18.79	1.01	17.78	87	1349	382	0	86.7
Crystal 138	238	351.7	102	11402	107	59.97	103	1942	109	32.39	18.64	1.07	17.58	122	1372	392	0	84.4
Crystal 260	230	349.7	101	11421	107	59.36	102	1935	108	32.73	18.49	1.00	17.49	87	1354	359	0	87.9
Crystal 262	227	341.7	99	11094	104	56.86	98	1850	103	32.41	18.16	1.07	17.09	89	1308	427	0	82.8
Crystal 269	229	352.1	102	10720	101	60.09	104	1836	103	30.45	18.75	1.14	17.62	87	1433	444	0	80.9
Crystal 360	203	346.0	100	11183	105	58.17	100	1886	106	32.33	18.34	1.04	17.30	87	1388	385	0	85.6
Crystal 361	201	350.2	101	10478	98	59.51	103	1779	100	29.98	18.62	1.11	17.52	106	1345	436	0	85.6
Crystal 363	222	350.6	102	11030	103	59.64	103	1876	105	31.49	18.62	1.09	17.54	100	1375	422	0	85.2
Crystal 364	214	339.9	98	11318	106	56.27	97	1871	105	33.39	18.08	1.09	16.99	112	1431	394	0	85.9
Crystal 367	220	344.4	100	11407	107	57.67	99	1913	107	33.19	18.30	1.08	17.22	92	1485	390	0	85.5
Crystal 368	217	344.6	100	10646	100	57.75	100	1780	100	31.05	18.46	1.24	17.22	92	1409	516	0	78.9
Crystal 369	231	344.8	100	11818	111	57.79	100	1982	111	34.35	18.50	1.27	17.23	203	1620	456	0	89.8
Crystal 371	226	349.0	101	10411	98	59.09	102	1766	99	29.76	18.52	1.08	17.45	87	1334	435	0	86.7
Hilleshög HIL2441	234	337.6	98	10859	102	55.58	96	1790	100	32.17	18.07	1.19	16.88	104	1375	498	1	89.9
Hilleshög HIL2442	204	347.0	100	10534	99	58.49	101	1775	99	30.44	18.52	1.19	17.34	91	1450	507	0	82.0
Hilleshög HIL2477	237	334.4	97	9926	93	54.59	94	1619	91	29.69	17.98	1.26	16.72	107	1509	523	0	88.3
Hilleshög HIL2478	209	329.0	95	10388	97	52.89	91	1665	93	31.71	17.64	1.20	16.44	120	1513	463	0	84.4
Hilleshög HIL2479	210	350.6	102	10693	100	59.64	103	1821	102	30.43	18.59	1.07	17.53	106	1317	433	0	85.9
Hilleshög HIL2480	228	348.2	101	9989	94	58.85	101	1687	94	28.77	18.53	1.13	17.41	100	1385	442	0	89.5
Hilleshög HIL2487 (Maribo MA942)	225	338.6	98	10092	95	55.89	96	1669	93	29.68	18.01	1.08	16.93	109	1300	429	0	87.5
Maribo MA943	235	344.1	100	11055	104	57.59	99	1855	104	32.16	18.26	1.05	17.21	92	1314	408	0	83.6
Maribo MA945	202	327.6	95	9567	90	52.47	90	1533	86	29.24	17.54	1.16	16.38	109	1465	449	0	83.6
Maribo MA946	207	341.9	99	10671	100	56.91	98	1776	99	31.26	18.20	1.11	17.09	94	1402	441	0	83.2
SV 231	236	339.6	98	11180	105	56.20	97	1846	103	33.08	18.10	1.13	16.97	86	1445	429	0	85.9
SV 232	216	343.5	99	11238	105	57.41	99	1879	105	32.74	18.22	1.04	17.18	83	1435	368	0	81.6
SX 1835	212	347.8	101	11521	108	58.74	101	1942	109	33.25	18.60	1.22	17.38	91	1499	494	0	86.3
SX 1836	221	341.4	99	10685	100	56.75	98	1777	99	31.34	18.10	1.01	17.08	79	1345	381	0	87.1
BTS 8337 (CommBench)	239	358.0	104	10714	101	61.92	107	1852	104	29.96	19.00	1.10	17.91	97	1456	404	0	87.1
Crystal 578RR (CommBench)	240	340.6	99	10605	99	56.51	97	1759	98	31.09	18.16	1.13	17.03	114	1433	429	0	89.5
BTS 8815 (CommBench)	241	339.6	98	10230	96	56.21	97	1692	95	30.13	18.15	1.17	16.98	101	1501	450	0	68.0
Crystal 803 (CommBench)	242	343.4	99	11087	104	57.37	99	1846	103	32.47	18.27	1.10	17.17	108	1403	424	0	89.1
BTS 8927 (1stYearBench)	243	348.9	101	9869	93	59.07	102	1671	93	28.32	18.46	1.01	17.45	98	1264	395	0	90.6
AP CK MOD SUS RR#5	244	340.0	98	10590	99	56.30	97	1757	98	31.16	18.11	1.11	17.00	104	1381	434	0	83.2
AP CK MOD SUS RR#6	245	344.3	100	11019	103	57.65	99	1843	103	32.12	18.35	1.14	17.21	90	1391	443	0	89.8
RA CK SUS RR#7	246	342.2	99	9598	90	56.99	98	1605	90	28.03	18.21	1.10	17.11	95	1327	446	0	93.0
AP CK MOD RES RR#7	247	340.0	98	11964	112	56.32	97	1983	111	35.19	18.07	1.07	17.00	95	1243	441	0	82.0
AP CK MOD SUS RR#8	248	351.6	102	10521	99	59.94	103	1787	100	30.06	18.61	1.04	17.58	96	1343	378	0	87.9
Comm Benchmark Mean		345.4		10659		58.01		1787		30.92	18.39	1.12		101	1450	448		82.0
Comm Trial Mean		343.9		10941		57.54		1830		31.83	18.25	1.06		97	1389	416		85.9
Coeff. of Var. (%)		2.2		6.0		4.2		6.8		5.8	2.0	6.4		14.1	3.8	11.1		7.8
Mean LSD (0.05)		6.9		587		2.17		112		1.64	0.33	0.06		12	47	42		5.3
Mean LSD (0.01)		9.2		773		2.85		147		2.17	0.43	0.08		16	62	55		7.0
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from Climax MN

Created 10/17/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 15. 2023 Performance of Varieties - ACSC RR Official Trials Grand Forks ND

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	%Bnch	Rev/A + $	%Bnch	Yield T/A	Gross	Sugar% LTM	Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	378.9	99	10716	108	68.45	99	1930	107	28.39	19.82	0.88	18.94	106	1473	249	0	87.4
BTS 8034	101	367.8	97	10965	110	65.01	94	1936	107	29.84	19.38	0.99	18.39	133	1673	276	0	90.0
BTS 8156	114	373.1	98	9726	98	66.65	96	1735	96	26.13	19.58	0.92	18.66	121	1603	245	0	83.3
BTS 8927	109	387.7	102	10606	107	71.19	103	1947	108	27.37	20.27	0.88	19.39	99	1472	259	0	89.3
Crystal 022	121	380.2	100	10712	108	68.88	100	1940	107	28.17	19.87	0.86	19.01	114	1448	238	0	89.8
Crystal 130	113	384.7	101	10637	107	70.28	102	1940	107	27.72	20.16	0.93	19.23	114	1562	262	0	86.3
Crystal 137	122	378.0	99	10246	103	68.19	99	1845	102	27.20	19.81	0.91	18.90	106	1648	230	0	90.0
Crystal 793	118	379.3	100	10928	110	68.58	99	1975	109	28.86	19.88	0.92	18.96	112	1531	264	0	87.0
Crystal 912	116	373.2	98	11204	113	66.68	97	2003	111	30.03	19.47	0.81	18.66	96	1379	230	0	88.9
Crystal 913	106	378.2	99	11212	113	68.25	99	2020	112	29.70	19.82	0.90	18.92	113	1514	259	0	83.9
Hilleshög HIL2317	120	383.1	101	10275	103	69.78	101	1869	104	26.85	20.04	0.89	19.15	97	1545	241	0	81.9
Hilleshög HIL2366	111	369.2	97	10074	101	65.45	95	1783	99	27.37	19.29	0.83	18.46	122	1447	213	0	85.3
Hilleshög HIL2368	119	389.1	102	9657	97	71.64	104	1778	98	24.84	20.37	0.92	19.45	94	1519	274	0	80.8
Hilleshög HIL2386	112	373.0	98	9954	100	66.63	96	1777	98	26.68	19.63	0.98	18.65	114	1576	303	0	89.9
Hilleshög HIL2389	105	376.7	99	10934	110	67.78	98	1968	109	28.99	19.80	0.96	18.84	117	1570	285	0	87.1
Hilleshög HIL9920	115	383.3	101	10794	108	69.83	101	1964	109	28.22	20.09	0.93	19.16	123	1629	243	0	87.2
Maribo MA717	110	376.3	99	10615	107	67.64	98	1907	106	28.26	19.70	0.89	18.81	121	1495	245	0	86.4
Maribo MA902	124	379.3	100	9779	98	68.58	99	1767	98	25.82	19.88	0.92	18.96	113	1523	264	0	84.0
SV 203	123	381.9	100	11162	112	69.40	100	2028	112	29.25	20.00	0.91	19.09	95	1572	251	0	91.9
SV 265	107	380.5	100	10908	110	68.97	100	1977	110	28.68	19.85	0.82	19.03	103	1552	190	0	88.5
SV 285	108	379.3	100	11122	112	68.59	99	2009	111	29.33	19.84	0.88	18.96	99	1547	235	0	89.5
SX 1815	104	381.1	100	11469	115	69.16	100	2080	115	30.11	19.94	0.89	19.05	89	1554	243	0	94.1
SX 1818	103	378.8	99	10989	110	68.42	99	1983	110	29.03	19.87	0.93	18.94	97	1567	270	0	86.9
SX 1898	102	386.4	101	11442	115	70.81	102	2095	116	29.63	20.20	0.89	19.31	90	1556	241	0	88.0
BTS 8337 (CommBench)	125	385.2	101	9457	95	70.43	102	1725	96	24.65	20.18	0.92	19.26	110	1651	234	0	83.6
Crystal 578RR (CommBench)	126	382.1	100	9739	98	69.45	101	1771	98	25.49	20.05	0.94	19.11	122	1601	263	0	88.7
BTS 8815 (CommBench)	127	373.4	98	9443	95	66.73	97	1688	94	25.29	19.68	1.01	18.67	129	1738	278	0	73.7
Crystal 803 (CommBench)	128	383.1	101	11191	112	69.78	101	2037	113	29.20	20.10	0.94	19.16	103	1563	280	0	89.7
BTS 8927 (1stYearBench)	129	387.2	102	10430	105	71.04	103	1916	106	26.91	20.20	0.84	19.36	101	1420	240	0	89.3
AP CK MOD SUS RR#5	130	379.0	99	9924	100	68.49	99	1793	99	26.24	19.89	0.94	18.95	109	1607	261	0	83.6
AP CK MOD SUS RR#6	131	388.1	102	10673	107	71.35	103	1959	109	27.53	20.33	0.92	19.41	101	1541	269	0	88.3
RA CK SUS RR#7	132	381.7	100	9247	93	69.32	100	1674	93	24.34	20.01	0.93	19.08	113	1573	258	0	90.4
Experimental Trial (Comm status)																		
BTS 8205	205	385.8	101	10503	105	70.63	102	1934	107	27.01	20.26	0.95	19.31	94	1540	296	0	85.9
BTS 8217	233	379.4	100	9776	98	68.60	99	1759	97	25.97	19.80	0.84	18.95	79	1499	232	0	86.0
BTS 8226	208	382.5	100	10256	103	69.56	101	1870	104	26.79	19.97	0.84	19.12	92	1376	245	0	78.7
BTS 8242	211	379.6	100	10103	101	68.67	99	1834	102	26.57	19.97	0.98	18.98	100	1549	302	0	83.2
BTS 8270	232	385.0	101	10351	104	70.37	102	1904	105	26.66	20.19	0.94	19.25	84	1547	286	0	83.2
BTS 8303	218	387.5	102	9281	93	71.15	103	1708	95	23.77	20.26	0.88	19.38	93	1577	235	0	81.6
BTS 8311	213	390.5	103	9612	97	72.07	104	1771	98	24.58	20.36	0.85	19.51	82	1454	248	0	79.9
BTS 8328	224	379.7	100	9903	99	68.71	99	1794	99	26.00	19.92	0.95	18.96	98	1593	280	0	78.0
BTS 8341	215	374.0	98	7737	78	66.95	97	1399	77	20.36	19.75	1.03	18.71	110	1596	334	0	83.6
BTS 8349	223	367.1	96	9766	98	64.79	94	1709	95	26.80	19.32	0.99	18.33	143	1617	291	0	90.1
BTS 8359	219	367.0	96	10355	104	64.76	94	1843	102	28.00	19.37	1.01	18.36	110	1610	317	0	79.0
BTS 8365	206	388.7	102	10608	107	71.51	103	1963	109	27.07	20.36	0.91	19.45	102	1486	264	0	82.2
Crystal 138	238	381.0	100	10793	108	69.10	100	1976	109	28.00	19.95	0.87	19.07	84	1486	238	0	83.5
Crystal 260	230	380.1	100	10684	107	68.83	100	1937	107	28.16	19.90	0.90	18.99	96	1507	263	0	85.1
Crystal 262	227	375.8	99	10422	105	67.50	98	1872	104	27.74	19.67	0.89	18.77	123	1353	285	0	84.2
Crystal 269	229	391.3	103	10339	104	72.33	105	1922	106	26.19	20.51	0.94	19.57	91	1596	273	0	74.3
Crystal 360	203	385.7	101	10624	107	70.60	102	1932	107	27.74	20.19	0.92	19.27	97	1533	273	0	89.1
Crystal 361	201	378.5	99	11174	112	68.31	99	2001	111	29.66	19.82	0.89	18.92	93	1458	270	0	77.0
Crystal 363	222	375.2	98	10385	104	67.33	97	1880	104	27.40	19.75	0.97	18.77	104	1540	299	0	84.7
Crystal 364	214	376.5	99	10668	107	67.72	98	1926	107	28.18	19.77	0.93	18.83	108	1652	246	0	87.6
Crystal 367	220	362.3	95	9728	98	63.31	92	1704	94	26.91	19.10	1.01	18.09	123	1704	289	0	87.2
Crystal 368	217	375.4	99	10179	102	67.39	98	1832	101	27.03	19.87	1.10	18.76	110	1643	376	0	83.6
Crystal 369	231	384.3	101	10582	106	70.11	101	1936	107	27.37	20.21	1.00	19.21	112	1696	286	0	87.4
Crystal 371	226	389.9	102	10300	103	71.89	104	1911	106	26.22	20.36	0.88	19.48	83	1450	271	0	82.0
Hilleshög HIL2441	234	387.3	102	9551	96	71.08	103	1770	98	24.30	20.31	0.95	19.36	87	1567	284	0	83.7
Hilleshög HIL2442	204	378.8	99	8763	88	68.43	99	1602	89	22.66	20.00	1.05	18.94	101	1598	358	0	81.1
Hilleshög HIL2477	237	361.8	95	9357	94	63.16	91	1649	91	25.62	19.12	1.04	18.08	115	1644	327	0	82.4
Hilleshög HIL2478	209	370.2	97	10556	106	65.77	95	1871	104	28.60	19.50	0.99	18.51	116	1633	297	0	85.2
Hilleshög HIL2479	210	381.7	100	9716	98	69.30	100	1772	98	25.41	20.04	0.95	19.09	116	1436	312	0	91.4
Hilleshög HIL2480	228	382.4	100	9914	100	69.54	101	1792	99	26.02	20.16	1.04	19.12	110	1613	340	0	88.3
Hilleshög HIL2487 (Maribo MA942)	225	374.2	98	9467	95	67.01	97	1690	94	25.46	19.60	0.90	18.70	93	1455	276	0	84.6
Maribo MA943	235	385.5	101	9648	97	70.51	102	1759	97	25.19	20.19	0.93	19.26	85	1532	288	0	74.1
Maribo MA945	202	364.7	96	10553	106	64.05	93	1860	103	28.77	19.20	0.96	18.24	99	1637	270	0	84.1
Maribo MA946	207	382.7	100	10537	106	69.63	101	1903	105	27.73	20.04	0.91	19.13	83	1562	267	0	83.3
SV 231	236	375.5	99	11081	111	67.41	98	1979	110	29.77	19.72	0.95	18.76	102	1561	288	0	88.7
SV 232	216	375.1	98	10530	106	67.29	97	1890	105	28.00	19.67	0.92	18.74	93	1572	265	0	78.0
SX 1835	212	378.1	99	10718	108	68.21	99	1920	106	28.57	19.87	0.98	18.88	104	1569	304	0	85.9
SX 1836	221	374.1	98	10632	107	66.97	97	1899	105	28.50	19.62	0.94	18.68	95	1575	274	0	84.9
BTS 8337 (CommBench)	239	390.2	102	9305	93	71.96	104	1721	95	23.92	20.45	0.96	19.49	115	1594	276	0	82.3
Crystal 578RR (CommBench)	240	377.0	99	9803	98	67.86	98	1762	98	25.93	19.75	0.90	18.84	96	1598	241	0	90.4
BTS 8815 (CommBench)	241	372.5	98	9201	92	66.50	96	1636	91	24.84	19.65	1.01	18.63	132	1731	279	0	75.4
Crystal 803 (CommBench)	242	384.1	101	11520	116	70.07	101	2102	116	29.95	20.16	0.93	19.23	103	1520	275	0	91.9
BTS 8927 (1stYearBench)	243	385.8	101	10105	101	70.61	102	1842	102	26.20	20.16	0.87	19.29	82	1416	270	0	84.0
AP CK MOD SUS RR#5	244	377.9	99	9987	100	68.16	99	1791	99	26.70	19.87	0.98	18.88	120	1647	285	0	83.1
AP CK MOD SUS RR#6	245	384.6	101	10561	106	70.25	102	1942	108	27.24	20.19	0.95	19.24	91	1560	289	0	83.4
RA CK SUS RR#7	246	378.3	99	8857	89	68.27	99	1615	89	23.18	19.85	0.93	18.91	85	1522	290	0	85.4
AP CK MOD RES RR#7	247	375.6	99	11094	111	67.44	98	1986	110	29.64	19.62	0.85	18.77	92	1390	255	0	87.1
AP CK MOD SUS RR#8	248	382.4	100	10730	108	69.53	101	1945	108	28.03	19.97	0.84	19.12	89	1445	236	0	88.0
Comm Benchmark Mean		381.0		9958		69.10		1805		26.16	20.00	0.95		116	1638	264		83.9
Comm Trial Mean		380.0		10507		68.79		1901		27.69	19.91	0.91		108	1552	253		87.0
Coeff. of Var. (%)		2.1		4.8		3.6		5.5		4.5	1.9	6.4		17.6	3.7	12.7		6.7
Mean LSD (0.05)		7.1		457		2.22		96		1.13	0.34	0.05		17	51	29		4.9
Mean LSD (0.01)		9.4		602		2.93		126		1.49	0.44	0.07		23	68	38		6.5
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from Grand Forks ND

Created 10/18/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 16. 2023 Performance of Varieties - ACSC RR Official Trials Scandia MN

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T %Bnch	Rev/A + $	Rev/A %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	348.6	100	12422	110	59.02	100	2106	110	35.58	18.20	0.77	17.43	102	1320	209	0	77.7
BTS 8034	101	347.8	100	12825	114	58.75	99	2165	113	36.88	18.22	0.84	17.38	115	1460	219	0	78.7
BTS 8156	114	344.2	99	12121	107	57.62	97	2027	106	35.24	18.01	0.80	17.21	99	1397	213	0	73.4
BTS 8927	109	346.6	99	12445	110	58.39	99	2096	110	35.90	18.08	0.75	17.33	110	1258	207	1	80.8
Crystal 022	121	359.6	103	12108	107	62.45	106	2103	110	33.68	18.73	0.75	17.98	84	1286	212	0	74.9
Crystal 130	113	351.2	101	12452	110	59.80	101	2120	111	35.47	18.30	0.74	17.56	89	1288	201	0	77.8
Crystal 137	122	358.9	103	12330	109	62.22	105	2132	111	34.45	18.72	0.77	17.95	90	1425	186	0	80.3
Crystal 793	118	353.8	101	12447	110	60.63	102	2131	111	35.16	18.48	0.79	17.69	88	1337	225	0	73.4
Crystal 912	116	344.3	99	12752	113	57.67	97	2135	112	37.05	17.97	0.75	17.22	115	1212	220	0	80.0
Crystal 913	106	352.3	101	12951	115	60.15	102	2209	115	36.81	18.39	0.77	17.62	94	1283	224	0	77.8
Hilleshög HIL2317	120	350.1	100	11403	101	59.47	101	1937	101	32.62	18.32	0.81	17.51	132	1414	207	0	68.7
Hilleshög HIL2366	111	337.7	97	11081	98	55.61	94	1821	95	32.90	17.69	0.80	16.89	119	1298	231	0	77.4
Hilleshög HIL2368	119	353.6	101	11443	101	60.57	102	1957	102	32.41	18.47	0.79	17.68	107	1367	210	0	66.3
Hilleshög HIL2386	112	350.0	100	12313	109	59.44	100	2094	109	35.14	18.30	0.80	17.50	89	1374	218	0	78.7
Hilleshög HIL2389	105	346.4	99	11664	103	58.32	99	1965	103	33.66	18.11	0.79	17.32	88	1391	210	0	76.0
Hilleshög HIL9920	115	344.0	99	11518	102	57.58	97	1927	101	33.50	18.06	0.85	17.21	146	1434	226	0	76.8
Maribo MA717	110	349.6	100	11984	106	59.33	100	2031	106	34.36	18.31	0.83	17.48	98	1400	236	0	79.6
Maribo MA902	124	345.6	99	11532	102	58.07	98	1936	101	33.39	18.06	0.78	17.28	94	1342	214	0	74.4
SV 203	123	353.8	101	12204	108	60.62	102	2088	109	34.54	18.46	0.77	17.69	89	1337	211	0	83.8
SV 265	107	348.0	100	11951	106	58.82	99	2019	106	34.40	18.20	0.80	17.40	98	1332	232	0	81.2
SV 285	108	350.8	100	12116	107	59.69	101	2056	107	34.62	18.37	0.83	17.54	103	1415	232	0	78.4
SX 1815	104	351.8	101	12351	109	60.00	101	2105	110	35.09	18.35	0.77	17.58	79	1332	210	0	78.9
SX 1818	103	347.8	100	12629	112	58.75	99	2135	112	36.28	18.19	0.80	17.39	95	1378	220	0	83.1
SX 1898	102	346.8	99	11781	104	58.44	99	1982	104	34.04	18.12	0.78	17.34	94	1349	216	0	79.8
BTS 8337 (CommBench)	125	357.5	102	10872	96	61.79	104	1878	98	30.43	18.79	0.91	17.88	106	1568	256	0	76.2
Crystal 578RR (CommBench)	126	340.6	98	11219	99	56.52	96	1862	97	32.93	17.91	0.88	17.03	129	1460	248	0	71.8
BTS 8815 (CommBench)	127	347.6	100	10431	92	58.71	99	1760	92	30.08	18.24	0.86	17.38	111	1503	225	0	63.5
Crystal 803 (CommBench)	128	350.6	100	12662	112	59.62	101	2153	113	36.08	18.35	0.82	17.53	83	1392	235	0	77.7
BTS 8927 (1stYearBench)	129	357.4	102	12225	108	61.75	104	2114	110	34.20	18.57	0.71	17.86	91	1211	194	0	73.2
AP CK MOD SUS RR#5	130	339.3	97	11057	98	56.12	95	1833	96	32.53	17.81	0.84	16.97	112	1410	239	0	67.5
AP CK MOD SUS RR#6	131	356.9	102	11771	104	61.60	104	2029	106	33.00	18.66	0.81	17.85	90	1316	249	0	76.8
RA CK SUS RR#7	132	339.3	97	11421	101	56.10	95	1889	99	33.67	17.77	0.81	16.96	118	1342	229	0	74.1
Experimental Trial (Comm status)																		
BTS 8205	205	354.2	101	12275	109	60.73	103	2116	111	34.20	18.54	0.84	17.70	77	1373	247	0	71.3
BTS 8217	233	348.3	100	12936	115	58.91	100	2178	114	37.32	18.20	0.78	17.43	96	1349	204	0	73.7
BTS 8226	208	353.6	101	12920	114	60.53	102	2208	115	36.57	18.43	0.75	17.69	94	1264	206	0	72.3
BTS 8242	211	349.3	100	11892	105	59.22	100	2008	105	34.24	18.30	0.84	17.47	102	1362	247	0	72.0
BTS 8270	232	356.7	102	12289	109	61.52	104	2110	110	34.62	18.65	0.81	17.84	94	1402	217	0	76.0
BTS 8303	218	351.6	101	11362	101	59.93	101	1937	101	32.24	18.43	0.85	17.58	109	1492	221	0	63.1
BTS 8311	213	361.9	104	11273	100	63.14	107	1959	102	31.33	18.89	0.79	18.10	105	1320	220	0	70.5
BTS 8328	224	361.7	104	12409	110	63.05	107	2168	113	34.16	18.97	0.88	18.09	97	1460	255	0	66.9
BTS 8341	215	348.8	100	8361	74	59.07	100	1426	75	23.72	18.33	0.90	17.43	100	1475	261	0	69.7
BTS 8349	223	340.8	98	12528	111	56.59	96	2078	109	36.62	17.94	0.90	17.04	134	1442	250	0	67.1
BTS 8359	219	356.4	102	12157	108	61.44	104	2090	109	34.20	18.66	0.84	17.82	94	1420	231	0	64.9
BTS 8365	206	356.7	102	11767	104	61.52	104	2032	106	32.91	18.62	0.79	17.83	97	1278	226	0	75.1
Crystal 138	238	347.6	100	12206	108	58.71	99	2062	108	35.07	18.15	0.78	17.38	101	1291	211	0	69.3
Crystal 260	230	346.6	99	12253	108	58.38	99	2056	107	35.54	18.11	0.79	17.33	104	1368	205	0	71.2
Crystal 262	227	349.2	100	12208	108	59.19	100	2071	108	34.82	18.25	0.80	17.46	112	1293	226	0	72.6
Crystal 269	229	364.5	104	11334	100	63.93	108	1997	104	30.81	19.11	0.88	18.23	104	1462	252	0	60.2
Crystal 360	203	352.8	101	11927	106	60.29	102	2043	107	33.56	18.46	0.83	17.63	87	1379	236	0	68.4
Crystal 361	201	360.1	103	12708	112	62.56	106	2215	116	35.09	18.75	0.74	18.01	92	1251	202	0	69.0
Crystal 363	222	365.4	105	11542	102	64.21	109	2029	106	31.59	19.14	0.86	18.28	87	1458	244	0	67.4
Crystal 364	214	341.1	98	12579	111	56.66	96	2079	109	37.04	17.96	0.90	17.06	151	1517	235	0	71.3
Crystal 367	220	342.1	98	12496	111	56.99	96	2081	109	36.54	17.96	0.85	17.11	108	1497	219	0	73.4
Crystal 368	217	346.9	99	11988	106	58.47	99	2027	106	34.42	18.24	0.90	17.35	98	1462	272	0	69.7
Crystal 369	231	356.0	102	12355	109	61.30	104	2130	111	34.66	18.71	0.90	17.81	107	1416	278	0	77.4
Crystal 371	226	363.9	104	12000	106	63.75	108	2106	110	32.79	18.96	0.76	18.20	90	1316	202	0	72.4
Hilleshög HIL2441	234	349.1	100	11348	100	59.15	100	1922	100	32.49	18.41	0.96	17.45	112	1466	300	0	72.3
Hilleshög HIL2442	204	340.1	97	11320	100	56.36	95	1876	98	33.24	17.94	0.94	17.00	108	1413	305	0	68.9
Hilleshög HIL2477	237	326.5	94	10920	97	52.15	88	1746	91	33.42	17.29	0.97	16.32	168	1465	296	0	64.1
Hilleshög HIL2478	209	337.7	97	12306	109	55.62	94	2025	106	36.54	17.80	0.91	16.89	149	1494	247	0	68.1
Hilleshög HIL2479	210	346.0	99	11859	105	58.19	98	1991	104	34.27	18.13	0.84	17.30	119	1349	242	0	77.5
Hilleshög HIL2480	228	351.7	101	11996	106	59.97	101	2032	106	34.34	18.53	0.95	17.58	114	1460	299	0	79.4
Hilleshög HIL2487 (Maribo MA942)	225	338.0	97	11944	106	55.72	94	1971	103	35.36	17.71	0.81	16.90	98	1298	237	0	74.7
Maribo MA943	235	358.7	103	11452	101	62.13	105	1989	104	31.54	18.81	0.88	17.93	93	1373	272	0	61.1
Maribo MA945	202	334.3	96	11722	104	54.57	92	1907	100	35.07	17.60	0.89	16.71	118	1457	251	0	74.5
Maribo MA946	207	350.7	100	12099	107	59.66	101	2061	108	34.29	18.40	0.87	17.53	121	1399	250	0	72.1
SV 231	236	339.7	97	11648	103	56.23	95	1921	100	34.34	17.86	0.87	16.99	115	1495	229	0	68.0
SV 232	216	351.4	101	11476	102	59.85	101	1947	102	32.83	18.37	0.80	17.58	98	1383	212	0	74.3
SX 1835	212	341.8	98	11923	106	56.89	96	1983	104	34.93	17.97	0.88	17.09	106	1451	250	0	70.0
SX 1836	221	336.2	96	11390	101	55.17	93	1865	97	33.94	17.71	0.90	16.81	125	1454	261	0	73.1
BTS 8337 (CommBench)	239	354.8	102	10330	91	60.92	103	1770	92	29.11	18.63	0.90	17.73	115	1523	244	0	62.0
Crystal 578RR (CommBench)	240	340.0	97	11812	105	56.33	95	1961	103	34.60	17.85	0.85	17.00	136	1427	219	0	65.7
BTS 8815 (CommBench)	241	349.8	100	10417	92	59.38	100	1776	93	29.65	18.34	0.85	17.50	104	1475	223	0	56.2
Crystal 803 (CommBench)	242	351.8	101	12625	112	60.00	101	2146	112	36.15	18.47	0.88	17.59	103	1404	264	0	70.2
BTS 8927 (1stYearBench)	243	354.9	102	12053	107	60.92	103	2066	108	33.99	18.50	0.76	17.74	92	1284	206	0	71.8
AP CK MOD SUS RR#5	244	348.8	100	11434	101	59.05	100	1939	101	32.70	18.27	0.84	17.44	101	1429	227	0	63.3
AP CK MOD SUS RR#6	245	349.8	100	11623	103	59.36	100	1976	103	33.17	18.38	0.90	17.48	107	1381	281	0	73.3
RA CK SUS RR#7	246	336.9	97	11107	98	55.37	94	1827	95	32.95	17.63	0.79	16.84	122	1348	203	0	63.8
AP CK MOD RES RR#7	247	345.3	99	13337	118	57.99	98	2235	117	38.54	18.14	0.88	17.27	138	1322	269	0	68.1
AP CK MOD SUS RR#8	248	352.7	101	11962	106	60.26	102	2048	107	33.72	18.43	0.80	17.63	96	1291	233	0	75.2
Comm Benchmark Mean		349.1		11296		59.16		1913		32.38	18.32	0.87		107	1481	241		72.3
Comm Trial Mean		349.1		11953		59.17		2025		34.25	18.26	0.80		102	1363	221		76.2
Coeff. of Var. (%)		2.3		5.1		4.2		5.9		4.9	2.1	6.3		19.3	4.4	11.6		10.4
Mean LSD (0.05)		7.0		541		2.19		106		1.51	0.34	0.04		18	52	23		6.7
Mean LSD (0.01)		9.3		712		2.89		140		1.99	0.44	0.06		23	69	30		8.8
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from Scandia MN

Created 10/19/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 17. 2023 Performance of Varieties - ACSC RR Official Trials East Grand Forks MN

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T %Bnch	Rev/A + $	Rev/A %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	310.7	100	11474	103	47.16	99	1737	103	37.00	16.95	1.41	15.54	170	1632	599	0	85.9
BTS 8034	101	294.6	94	10608	95	42.14	89	1522	90	36.05	16.34	1.62	14.72	285	1926	639	0	90.3
BTS 8156	114	324.1	104	11424	103	51.37	108	1806	107	35.40	17.64	1.43	16.21	171	1861	553	0	85.5
BTS 8927	109	322.4	103	11013	99	50.83	107	1737	103	34.29	17.43	1.32	16.11	150	1571	548	0	90.1
Crystal 022	121	319.8	102	11588	104	50.00	105	1809	107	36.12	17.41	1.41	16.00	153	1643	598	0	84.9
Crystal 130	113	317.4	102	11804	106	49.27	103	1818	108	37.40	17.24	1.37	15.87	163	1655	562	0	86.6
Crystal 137	122	317.4	102	11174	100	49.26	103	1738	103	35.16	17.29	1.42	15.87	177	1871	544	1	83.8
Crystal 793	118	314.7	101	11540	104	48.42	102	1773	105	36.66	17.08	1.34	15.74	187	1652	534	0	86.8
Crystal 912	116	295.6	95	12005	108	42.47	89	1733	102	40.46	16.27	1.50	14.77	228	1619	645	0	88.2
Crystal 913	106	318.9	102	11704	105	49.74	104	1819	108	36.73	17.30	1.34	15.96	196	1598	542	0	91.7
Hilleshög HIL2317	120	303.4	97	10844	97	44.91	94	1611	95	35.91	16.62	1.46	15.16	226	1802	572	0	79.4
Hilleshög HIL2366	111	291.6	93	10445	94	41.21	87	1476	87	35.77	15.92	1.35	14.57	226	1614	532	0	85.2
Hilleshög HIL2368	119	300.7	96	10126	91	44.04	92	1483	88	33.79	16.49	1.46	15.03	212	1629	620	0	79.6
Hilleshög HIL2386	112	302.8	97	10651	96	44.71	94	1570	93	35.32	16.51	1.38	15.13	224	1655	549	0	85.7
Hilleshög HIL2389	105	316.6	101	11309	102	49.01	103	1746	103	35.80	17.19	1.36	15.83	177	1719	528	0	86.9
Hilleshög HIL9920	115	299.7	96	10664	96	43.73	92	1552	92	35.58	16.45	1.46	14.99	227	1838	558	0	84.2
Maribo MA717	110	290.6	93	10471	94	40.91	86	1461	86	36.16	15.80	1.27	14.53	241	1644	462	0	87.7
Maribo MA902	124	293.0	94	9770	88	41.64	87	1387	82	33.38	16.05	1.39	14.66	250	1596	566	0	82.2
SV 203	123	321.7	103	11292	101	50.60	106	1782	105	35.03	17.37	1.28	16.09	155	1699	489	0	84.8
SV 265	107	299.3	96	10616	95	43.62	92	1544	91	35.50	16.31	1.34	14.97	195	1723	511	0	88.6
SV 285	108	307.7	99	11161	100	46.25	97	1678	99	36.34	16.82	1.43	15.39	193	1841	550	0	88.5
SX 1815	104	317.8	102	11129	100	49.39	104	1722	102	35.18	17.30	1.40	15.90	165	1720	568	0	87.4
SX 1818	103	298.3	96	11028	99	43.30	91	1599	95	37.18	16.37	1.47	14.90	162	1832	589	0	85.6
SX 1898	102	301.7	97	10663	96	44.35	93	1564	93	35.47	16.52	1.44	15.08	198	1863	550	0	90.7
BTS 8337 (CommBench)	125	328.3	105	10976	99	52.69	111	1752	104	33.62	17.90	1.48	16.42	190	1749	615	0	84.4
Crystal 578RR (CommBench)	126	291.3	93	10662	96	41.11	86	1493	88	36.78	16.08	1.51	14.57	229	1808	606	0	86.8
BTS 8815 (CommBench)	127	312.4	100	11183	100	47.72	100	1713	101	35.68	17.11	1.49	15.62	228	1917	560	0	76.0
Crystal 803 (CommBench)	128	316.3	101	11696	105	48.93	103	1805	107	37.04	17.22	1.40	15.82	160	1661	587	1	87.5
BTS 8927 (1stYearBench)	129	325.8	104	10753	97	51.90	109	1711	101	32.77	17.64	1.34	16.30	164	1569	562	0	82.9
AP CK MOD SUS RR#5	130	304.1	97	11582	104	45.11	95	1703	101	38.29	16.79	1.58	15.21	217	1909	637	0	85.3
AP CK MOD SUS RR#6	131	327.8	105	11500	103	52.52	110	1836	109	35.15	17.76	1.37	16.39	156	1655	564	0	90.5
RA CK SUS RR#7	132	289.3	93	9659	87	40.49	85	1351	80	33.52	15.79	1.34	14.45	285	1593	504	0	85.9
Experimental Trial (Comm status)																		
BTS 8205	205	315.3	101	11181	100	48.61	102	1720	102	35.61	17.18	1.41	15.77	148	1598	560	0	75.9
BTS 8217	233	324.0	104	11536	104	51.31	108	1814	107	35.62	17.53	1.32	16.22	163	1752	447	0	82.2
BTS 8226	208	324.9	104	11323	102	51.60	108	1791	106	34.95	17.51	1.23	16.28	126	1471	472	0	80.9
BTS 8242	211	324.3	104	11410	103	51.40	108	1799	106	35.50	17.59	1.38	16.21	152	1549	556	0	81.3
BTS 8270	232	316.8	102	11111	100	49.09	103	1711	101	35.49	17.20	1.36	15.85	157	1573	523	0	86.2
BTS 8303	218	324.3	104	11138	100	51.40	108	1765	104	34.65	17.61	1.39	16.22	158	1629	529	0	82.7
BTS 8311	213	336.5	108	10359	93	55.19	116	1705	101	31.06	18.03	1.19	16.84	121	1485	437	0	67.7
BTS 8328	224	319.0	102	11324	102	49.75	104	1758	104	35.76	17.30	1.34	15.97	192	1646	476	0	83.3
BTS 8341	215	317.1	102	8982	81	49.18	103	1410	83	28.01	17.25	1.38	15.87	162	1594	533	0	73.3
BTS 8349	223	295.5	95	10712	96	42.47	89	1537	91	36.36	16.23	1.46	14.76	223	1779	526	0	85.3
BTS 8359	219	314.3	101	11589	104	48.29	101	1788	106	36.84	17.08	1.35	15.73	143	1592	515	0	79.2
BTS 8365	206	329.6	106	10589	95	53.07	111	1696	100	32.27	17.76	1.25	16.51	142	1544	463	0	84.1
Crystal 138	238	320.9	103	11741	105	50.35	106	1843	109	36.71	17.46	1.40	16.06	156	1627	538	0	80.1
Crystal 260	230	315.5	101	11055	99	48.68	102	1701	101	35.46	17.16	1.39	15.77	161	1638	527	0	85.7
Crystal 262	227	312.3	100	11944	107	47.69	100	1814	107	38.33	17.02	1.39	15.62	181	1554	548	0	82.0
Crystal 269	229	306.6	98	11245	101	45.90	96	1677	99	36.95	16.88	1.56	15.32	214	1689	624	0	81.9
Crystal 360	203	315.5	101	11440	103	48.68	102	1767	105	36.29	17.11	1.31	15.81	119	1583	505	0	83.8
Crystal 361	201	320.6	103	11036	99	50.25	106	1720	102	34.82	17.33	1.29	16.05	151	1432	512	0	75.2
Crystal 363	222	321.8	103	11021	99	50.61	106	1735	103	34.61	17.37	1.30	16.08	124	1559	500	0	81.9
Crystal 364	214	306.2	98	12606	113	45.78	96	1877	111	41.42	16.78	1.46	15.31	210	1799	527	0	89.9
Crystal 367	220	305.3	98	11232	101	45.49	96	1668	99	36.75	16.81	1.52	15.29	216	1874	537	0	87.5
Crystal 368	217	314.7	101	10871	98	48.43	102	1668	99	34.93	17.12	1.38	15.74	179	1544	535	0	83.4
Crystal 369	231	308.7	99	11611	104	46.57	98	1745	103	37.66	17.01	1.54	15.47	196	1674	612	0	87.2
Crystal 371	226	321.3	103	10312	93	50.46	106	1620	96	32.06	17.35	1.26	16.09	139	1500	474	0	72.1
Hilleshög HIL2441	234	300.5	96	10621	95	44.00	92	1554	92	35.20	16.57	1.53	15.04	179	1612	630	0	82.7
Hilleshög HIL2442	204	310.6	100	10458	94	47.16	99	1591	94	33.61	16.96	1.39	15.56	174	1533	552	0	77.8
Hilleshög HIL2477	237	292.4	94	10820	97	41.51	87	1537	91	36.91	16.22	1.60	14.61	282	1783	602	0	75.8
Hilleshög HIL2478	209	278.1	89	10786	97	37.08	78	1448	86	38.58	15.51	1.59	13.91	319	1833	569	0	80.1
Hilleshög HIL2479	210	310.3	99	10573	95	47.07	99	1598	95	34.07	16.99	1.46	15.52	210	1498	600	0	80.7
Hilleshög HIL2480	228	304.0	97	11046	99	45.09	95	1637	97	36.28	16.79	1.57	15.21	263	1627	629	0	85.8
Hilleshög HIL2487 (Maribo MA942)	225	318.9	102	10609	95	49.74	104	1652	98	33.48	17.26	1.32	15.95	155	1564	498	0	82.5
Maribo MA943	235	308.4	99	10871	98	46.51	98	1633	97	35.28	17.04	1.58	15.45	238	1710	617	0	68.9
Maribo MA945	202	302.7	97	11342	102	44.71	94	1671	99	37.47	16.60	1.43	15.16	179	1728	530	0	79.8
Maribo MA946	207	313.6	100	10775	97	48.10	101	1644	97	34.73	16.99	1.30	15.69	206	1535	468	0	79.5
SV 231	236	315.0	101	11706	105	48.52	102	1799	106	37.32	17.11	1.35	15.77	166	1685	486	0	85.5
SV 232	216	304.0	97	9965	90	45.11	95	1476	87	32.94	16.61	1.38	15.22	199	1765	474	0	77.7
SX 1835	212	303.8	97	11313	102	45.03	95	1681	99	37.28	16.60	1.39	15.20	202	1690	499	0	83.1
SX 1836	221	306.0	98	10824	97	45.72	96	1610	95	35.48	16.76	1.43	15.32	186	1758	522	0	74.5
BTS 8337 (CommBench)	239	324.3	104	10641	96	51.39	108	1687	100	32.82	17.68	1.46	16.22	182	1688	554	0	81.5
Crystal 578RR (CommBench)	240	303.1	97	11619	104	44.83	94	1717	102	38.11	16.66	1.48	15.18	204	1745	541	0	82.3
BTS 8815 (CommBench)	241	307.9	99	10852	98	46.33	97	1628	96	35.42	16.92	1.53	15.39	231	1754	574	0	71.7
Crystal 803 (CommBench)	242	313.0	100	11405	102	47.90	101	1732	102	36.77	17.06	1.41	15.64	188	1627	536	0	89.8
BTS 8927 (1stYearBench)	243	324.8	104	10582	95	51.54	108	1684	100	32.70	17.55	1.30	16.26	198	1484	485	0	83.2
AP CK MOD SUS RR#5	244	294.7	94	11527	104	42.22	89	1647	97	39.16	16.28	1.55	14.73	242	1783	578	0	76.4
AP CK MOD SUS RR#6	245	316.1	101	11137	100	48.87	103	1714	101	35.54	17.24	1.44	15.80	152	1631	573	0	82.7
RA CK SUS RR#7	246	293.1	94	9729	87	41.74	88	1385	82	32.93	16.05	1.37	14.68	252	1516	504	0	84.6
AP CK MOD RES RR#7	247	304.3	97	11612	104	45.19	95	1720	102	38.49	16.61	1.40	15.20	197	1540	543	0	73.3
AP CK MOD SUS RR#8	248	325.2	104	11319	102	51.67	109	1801	107	34.97	17.61	1.34	16.28	149	1541	512	0	82.6
Comm Benchmark Mean		312.1		11129		47.61		1691		35.78	17.08	1.47		202	1784	592		83.7
Comm Trial Mean		308.6		11016		46.53		1657		35.77	16.84	1.41		199	1721	564		85.9
Coeff. of Var. (%)		3.5		5.9		7.3		8.7		5.0	2.9	7.8		21.9	5.8	10.7		8.9
Mean LSD (0.05)		9.9		587		3.10		129		1.62	0.45	0.10		39	87	55		6.4
Mean LSD (0.01)		13.1		773		4.08		170		2.13	0.59	0.13		51	115	72		8.4
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from East Grand Forks MN

Created 10/19/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 18. 2023 Performance of Varieties - ACSC RR Official Trials Stephen MN

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T + %Bnch	Rev/A + $	Rev/A + %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	374.3	99	13760	106	67.04	99	2461	105	36.83	19.49	0.78	18.71	106	1374	200	0	75.0
BTS 8034	101	357.8	95	13506	104	61.87	91	2328	100	37.89	18.79	0.90	17.89	161	1536	234	0	80.6
BTS 8156	114	372.2	99	13489	104	66.39	98	2401	103	36.32	19.48	0.87	18.61	152	1483	225	0	70.2
BTS 8927	109	380.8	101	13534	104	69.07	102	2452	105	35.60	19.84	0.80	19.04	128	1345	214	0	76.5
Crystal 022	121	387.9	103	13783	106	71.27	105	2530	108	35.57	20.16	0.76	19.40	97	1336	199	0	79.2
Crystal 130	113	384.9	102	14227	109	70.33	104	2596	111	37.04	20.03	0.78	19.25	113	1405	190	0	73.8
Crystal 137	122	369.8	98	13492	104	65.61	97	2391	102	36.53	19.34	0.85	18.49	128	1494	217	0	76.9
Crystal 793	118	378.8	101	14485	111	68.45	101	2613	112	38.32	19.82	0.88	18.94	131	1433	250	0	79.1
Crystal 912	116	372.4	99	13917	107	66.44	98	2485	106	37.32	19.39	0.77	18.62	127	1314	202	0	79.0
Crystal 913	106	376.4	100	14363	110	67.68	100	2583	111	38.15	19.64	0.81	18.83	124	1398	215	0	81.5
Hilleshög HIL2317	120	378.2	101	13474	104	68.25	101	2431	104	35.63	19.73	0.82	18.91	119	1489	200	0	63.4
Hilleshög HIL2366	111	363.5	97	12845	99	63.65	94	2250	96	35.33	19.05	0.87	18.18	146	1433	244	0	80.3
Hilleshög HIL2368	119	375.3	100	12195	94	67.35	100	2186	94	32.56	19.60	0.84	18.76	136	1417	227	0	69.0
Hilleshög HIL2386	112	372.1	99	13228	102	66.33	98	2357	101	35.59	19.49	0.89	18.60	128	1452	255	0	75.5
Hilleshög HIL2389	105	378.8	101	13934	107	68.42	101	2514	108	36.86	19.74	0.80	18.94	102	1395	216	0	81.8
Hilleshög HIL9920	115	377.0	100	13839	106	67.87	100	2493	107	36.68	19.69	0.84	18.85	124	1510	208	0	76.4
Maribo MA717	110	379.3	101	13775	106	68.60	101	2491	107	36.30	19.82	0.85	18.97	122	1496	215	0	79.6
Maribo MA902	124	368.9	98	13211	102	65.36	97	2338	100	35.85	19.33	0.88	18.45	173	1461	230	0	80.1
SV 203	123	376.4	100	14604	112	67.69	100	2621	112	38.90	19.64	0.83	18.81	103	1395	233	0	85.4
SV 265	107	373.4	99	13989	108	66.76	99	2496	107	37.55	19.52	0.85	18.67	120	1456	229	0	82.1
SV 285	108	379.9	101	14049	108	68.78	102	2540	109	37.04	19.80	0.80	19.00	113	1450	196	0	85.5
SX 1815	104	377.7	100	14306	110	68.08	101	2577	110	37.91	19.72	0.84	18.88	111	1432	229	0	81.0
SX 1818	103	367.2	98	14207	109	64.80	96	2505	107	38.74	19.19	0.83	18.36	119	1445	218	0	79.5
SX 1898	102	378.0	100	14321	110	68.18	101	2583	111	37.89	19.68	0.78	18.90	108	1354	206	0	78.8
BTS 8337 (CommBench)	125	385.2	102	12655	97	70.43	104	2312	99	32.90	20.11	0.85	19.26	125	1528	205	0	72.7
Crystal 578RR (CommBench)	126	375.8	100	12919	99	67.49	100	2318	99	34.42	19.62	0.83	18.79	115	1478	209	0	72.8
BTS 8815 (CommBench)	127	372.5	99	12126	93	66.47	98	2161	93	32.63	19.50	0.88	18.62	136	1542	222	0	63.6
Crystal 803 (CommBench)	128	371.7	99	14305	110	66.20	98	2549	109	38.48	19.45	0.87	18.58	129	1502	224	0	80.8
BTS 8927 (1stYearBench)	129	383.1	102	13751	106	69.77	103	2502	107	35.95	19.97	0.81	19.16	113	1365	226	0	81.4
AP CK MOD SUS RR#5	130	374.2	99	13614	105	66.98	99	2437	104	36.39	19.60	0.89	18.71	123	1559	229	0	71.8
AP CK MOD SUS RR#6	131	389.2	103	14169	109	71.67	106	2608	112	36.43	20.24	0.78	19.46	106	1355	210	0	79.3
RA CK SUS RR#7	132	372.5	99	12499	96	66.46	98	2231	96	33.54	19.49	0.86	18.63	128	1479	230	0	74.7
Experimental Trial (Comm status)																		
BTS 8205	205	389.2	103	14788	114	71.67	106	2728	117	37.99	20.30	0.85	19.46	112	1417	233	0	75.9
BTS 8217	233	370.5	98	13475	104	65.82	97	2404	103	36.22	19.31	0.79	18.52	124	1439	177	0	69.0
BTS 8226	208	381.0	101	13845	106	69.14	102	2516	108	36.13	19.81	0.77	19.05	115	1297	200	0	73.6
BTS 8242	211	393.1	104	14559	112	72.89	108	2701	116	37.00	20.41	0.76	19.66	102	1340	190	0	81.6
BTS 8270	232	375.8	100	14248	110	67.48	100	2571	110	37.77	19.67	0.88	18.79	122	1506	232	0	74.4
BTS 8303	218	389.3	103	13462	104	71.71	106	2482	106	34.50	20.34	0.88	19.47	111	1525	227	0	71.0
BTS 8311	213	396.8	105	13067	101	74.04	109	2451	105	32.84	20.64	0.82	19.83	109	1465	198	0	71.6
BTS 8328	224	377.2	100	13306	102	67.93	100	2403	103	35.12	19.71	0.85	18.87	120	1495	210	0	73.9
BTS 8341	215	377.7	100	10488	81	68.09	101	1902	81	27.68	19.76	0.89	18.88	134	1507	236	0	71.6
BTS 8349	223	372.9	99	13696	105	66.57	98	2452	105	36.76	19.45	0.82	18.63	128	1444	195	0	81.2
BTS 8359	219	372.5	99	13253	102	66.45	98	2369	101	35.57	19.50	0.87	18.63	115	1480	227	0	73.8
BTS 8365	206	396.6	105	14189	109	73.99	109	2648	113	35.60	20.57	0.73	19.85	100	1323	172	0	69.2
Crystal 138	238	374.5	100	14618	112	67.08	99	2623	112	39.04	19.54	0.81	18.73	112	1410	204	0	73.2
Crystal 260	230	370.7	99	14599	112	65.88	97	2606	112	39.19	19.37	0.84	18.53	125	1463	207	0	75.5
Crystal 262	227	371.8	99	13809	106	66.23	98	2464	106	37.00	19.43	0.84	18.59	163	1402	211	0	78.8
Crystal 269	229	401.7	107	14111	109	75.59	112	2662	114	34.90	20.92	0.84	20.09	113	1519	201	0	62.4
Crystal 360	203	381.5	101	14069	108	69.29	102	2555	109	36.80	19.88	0.81	19.08	110	1436	203	0	73.2
Crystal 361	201	391.9	104	13986	108	72.53	107	2591	111	35.79	20.38	0.80	19.59	116	1356	209	0	74.5
Crystal 363	222	390.4	104	13388	103	72.06	107	2470	106	34.11	20.35	0.83	19.53	100	1443	219	0	71.2
Crystal 364	214	363.8	97	14118	109	63.75	94	2468	106	38.80	19.11	0.92	18.19	195	1488	243	0	77.9
Crystal 367	220	367.9	98	13342	103	65.03	96	2360	101	36.26	19.27	0.87	18.40	119	1515	219	0	78.2
Crystal 368	217	377.5	100	13727	106	68.02	101	2468	106	36.47	19.78	0.91	18.88	121	1534	249	0	72.7
Crystal 369	231	387.5	103	13556	104	71.16	105	2497	107	34.81	20.27	0.90	19.38	108	1571	233	0	75.3
Crystal 371	226	383.9	102	12886	99	70.02	104	2356	101	33.38	20.03	0.83	19.21	118	1346	229	0	63.3
Hilleshög HIL2441	234	384.1	102	12666	97	70.08	104	2307	99	32.95	20.10	0.91	19.20	125	1546	244	0	75.8
Hilleshög HIL2442	204	377.5	100	12723	98	68.03	101	2293	98	33.59	20.09	1.22	18.87	104	1557	480	0	69.4
Hilleshög HIL2477	237	360.5	96	13095	101	62.71	93	2278	98	36.22	18.94	0.92	18.02	140	1569	240	0	72.9
Hilleshög HIL2478	209	365.9	97	13032	100	64.39	95	2300	98	35.38	19.15	0.84	18.31	138	1471	203	0	70.8
Hilleshög HIL2479	210	383.9	102	13435	103	70.03	104	2464	106	34.83	20.08	0.90	19.19	143	1406	266	0	75.7
Hilleshög HIL2480	228	381.3	101	12551	97	69.22	102	2285	98	32.65	19.99	0.92	19.08	149	1420	269	0	77.4
Hilleshög HIL2487 (Maribo MA942)	225	381.4	101	13039	100	69.25	102	2371	102	33.97	19.86	0.79	19.08	104	1362	209	0	81.5
Maribo MA943	235	380.9	101	12727	98	69.08	102	2316	99	33.39	19.97	0.93	19.05	116	1536	264	0	62.4
Maribo MA945	202	374.6	100	13398	103	67.09	99	2401	103	35.60	19.57	0.84	18.73	131	1487	204	0	70.8
Maribo MA946	207	385.6	102	13319	102	70.57	104	2436	104	34.56	20.16	0.88	19.29	139	1437	242	0	76.6
SV 231	236	381.7	101	14769	114	69.33	102	2698	116	38.38	19.91	0.83	19.09	102	1433	218	0	76.1
SV 232	216	365.5	97	13413	103	64.27	95	2366	101	36.56	19.15	0.88	18.27	135	1550	213	0	67.8
SX 1835	212	375.5	100	15366	118	67.39	100	2766	118	40.74	19.65	0.89	18.76	123	1488	240	0	78.8
SX 1836	221	382.3	102	13804	106	69.52	103	2516	108	35.92	19.95	0.84	19.12	101	1468	215	0	71.1
BTS 8337 (CommBench)	239	374.1	99	13170	101	66.95	99	2353	101	35.37	19.61	0.91	18.70	130	1562	236	0	67.5
Crystal 578RR (CommBench)	240	370.3	98	13667	105	65.77	97	2424	104	36.97	19.36	0.84	18.52	142	1478	202	0	81.3
BTS 8815 (CommBench)	241	375.6	100	11401	88	67.42	100	2041	87	30.47	19.63	0.85	18.78	136	1533	194	0	58.0
Crystal 803 (CommBench)	242	385.3	102	13766	106	70.46	104	2522	108	35.63	20.09	0.84	19.26	106	1480	215	0	79.9
BTS 8927 (1stYearBench)	243	394.6	105	14436	111	73.35	108	2686	115	36.42	20.51	0.79	19.73	98	1373	204	0	77.0
AP CK MOD SUS RR#5	244	385.3	102	14020	108	70.47	104	2554	109	36.51	20.12	0.85	19.28	120	1520	206	0	75.7
AP CK MOD SUS RR#6	245	380.8	101	13676	105	69.06	102	2476	106	36.06	19.85	0.82	19.04	119	1396	213	0	80.5
RA CK SUS RR#7	246	371.1	99	12392	95	66.01	98	2210	95	33.39	19.45	0.89	18.56	129	1499	236	0	66.3
AP CK MOD RES RR#7	247	373.4	99	14899	115	66.74	99	2659	114	39.89	19.49	0.82	18.67	141	1388	210	0	73.5
AP CK MOD SUS RR#8	248	381.2	101	13758	106	69.17	102	2503	107	36.04	19.86	0.81	19.06	123	1349	215	0	73.8
Comm Benchmark Mean		376.3		13001		67.65		2335		34.61	19.67	0.86		126	1513	215		72.5
Comm Trial Mean		375.8		13643		67.49		2448		36.35	19.62	0.83		124	1441	219		77.1
Coeff. of Var. (%)		2.3		5.8		4.0		6.2		5.9	2.1	7.0		22.2	4.3	13.9		11.1
Mean LSD (0.05)		7.8		705		2.45		137		1.93	0.37	0.05		24	56	27		7.4
Mean LSD (0.01)		10.3		928		3.22		180		2.55	0.49	0.07		32	73	36		9.7
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from Stephen MN

Created 10/19/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 19. 2023 Performance of Varieties - ACSC RR Official Trials St. Thomas ND

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T + %Bnch	Rev/A + $	Rev/A + %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	328.0	99	13311	107	52.57	99	2130	107	40.57	17.16	0.76	16.40	128	1346	185	0	76.2
BTS 8034	101	317.9	96	12143	98	49.43	93	1892	95	38.15	16.69	0.80	15.89	131	1402	199	0	76.9
BTS 8156	114	323.6	98	11860	96	51.21	96	1879	94	36.65	16.95	0.77	16.18	105	1319	209	0	74.9
BTS 8927	109	340.9	103	13013	105	56.62	106	2160	108	38.17	17.72	0.67	17.05	90	1204	169	0	80.8
Crystal 022	121	340.4	103	13022	105	56.45	106	2159	108	38.20	17.72	0.70	17.02	100	1261	174	0	78.6
Crystal 130	113	329.0	100	12876	104	52.88	99	2068	103	39.20	17.17	0.73	16.44	108	1287	182	0	78.4
Crystal 137	122	328.2	99	12204	98	52.63	99	1960	98	37.16	17.20	0.79	16.41	104	1352	215	0	82.9
Crystal 793	118	329.5	100	12995	105	53.05	100	2097	105	39.31	17.24	0.77	16.47	129	1323	197	0	80.5
Crystal 912	116	324.7	98	12971	105	51.55	97	2050	103	40.11	17.01	0.77	16.24	131	1214	226	1	80.3
Crystal 913	106	331.0	100	13597	110	53.51	101	2195	110	41.14	17.30	0.75	16.55	121	1287	194	0	82.2
Hilleshög HIL2317	120	334.1	101	13173	106	54.47	102	2139	107	39.59	17.42	0.72	16.70	115	1292	172	0	72.5
Hilleshög HIL2366	111	312.1	95	11925	96	47.62	90	1818	91	38.24	16.43	0.83	15.60	187	1286	232	0	81.4
Hilleshög HIL2368	119	334.7	101	11373	92	54.67	103	1856	93	33.93	17.49	0.75	16.74	125	1295	194	0	75.2
Hilleshög HIL2386	112	319.6	97	11833	95	49.95	94	1849	93	36.99	16.80	0.82	15.98	125	1267	254	0	79.2
Hilleshög HIL2389	105	324.2	98	12809	103	51.39	97	2034	102	39.52	16.93	0.73	16.20	103	1256	192	0	81.9
Hilleshög HIL9920	115	330.2	100	12790	103	53.26	100	2061	103	38.70	17.26	0.75	16.51	138	1295	188	0	75.2
Maribo MA717	110	325.1	99	11862	96	51.66	97	1884	94	36.54	17.04	0.78	16.26	133	1271	221	0	75.8
Maribo MA902	124	313.8	95	11836	95	48.16	91	1816	91	37.67	16.49	0.80	15.69	153	1324	210	0	74.9
SV 203	123	327.5	99	12755	103	52.42	99	2043	102	39.02	17.03	0.66	16.37	88	1179	166	0	78.5
SV 265	107	324.9	98	12771	103	51.60	97	2029	102	39.35	16.95	0.71	16.24	90	1221	195	0	84.4
SV 285	108	316.6	96	12183	98	49.01	92	1887	94	38.45	16.56	0.73	15.83	107	1252	198	0	82.7
SX 1815	104	327.0	99	12899	104	52.27	98	2062	103	39.46	17.04	0.68	16.36	91	1208	177	0	81.5
SX 1818	103	317.2	96	13299	107	49.22	93	2061	103	41.95	16.64	0.78	15.86	106	1412	188	0	78.9
SX 1898	102	327.8	99	13248	107	52.50	99	2122	106	40.48	17.08	0.69	16.39	89	1245	173	0	78.4
BTS 8337 (CommBench)	125	334.2	101	11839	95	54.51	102	1934	97	35.36	17.55	0.84	16.71	128	1497	209	0	72.7
Crystal 578RR (CommBench)	126	323.5	98	12892	104	51.17	96	2038	102	39.87	17.01	0.83	16.18	130	1429	219	0	81.8
BTS 8815 (CommBench)	127	325.3	99	11503	93	51.75	97	1828	91	35.33	17.11	0.84	16.27	142	1449	213	0	66.2
Crystal 803 (CommBench)	128	337.0	102	13377	108	55.38	104	2195	110	39.78	17.60	0.75	16.85	95	1318	199	0	84.9
BTS 8927 (1stYearBench)	129	331.3	100	12730	103	53.62	101	2060	103	38.46	17.35	0.78	16.57	124	1308	212	0	74.7
AP CK MOD SUS RR#5	130	323.7	98	12758	103	51.23	96	2021	101	39.44	17.01	0.82	16.19	125	1349	234	0	73.3
AP CK MOD SUS RR#6	131	335.1	102	12929	104	54.81	103	2115	106	38.60	17.49	0.73	16.76	86	1243	207	0	83.6
RA CK SUS RR#7	132	315.4	96	10432	84	48.64	91	1608	80	33.10	16.56	0.79	15.77	142	1366	199	0	67.6
Experimental Trial (Comm status)																		
BTS 8205	205	329.4	100	11721	95	53.00	100	1887	94	35.68	17.32	0.84	16.48	132	1486	271	0	85.6
BTS 8217	233	318.1	96	11487	93	49.54	93	1789	89	36.05	16.72	0.80	15.92	134	1526	229	0	80.1
BTS 8226	208	341.5	103	13146	106	56.79	107	2174	109	38.67	17.75	0.68	17.07	96	1272	197	0	83.2
BTS 8242	211	331.8	101	11775	95	53.77	101	1903	95	35.78	17.30	0.69	16.60	99	1337	199	0	78.3
BTS 8270	232	331.4	100	12949	104	53.61	101	2096	105	39.09	17.33	0.76	16.58	117	1415	226	0	82.4
BTS 8303	218	334.9	101	11449	92	54.72	103	1869	94	34.30	17.50	0.75	16.75	125	1420	212	0	72.8
BTS 8311	213	343.0	104	12220	99	57.23	108	2039	102	35.74	17.85	0.69	17.15	101	1286	214	0	74.2
BTS 8328	224	336.9	102	12066	97	55.34	104	1973	99	36.15	17.61	0.76	16.85	101	1493	208	0	71.6
BTS 8341	215	333.5	101	9239	74	54.29	102	1512	76	27.48	17.46	0.79	16.67	136	1397	250	0	74.3
BTS 8349	223	316.1	96	12290	99	48.93	92	1908	95	38.79	16.56	0.74	15.82	139	1392	209	0	88.1
BTS 8359	219	328.7	100	12819	103	52.80	99	2053	103	38.99	17.20	0.76	16.44	122	1432	218	0	73.8
BTS 8365	206	349.8	106	12992	105	59.32	111	2190	110	37.41	18.16	0.68	17.49	86	1310	191	0	81.3
Crystal 138	238	333.1	101	12899	104	54.19	102	2107	105	38.60	17.38	0.73	16.65	104	1411	207	0	77.8
Crystal 260	230	320.4	97	12763	103	50.24	94	1994	100	39.82	16.75	0.73	16.02	119	1333	224	0	80.4
Crystal 262	227	332.5	101	13158	106	53.99	101	2145	107	39.16	17.29	0.68	16.61	112	1217	207	0	81.3
Crystal 269	229	345.9	105	12334	99	58.11	109	2066	103	35.82	18.12	0.81	17.31	115	1597	229	0	74.9
Crystal 360	203	332.5	101	13220	107	53.99	101	2154	108	39.44	17.33	0.71	16.62	105	1290	227	0	80.3
Crystal 361	201	348.5	106	13910	112	58.89	111	2337	117	40.16	18.09	0.68	17.42	103	1302	189	0	76.1
Crystal 363	222	336.1	102	12250	99	55.09	104	2003	100	36.56	17.50	0.70	16.80	102	1400	185	0	76.1
Crystal 364	214	328.5	100	13183	106	52.76	99	2107	105	40.28	17.31	0.86	16.45	148	1575	263	0	79.7
Crystal 367	220	318.0	96	10985	89	49.51	93	1716	86	34.46	16.70	0.79	15.91	129	1451	243	0	79.9
Crystal 368	217	347.9	105	12438	100	58.70	110	2101	105	35.82	18.22	0.82	17.40	102	1556	245	0	75.1
Crystal 369	231	351.9	107	13674	110	59.97	113	2320	116	39.08	18.44	0.82	17.62	116	1520	255	0	79.3
Crystal 371	226	341.4	103	12250	99	56.73	107	2034	102	35.92	17.78	0.70	17.07	105	1299	218	0	77.3
Hilleshög HIL2441	234	331.3	100	11328	91	53.61	101	1842	92	34.10	17.33	0.77	16.57	128	1351	249	0	74.4
Hilleshög HIL2442	204	320.1	97	11130	90	50.15	94	1746	87	34.65	16.83	0.81	16.02	152	1337	284	0	76.2
Hilleshög HIL2477	237	315.4	96	11379	92	48.70	92	1751	88	36.12	16.69	0.90	15.79	159	1433	332	0	76.2
Hilleshög HIL2478	209	318.4	96	12174	98	49.64	93	1890	95	38.45	16.78	0.84	15.94	177	1413	277	0	72.2
Hilleshög HIL2479	210	327.7	99	11931	96	52.51	99	1906	95	36.66	17.16	0.76	16.40	143	1296	243	0	81.4
Hilleshög HIL2480	228	330.2	100	12137	98	53.27	100	1959	98	36.79	17.29	0.77	16.52	119	1316	260	0	78.1
Hilleshög HIL2487 (Maribo MA942)	225	330.5	100	11715	94	53.36	100	1891	95	35.53	17.33	0.80	16.53	115	1362	276	0	81.2
Maribo MA943	235	331.8	101	11565	93	53.74	101	1891	95	34.70	17.36	0.77	16.60	119	1420	233	0	64.9
Maribo MA945	202	318.9	97	12277	99	49.80	94	1909	95	38.57	16.72	0.77	15.96	135	1434	224	0	76.7
Maribo MA946	207	321.4	97	12385	100	50.56	95	1941	97	38.79	16.86	0.78	16.09	146	1328	250	0	78.1
SV 231	236	326.4	99	12986	105	52.09	98	2058	103	40.13	17.05	0.72	16.33	108	1325	222	0	81.6
SV 232	216	319.4	97	12204	98	49.93	94	1914	96	37.86	16.65	0.68	15.96	106	1254	209	0	74.1
SX 1835	212	329.9	100	12907	104	53.17	100	2069	104	39.24	17.27	0.77	16.50	106	1414	238	0	84.1
SX 1836	221	327.1	99	12981	105	52.30	98	2066	103	39.70	17.05	0.70	16.35	100	1322	207	0	81.8
BTS 8337 (CommBench)	239	338.6	103	12113	98	55.85	105	1986	99	35.89	17.70	0.78	16.92	122	1492	217	0	79.1
Crystal 578RR (CommBench)	240	331.2	100	12707	102	53.57	101	2056	103	38.24	17.34	0.79	16.56	133	1468	231	0	82.8
BTS 8815 (CommBench)	241	320.9	97	11500	93	50.38	95	1807	90	35.84	16.89	0.84	16.05	173	1498	249	0	59.5
Crystal 803 (CommBench)	242	329.4	100	13292	107	53.00	100	2146	107	40.37	17.33	0.86	16.48	134	1484	283	0	82.5
BTS 8927 (1stYearBench)	243	330.1	100	12017	97	53.22	100	1930	97	36.56	17.26	0.74	16.52	116	1369	224	0	78.3
AP CK MOD SUS RR#5	244	318.3	96	12849	104	49.60	93	1996	100	40.34	16.70	0.79	15.92	141	1484	221	0	73.2
AP CK MOD SUS RR#6	245	336.9	102	12312	99	55.33	104	2018	101	36.54	17.61	0.77	16.84	113	1383	242	0	82.3
RA CK SUS RR#7	246	326.5	99	10537	85	52.11	98	1695	85	32.15	17.04	0.71	16.33	128	1331	208	0	77.9
AP CK MOD RES RR#7	247	320.8	97	12945	104	50.35	95	2029	102	40.43	16.81	0.77	16.05	153	1260	262	0	76.0
AP CK MOD SUS RR#8	248	342.9	104	13076	105	57.21	108	2194	110	37.98	17.83	0.68	17.14	88	1305	205	0	80.4
Comm Benchmark Mean		330.0		12403		53.20		1999		37.59	17.32	0.82		124	1423	210		76.4
Comm Trial Mean		326.7		12538		52.16		2002		38.39	17.09	0.76		118	1305	200		78.0
Coeff. of Var. (%)		2.6		4.9		5.1		6.3		4.6	2.4	6.9		20.8	4.6	14.2		9.7
Mean LSD (0.05)		7.6		539		2.37		110		1.56	0.36	0.05		22	54	25		6.3
Mean LSD (0.01)		10.0		710		3.12		145		2.06	0.47	0.06		29	71	33		8.2
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from St. Thomas ND

Created 10/19/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 20. 2023 Performance of Varieties - ACSC RR Official Trials Bathgate ND

Description *	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Rev/T + $	Rev/T + %Bnch	Rev/A + $	Rev/A + %Bnch	Yield T/A	Sugar% Gross	Sugar% LTM	Sugar% Rec	Na ppm	K ppm	AmN ppm	Bolters ++	Emerg. %
Commercial Trial																		
BTS 8018	117	352.1	99	13500	105	60.10	98	2303	104	38.28	18.57	0.96	17.61	85	1518	312	0	81.6
BTS 8034	101	342.3	96	12819	99	57.04	93	2136	96	37.53	18.12	1.01	17.11	91	1731	289	0	91.6
BTS 8156	114	352.1	99	12242	95	60.11	98	2088	94	34.77	18.58	0.97	17.61	97	1724	262	0	85.5
BTS 8927	109	354.6	100	12795	99	60.87	100	2195	99	36.28	18.65	0.92	17.73	84	1544	276	0	87.2
Crystal 022	121	357.5	101	12785	99	61.77	101	2209	99	35.78	18.79	0.91	17.88	79	1450	295	0	87.5
Crystal 130	113	352.1	99	13145	102	60.10	98	2241	101	37.40	18.56	0.96	17.60	90	1576	290	0	85.4
Crystal 137	122	366.8	103	13080	101	64.70	106	2301	104	35.80	19.30	0.96	18.34	85	1634	284	0	87.9
Crystal 793	118	357.0	100	13345	103	61.62	101	2304	104	37.37	18.80	0.95	17.85	81	1588	287	0	84.1
Crystal 912	116	346.2	97	14216	110	58.24	95	2391	108	41.07	18.29	0.98	17.31	94	1546	313	0	85.0
Crystal 913	106	356.1	100	13605	105	61.35	100	2343	105	38.20	18.75	0.95	17.80	87	1545	295	0	87.1
Hilleshög HIL2317	120	355.9	100	13006	101	61.28	100	2233	100	36.66	18.77	0.98	17.79	109	1722	263	0	76.7
Hilleshög HIL2366	111	348.3	98	12684	98	58.91	96	2148	97	36.49	18.40	0.99	17.41	106	1586	306	0	87.8
Hilleshög HIL2368	119	363.9	102	12203	94	63.79	104	2134	96	33.64	19.12	0.93	18.19	84	1571	271	0	72.6
Hilleshög HIL2386	112	347.0	98	12139	94	58.49	96	2044	92	35.02	18.41	1.06	17.35	99	1687	339	0	86.5
Hilleshög HIL2389	105	358.7	101	13226	102	62.17	102	2285	103	36.98	18.85	0.92	17.93	101	1592	250	0	89.8
Hilleshög HIL9920	115	363.0	102	13017	101	63.51	104	2278	103	35.83	19.14	0.99	18.15	94	1715	279	0	78.3
Maribo MA717	110	354.7	100	13203	102	60.90	100	2267	102	37.23	18.73	1.00	17.73	87	1628	309	0	87.5
Maribo MA902	124	347.7	98	12327	95	58.71	96	2075	93	35.49	18.35	0.97	17.38	105	1582	298	0	87.0
SV 203	123	365.1	103	13254	103	64.16	105	2327	105	36.36	19.17	0.92	18.25	84	1566	264	0	88.9
SV 265	107	348.7	98	12743	99	59.05	97	2155	97	36.67	18.40	0.96	17.44	86	1636	281	1	92.6
SV 285	108	356.9	100	12864	100	61.58	101	2214	100	36.27	18.78	0.93	17.85	77	1580	277	0	87.7
SX 1815	104	352.9	99	13055	101	60.35	99	2234	101	37.05	18.62	0.98	17.64	97	1605	297	0	79.6
SX 1818	103	353.5	99	13424	104	60.53	99	2297	103	38.00	18.57	0.90	17.67	79	1584	245	0	87.9
SX 1898	102	353.9	100	13192	102	60.66	99	2262	102	37.19	18.67	0.98	17.69	81	1627	297	0	86.2
BTS 8337 (CommBench)	125	363.5	102	12896	100	63.66	104	2260	102	35.34	19.16	0.98	18.18	94	1672	284	0	82.4
Crystal 578RR (CommBench)	126	351.4	99	13221	102	59.87	98	2249	101	37.62	18.54	0.98	17.56	90	1666	282	0	86.0
BTS 8815 (CommBench)	127	345.9	97	11906	92	58.18	95	2003	90	34.43	18.39	1.10	17.29	107	1809	331	0	73.5
Crystal 803 (CommBench)	128	360.9	102	13647	106	62.84	103	2377	107	37.79	18.99	0.94	18.05	88	1545	286	0	85.0
BTS 8927 (1stYearBench)	129	370.7	104	13351	103	65.91	108	2378	107	35.89	19.40	0.86	18.54	73	1475	249	0	85.7
AP CK MOD SUS RR#5	130	349.1	98	12953	100	59.17	97	2195	99	37.12	18.52	1.06	17.46	119	1698	329	0	80.4
AP CK MOD SUS RR#6	131	348.8	98	12327	95	59.07	97	2085	94	35.35	18.45	1.02	17.43	92	1590	334	0	87.5
RA CK SUS RR#7	132	347.4	98	12356	96	58.63	96	2086	94	35.53	18.37	1.00	17.37	104	1628	301	0	85.0
Experimental Trial (Comm status)																		
BTS 8205	205	352.5	99	13092	101	60.20	98	2231	100	37.69	18.60	0.97	17.62	87	1550	331	0	90.1
BTS 8217	233	359.5	101	13026	101	62.43	102	2231	100	36.82	18.96	0.98	17.98	107	1633	311	0	72.0
BTS 8226	208	364.9	103	12703	98	64.15	105	2251	101	35.15	19.15	0.91	18.24	86	1449	302	0	81.0
BTS 8242	211	365.6	103	12944	100	64.36	105	2244	101	35.99	19.21	0.93	18.27	97	1461	325	0	88.0
BTS 8270	232	353.3	99	13123	102	60.47	99	2256	102	37.17	18.60	0.93	17.66	96	1546	300	0	83.0
BTS 8303	218	370.2	104	12961	100	65.81	108	2313	104	35.08	19.46	0.96	18.50	112	1698	277	0	83.2
BTS 8311	213	363.7	102	11633	90	63.75	104	2037	92	32.65	19.13	0.94	18.18	89	1483	322	0	79.8
BTS 8328	224	376.7	106	13260	103	67.87	111	2379	107	35.45	19.84	1.00	18.83	99	1676	317	0	79.8
BTS 8341	215	352.8	99	9262	72	60.32	99	1601	72	26.21	18.72	1.08	17.64	102	1621	394	0	76.4
BTS 8349	223	339.7	96	12990	101	56.17	92	2170	98	38.50	17.97	0.97	16.99	133	1651	289	0	87.1
BTS 8359	219	358.6	101	13169	102	62.13	102	2305	104	36.76	18.99	1.07	17.92	112	1641	374	0	81.3
BTS 8365	206	363.5	102	13297	103	63.68	104	2330	105	36.76	19.08	0.91	18.17	85	1486	304	0	86.4
Crystal 138	238	352.0	99	13190	102	60.06	98	2278	103	37.52	18.56	0.96	17.59	87	1505	334	0	86.6
Crystal 260	230	343.7	97	12813	99	57.45	94	2147	97	37.72	18.19	1.00	17.19	107	1579	337	0	89.4
Crystal 262	227	347.4	98	13152	102	58.60	96	2225	100	37.76	18.34	0.97	17.37	119	1510	332	0	83.4
Crystal 269	229	362.3	102	12610	98	63.30	104	2178	98	35.70	19.15	1.03	18.11	111	1658	337	0	78.2
Crystal 360	203	353.8	100	12863	100	60.63	99	2186	98	37.14	18.64	0.94	17.69	93	1597	298	0	89.9
Crystal 361	201	358.0	101	13139	102	61.95	101	2274	102	36.83	18.86	0.96	17.90	122	1463	333	0	87.6
Crystal 363	222	371.8	105	13005	101	66.33	108	2340	105	35.38	19.59	1.00	18.59	90	1611	339	0	81.3
Crystal 364	214	364.2	102	13734	106	63.93	105	2389	107	38.16	19.22	1.00	18.21	125	1725	298	0	86.6
Crystal 367	220	350.7	99	12164	94	59.61	98	2072	93	34.92	18.54	1.00	17.53	122	1676	308	0	83.6
Crystal 368	217	352.3	99	12949	100	60.16	98	2215	100	36.68	18.64	1.02	17.62	93	1601	357	0	82.2
Crystal 369	231	360.0	101	12772	99	62.60	102	2227	100	36.06	19.06	1.06	18.00	90	1677	360	0	88.7
Crystal 371	226	370.0	104	12705	98	65.75	108	2258	102	34.38	19.38	0.90	18.48	97	1428	294	0	85.1
Hilleshög HIL2441	234	362.2	102	13197	102	63.29	104	2288	103	36.52	19.14	1.03	18.10	116	1628	349	0	81.2
Hilleshög HIL2442	204	362.2	102	11854	92	63.27	103	2051	92	33.28	19.21	1.09	18.12	100	1616	405	0	79.3
Hilleshög HIL2477	237	331.8	93	11931	92	53.67	88	1939	87	36.27	17.87	1.26	16.61	177	1758	467	0	79.9
Hilleshög HIL2478	209	356.6	100	13746	106	61.50	101	2372	107	38.63	18.85	1.03	17.82	123	1631	343	0	74.0
Hilleshög HIL2479	210	361.4	102	12537	97	63.03	103	2230	100	34.20	19.01	0.94	18.07	113	1497	317	0	82.8
Hilleshög HIL2480	228	353.4	99	12700	98	60.50	99	2166	97	35.64	18.80	1.13	17.67	119	1651	417	0	90.1
Hilleshög HIL2487 (Maribo MA942)	225	358.8	101	12305	95	62.21	102	2143	96	34.69	18.90	0.96	17.94	89	1555	320	0	79.8
Maribo MA943	235	370.0	104	12834	99	65.76	108	2271	102	34.95	19.45	0.95	18.50	94	1559	314	0	70.4
Maribo MA945	202	355.1	100	13685	106	61.04	100	2333	105	38.93	18.76	1.00	17.76	92	1713	308	0	80.1
Maribo MA946	207	357.1	100	12602	98	61.65	101	2195	99	35.32	18.86	1.01	17.85	93	1564	354	0	86.1
SV 231	236	359.1	101	13692	106	62.30	102	2358	106	38.18	18.90	0.95	17.95	104	1612	293	0	84.0
SV 232	216	358.0	101	13330	103	61.95	101	2306	104	37.72	18.84	0.94	17.90	94	1598	295	0	84.1
SX 1835	212	354.1	100	12846	99	60.74	99	2214	100	36.38	18.75	1.04	17.71	107	1677	347	0	85.1
SX 1836	221	348.8	98	13189	102	59.06	97	2244	101	37.79	18.44	0.99	17.44	107	1616	320	0	79.8
BTS 8337 (CommBench)	239	359.8	101	12359	96	62.52	102	2142	96	34.49	19.01	1.03	17.98	116	1670	333	0	77.9
Crystal 578RR (CommBench)	240	358.9	101	13731	106	62.26	102	2389	107	38.26	18.91	0.96	17.95	117	1653	291	0	82.0
BTS 8815 (CommBench)	241	346.0	97	11777	91	58.14	95	1992	90	33.92	18.34	1.04	17.30	114	1716	333	0	71.7
Crystal 803 (CommBench)	242	357.0	100	13802	107	61.64	101	2366	106	38.50	18.81	0.96	17.85	94	1555	321	0	80.1
BTS 8927 (1stYearBench)	243	363.4	102	12346	96	63.65	104	2177	98	34.16	19.09	0.92	18.17	92	1460	318	0	90.9
AP CK MOD SUS RR#5	244	348.9	98	12963	100	59.10	97	2213	100	37.56	18.50	1.04	17.45	104	1659	350	0	82.2
AP CK MOD SUS RR#6	245	360.1	101	13219	102	62.64	102	2271	102	36.86	18.98	0.98	18.00	94	1507	347	0	88.9
RA CK SUS RR#7	246	360.8	102	12218	95	62.85	103	2133	96	33.98	19.00	0.96	18.04	102	1568	311	0	81.5
AP CK MOD RES RR#7	247	352.3	99	13830	107	60.16	98	2365	106	39.02	18.56	0.94	17.61	135	1426	323	0	77.6
AP CK MOD SUS RR#8	248	370.1	104	13124	102	65.80	108	2312	104	36.03	19.42	0.91	18.50	94	1456	309	0	83.4
Comm Benchmark Mean		355.4		12918		61.14		2222		36.30	18.77	1.00		95	1673	296		81.7
Comm Trial Mean		354.5		12954		60.85		2222		36.58	18.69	0.97		91	1613	290		84.9
Coeff. of Var. (%)		3.1		4.9		5.6		6.6		4.2	2.7	5.7		16.7	3.9	10.5		8.9
Mean LSD (0.05)		9.7		566		3.02		129		1.39	0.45	0.05		13	56	28		6.6
Mean LSD (0.01)		12.7		746		3.97		170		1.83	0.60	0.07		18	74	36		8.6
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2023 Data from Bathgate ND

Created 10/20/2023

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.
* Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.
+ Revenue estimates are based on a $50.09 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.
++ Number of bolters observed at location.
Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

Table 21. Calculation for Approval of Sugarbeet Varieties for ACSC Market for 2024

Description	Approval Status	Rec/Ton 2022	Rec/Ton 2023	Rec/Ton 2 Yr	Rec/Ton % Bench	Rev/Acre++ 2022	Rev/Acre++ 2023	Rev/Acre++ 2 Yr	Rev/Acre++ % Bench	R/T + $/A Bench	Cercospora Rating * 2021	Cercospora Rating * 2022	Cercospora Rating * 2023	Cercospora Rating * 2 Yr Mean	Cercospora Rating * 3 Yr Mean
Previously Approved (3 Yr)															**<=5.30**
BTS 8018	Approved	328.6	348.4	338.5	100.2	1447	1960	1704	106.0	206.3	2.31	2.03	2.42	2.23	2.25
BTS 8034	Approved	315.1	338.6	326.9	96.8	1362	1896	1629	101.4	198.2	2.56	2.28	2.54	2.41	2.46
BTS 8156	Approved	327.5	348.1	337.8	100.0	1410	1890	1650	102.7	202.7	2.48	2.43	2.53	2.48	2.48
BTS 8927	Approved	338.8	353.5	346.2	102.5	1452	1948	1700	105.8	208.3	4.48	4.42	4.38	4.40	4.43
Crystal 022	Approved	339.2	358.1	348.7	103.2	1449	1975	1712	106.6	209.8	4.97	4.60	4.97	4.79	4.85
Crystal 130	Approved	332.3	353.3	342.8	101.5	1436	2009	1723	107.2	208.7	2.38	2.10	2.60	2.35	2.36
Crystal 137	Approved	324.6	349.6	337.1	99.8	1390	1922	1656	103.1	202.9	2.53	2.57	2.65	2.61	2.58
Crystal 138	Approved	332.5	349.4	341.0	101.0	1471	1983	1727	107.5	208.4	4.74	4.87	4.77	4.82	4.79
Crystal 793	Approved	330.6	349.4	340.0	100.7	1476	1981	1729	107.6	208.3	4.13	4.10	4.20	4.15	4.15
Crystal 912	Approved	312.6	340.3	326.5	96.7	1433	2025	1729	107.6	204.3	5.13	4.81	5.00	4.91	4.98
Crystal 913	Approved	329.1	349.9	339.5	100.5	1458	2042	1750	108.9	209.4	4.10	3.73	3.91	3.82	3.92
Hilleshög HIL2317	Approved	326.8	347.5	337.2	99.8	1371	1862	1617	100.6	200.4	4.57	5.13	4.84	4.99	4.85
Hilleshög HIL2366	Approved	319.3	333.3	326.3	96.6	1351	1751	1551	96.5	193.2	5.01	5.00	5.02	5.01	5.01
Hilleshög HIL2368	Approved	329.1	349.1	339.1	100.4	1154	1737	1446	90.0	190.4	4.66	4.56	4.41	4.48	4.54
Hilleshög HIL2386	Approved	322.3	342.7	332.5	98.5	1424	1836	1630	101.4	199.9	4.30	4.54	4.23	4.39	4.36
Hilleshög HIL2389	Approved	326.8	349.2	338.0	100.1	1407	1948	1678	104.4	204.5	4.85	4.69	4.51	4.60	4.68
Hilleshög HIL9920	Approved	324.5	347.4	336.0	99.5	1383	1878	1631	101.5	201.0	4.75	4.92	5.15	5.04	4.94
Maribo MA717	Approved	318.6	343.0	330.8	98.0	1397	1871	1634	101.7	199.7	4.68	5.05	5.04	5.05	4.92
Maribo MA902	Approved	321.2	339.1	330.2	97.8	1310	1730	1520	94.6	192.4	4.63	4.95	4.66	4.80	4.75
SV 203	Approved	322.0	350.6	336.3	99.6	1296	1972	1634	101.7	201.3	4.75	4.74	4.78	4.76	4.76
SV 265	Approved	318.1	342.7	330.4	97.8	1321	1859	1590	99.0	196.8	4.30	4.46	4.65	4.56	4.47
SV 285	Approved	322.6	346.2	334.4	99.0	1276	1909	1593	99.1	198.1	4.78	4.72	4.83	4.78	4.78
SX 1815	Approved	328.4	350.9	339.7	100.6	1403	1996	1700	105.8	206.4	4.78	5.07	4.74	4.91	4.86
SX 1818	Approved	321.4	345.0	333.2	98.7	1361	1958	1660	103.3	202.0	4.86	4.72	4.53	4.63	4.71
SX 1898	Approved	320.4	345.9	333.2	98.7	1297	1927	1612	100.3	199.0	4.76	4.72	4.88	4.80	4.79
Candidates for Approval (2 Yr)														**<=5.00**	
BTS 8205	Approved	325.1	351.1	338.1	100.1	1426	1981	1704	106.0	206.1	--	4.27	4.69	4.48	--
BTS 8217	Not Approved	323.1	347.7	335.4	99.3	1373	1924	1649	102.6	201.9	--	2.25	2.27	2.26	--
BTS 8226	Approved	343.0	355.3	349.2	103.4	1521	1945	1733	107.9	211.2	--	2.00	2.33	2.17	--
BTS 8242	Approved	340.4	356.3	348.4	103.2	1441	1940	1691	105.2	208.4	--	4.35	4.48	4.41	--
BTS 8270	Approved	333.6	352.3	343.0	101.6	1472	1966	1719	107.0	208.5	--	1.97	2.43	2.20	--
Crystal 260	Approved	333.9	348.0	341.0	101.0	1488	1962	1725	107.4	208.3	--	2.05	2.15	2.10	--
Crystal 262	Approved	325.3	345.7	335.5	99.3	1463	1932	1698	105.6	205.0	--	4.43	4.36	4.39	--
Crystal 269	Approved	333.8	358.1	346.0	102.4	1466	1932	1699	105.7	208.2	--	4.60	4.38	4.49	--
Hilleshög HIL2441	Not Approved	327.0	347.3	337.2	99.8	1312	1797	1555	96.7	196.6	--	4.01	3.85	3.93	--
Hilleshög HIL2442	Approved	331.7	348.8	340.3	100.8	1312	1761	1537	95.6	196.4	--	4.39	4.10	4.24	--
Hilleshög HIL2487 (MA942)	Approved	328.8	346.8	337.8	100.0	1310	1794	1552	96.6	196.6	--	4.57	4.74	4.65	--
Maribo MA943	Approved	326.3	350.7	338.5	100.2	1333	1810	1572	97.8	198.0	--	4.28	4.44	4.36	--

Benchmark Varieties		2021	2022	2023	2yr	3yr	2021	2022	2023	2yr	3yr
BTS 8572 (Check)	Benchmark	336.2					1367				
BTS 8337 (Check)	Benchmark	337.6	334.8	358.3			1408	1322	1837		
Crystal 578RR (Check)	Benchmark	328.7	313.1	342.4			1524	1339	1838		
BTS 8815 (Check)	Benchmark	336.9	324.9	343.9			1461	1320	1733		
Crystal 803 (Check)	Benchmark		331.6	352.6				1433	2033		
Benchmark mean		334.9	326.1	349.3	337.7	336.8	1440	1353	1860	1607	1551

Variety approval criteria include: 1) Two years of official trial data, 2) Cercospora rating must not exceed 5.00 (1982 adjusted data), AND 3a) R/T >= 100% of Bench OR 3b) R/T >= 97% and R/T + $/A >= 202% of Bench. Three years of data may be considered for initial approval.

Created 10/31/2023

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

++2023 Revenue estimate based on a $50.09 beet payment (5-yr ave) at 17.5% crop with a 1.5% loss to molasses and 2022 Revenue estimate based on a $46.80 beet payment. Revenue does not consider hauling or production costs.

* All Cercospora ratings 2021-2023 were adjusted to 1982 basis.

Table 22. 2023 First Year Experimental Varieties
New Benchmark Comparison
Projected Calculation for Approval of Sugarbeet Varieties for ACSC Market

		Rec/Ton		Rev/Acre		R/T +	CR Rating ^^
	Approval ^	%		%		$/A	
Description	Likely	2023	Bench	2023[++]	Bench	Bench	2023
Candidates for Retesting (1 Yr)							
BTS 8303	On Track	355.3	101.7	1879	100.1	201.8	4.46
BTS 8311	On Track	364.3	104.3	1866	99.4	203.7	2.39
BTS 8328	On Track	356.1	101.9	1961	104.4	206.4	4.54
BTS 8341	Not On Track	348.2	99.7	1407	74.9	174.6	2.52
BTS 8349	Not On Track	336.4	96.3	1827	97.3	193.6	2.27
BTS 8359	On Track	350.9	100.5	1957	104.2	204.7	2.26
BTS 8365	On Track	362.2	103.7	1980	105.5	209.1	4.15
Crystal 360	On Track	351.2	100.5	1963	104.6	205.1	2.17
Crystal 361	On Track	357.9	102.5	2012	107.2	209.6	2.24
Crystal 363	On Track	358.1	102.5	1918	102.2	204.7	3.16
Crystal 364	On Track	342.5	98.0	2000	106.5	204.6	4.26
Crystal 367	Not On Track	342.2	98.0	1860	99.1	197.0	2.39
Crystal 368	On Track	350.4	100.3	1906	101.5	201.8	4.11
Crystal 369	On Track	354.6	101.5	1984	105.7	207.2	3.78
Crystal 371	On Track	360.6	103.2	1883	100.3	203.5	2.00
Hilleshög HIL2477	Not On Track	333.1	95.4	1696	90.3	185.7	4.29
Hilleshög HIL2478	Not On Track	334.6	95.8	1821	97.0	192.8	5.03
Hilleshög HIL2479	On Track	353.0	101.1	1861	99.1	200.2	4.09
Hilleshög HIL2480	On Track	349.4	100.0	1817	96.8	196.8	4.00
Maribo MA945	Not On Track	339.4	97.2	1848	98.4	195.6	4.62
Maribo MA946	Not On Track	347.9	99.6	1864	99.3	198.9	4.25
SV 231	On Track	346.4	99.2	1965	104.7	203.8	4.83
SV 232	Not On Track	345.4	98.9	1884	100.3	199.2	4.31
SX 1835	On Track	347.3	99.4	1968	104.8	204.2	4.55
SX 1836	Not On Track	344.6	98.6	1886	100.5	199.1	4.33
Benchmarks Varieties*							
Crystal 578RR (Check)		346.1	99.1	1907	101.6		
BTS 8815 (Check)		344.7	98.7	1703	90.7		
Crystal 803 (Check)		350.5	100.3	2003	106.7		
BTS 8927 (Check)		356.0	101.9	1897	101.0		
Benchmark Mean		349.3		1877			

Variety approval criteria include: 1) Two years of official trial data, 2) Cercospora rating must not exceed 5.00 (1982 adjusted data), AND 3a) R/T >= 100% of Bench OR 3b) R/T >= 97% and R/T + $/A >= 202% of Bench.

Created 10/31/2023

[++] 2023 Revenue estimate based on a $50.09 beet payment (5-yr ave) at 17.5% crop with a 1.5% loss to molasses.
Revenue does not consider hauling or production cost

* 2023 benchmark varieties for first year entries dropped BTS 8337 and added BTS 8927

^^ All Cercospora ratings from 2023 were adjusted to 1982 basis.

^ Not on Track = data is not tracking for potential approval. On Track = data is tracking for potential approval.

Table 23. Calculation for Approval of Sugarbeet Varieties for ACSC Aphanomyces Specialty Market for 2024

Description	Approval Status	Aphanomyces R 2021	Aphanomyces R 2022	Aphanomyces R 2023	Aphanomyces R 2 Yr	Aphanomyces R 3 Yr	Cercospora Rating * 2021	Cercospora Rating * 2022	Cercospora Rating * 2023	Cercospora Rating * 2 Yr	Cercospora Rating * 3 Yr
Previously Approved (3 Yrs)						**<=4.50**					**<=5.30**
BTS 8018	Approved	4.52	4.00	3.95	3.98	4.16	2.31	2.03	2.42	2.23	2.25
BTS 8034	Approved	3.24	3.89	3.80	3.85	3.64	2.56	2.28	2.54	2.41	2.46
BTS 8156	Approved	3.64	4.21	3.97	4.09	3.94	2.48	2.43	2.53	2.48	2.48
BTS 8927	Approved	4.51	4.00	3.26	3.63	3.92	4.48	4.42	4.38	4.40	4.43
Crystal 022	Approved	4.79	4.03	3.66	3.85	4.16	4.97	4.60	4.97	4.79	4.85
Crystal 130	Approved	4.23	3.57	4.00	3.79	3.93	2.38	2.10	2.60	2.35	2.36
Crystal 137	Approved	3.13	4.25	4.21	4.23	3.86	2.53	2.57	2.65	2.61	2.58
Crystal 138	Approved	4.19	3.87	4.06	3.97	4.04	4.74	4.87	4.77	4.82	4.79
Crystal 793	Approved	3.74	3.82	4.31	4.07	3.96	4.13	4.10	4.20	4.15	4.14
Crystal 912	Approved	3.95	3.44	3.41	3.43	3.60	5.13	4.81	5.00	4.91	4.98
Crystal 913	Approved	4.39	3.79	4.05	3.92	4.08	4.10	3.73	3.91	3.82	3.91
Hilleshög HIL2317	Not Approved	5.01	3.91	5.22	4.57	4.71	4.57	5.13	4.84	4.99	4.85
Hilleshög HIL2389	Approved	3.86	3.78	5.42	4.60	4.35	4.85	4.69	4.51	4.60	4.68
Hilleshög HIL9920	Not Approved	4.65	4.33	5.49	4.91	4.82	4.75	4.92	5.15	5.04	4.94
SV 203	Not Approved	4.35	4.24	7.15	5.70	5.25	4.75	4.74	4.78	4.76	4.76
SV 285	Not Approved	4.48	4.35	7.39	5.87	5.41	4.78	4.72	4.83	4.78	4.78
SX 1898	Not Approved	4.97	4.25	6.70	5.48	5.31	4.76	4.72	4.88	4.80	4.79
Candidates for Approval (2 Yrs)					**<=4.20**					**<=5.00**	
BTS 8205	Approved	--	3.69	3.67	3.68	--	--	4.27	4.69	4.48	--
BTS 8217	Not Approved	--	4.07	4.35	4.21	--	--	2.25	2.27	2.26	--
BTS 8226	Approved	--	3.79	3.72	3.76	--	--	2.00	2.33	2.17	--
BTS 8242	Not Approved	--	4.47	4.25	4.36	--	--	4.35	4.48	4.42	--
BTS 8270	Approved	--	3.87	3.90	3.89	--	--	1.97	2.43	2.20	--
Crystal 260	Approved	--	3.89	3.84	3.87	--	--	2.05	2.15	2.10	--
Crystal 262	Approved	--	3.42	4.61	4.02	--	--	4.43	4.36	4.40	--
Crystal 269	Approved	--	3.48	3.62	3.55	--	--	4.60	4.38	4.49	--
Hilleshög HIL2366	Not Approved	5.81	4.32	4.68	4.50	4.94	5.01	5.00	5.02	5.01	5.01
Hilleshög HIL2368	Not Approved	5.25	4.63	5.02	4.83	4.97	4.66	4.56	4.41	4.49	4.54
Hilleshög HIL2386	Not Approved	5.98	4.31	4.21	4.26	4.83	4.30	4.54	4.23	4.39	4.36
Hilleshög HIL2441	Approved	--	3.91	4.18	4.05	--	--	4.01	3.85	3.93	--
Hilleshög HIL2442	Not Approved	--	4.83	4.73	4.78	--	--	4.39	4.10	4.25	--
Hilleshög HIL2487 (MA942)	Approved	--	4.20	4.06	4.13	--	--	4.57	4.74	4.66	--
Maribo MA717	Not Approved	6.75	4.39	4.61	4.50	5.25	4.68	5.05	5.04	5.05	4.92
Maribo MA902	Not Approved	6.96	4.59	5.77	5.18	5.77	4.63	4.95	4.66	4.81	4.75
Maribo MA943	Not Approved	--	4.21	4.80	4.51	--	--	4.28	4.44	4.36	--
SV 265	Not Approved	4.95	4.30	7.47	5.89	5.57	4.30	4.46	4.65	4.56	4.47
SX 1815	Not Approved	4.19	4.28	6.15	5.22	4.87	4.78	5.07	4.74	4.91	4.86
SX 1818	Not Approved	5.56	4.82	7.09	5.96	5.82	4.86	4.72	4.53	4.63	4.70
Approval Criteria for New Varieties					**4.20**					**5.00**	
Criteria to Maintain Approval						**4.50**					**5.30**

Aphanomyces approval criteria include: 1) Cercospora rating two-year mean must not exceed 5.00 and 2) Aphanomyces root rating two-year mean <= 4.20.

Created 11/01/2023

Three years of data may be considered for initial approval.

To maintain Aphanomyces approval, criteria include: 1) Cercospora three-year mean must not exceed 5.30 and 2) Aphanomyces root rating three-year mean <= 4.50.

Previously approved varieties not meeting current approval standards may be sold in 2024.

* Aphanomyces ratings adjusted to 2003 basis.

Cercospora ratings were adjusted to 1982 basis.

Table 24. Calculation for Approval of Sugarbeet Varieties for ACSC Rhizoctonia Specialty Market for 2024

Description	Approval Status	Rhizoctonia Rating* 2021	2022	2023	2 Yr Mn	3 Yr Mn	Cercospora Rating* 2021	2022	2023	2 Yr Mn	3 Yr Mn
Previously Approved (3 Yr)						<=4.12					<=5.30
Crystal 022	Approved	3.53	4.10	3.85	3.98	3.83	4.97	4.60	4.97	4.79	4.85
Crystal 138	Approved	3.52	3.81	3.81	3.81	3.71	4.74	4.87	4.77	4.82	4.79
Crystal 912	Approved	3.77	3.28	3.50	3.39	3.52	5.13	4.81	5.00	4.91	4.98
Hilleshög HIL2368	Approved	2.92	3.46	3.55	3.51	3.31	4.66	4.56	4.41	4.49	4.54
Maribo MA902	Approved	3.80	3.57	3.87	3.72	3.75	4.63	4.95	4.66	4.81	4.75
Candidates for Approval (2 Yr)					<=3.82					<=5.00	
BTS 8018	Not Approved	3.83	3.93	4.06	4.00	3.94	2.31	2.03	2.42	2.23	2.25
BTS 8034	Not Approved	3.88	4.49	4.09	4.29	4.15	2.56	2.28	2.54	2.41	2.46
BTS 8156	Not Approved	3.81	4.24	3.93	4.09	3.99	2.48	2.43	2.53	2.48	2.48
BTS 8205	Approved	--	3.82	3.77	3.80	--	--	4.27	4.69	4.48	--
BTS 8217	Not Approved	--	4.14	3.90	4.02	--	--	2.25	2.27	2.26	--
BTS 8226	Approved	--	3.74	3.78	3.76	--	--	2.00	2.33	2.17	--
BTS 8242	Not Approved	--	4.00	4.07	4.04	--	--	4.35	4.48	4.42	--
BTS 8270	Not Approved	--	4.33	3.67	4.00	--	--	1.97	2.43	2.20	--
BTS 8927	Not Approved	3.68	4.13	3.98	4.06	3.93	4.48	4.42	4.38	4.40	4.43
Crystal 130	Not Approved	3.57	4.08	3.69	3.89	3.78	2.38	2.10	2.60	2.35	2.36
Crystal 137	Not Approved	3.53	4.18	4.01	4.10	3.91	2.53	2.57	2.65	2.61	2.58
Crystal 260	Approved	--	3.70	3.46	3.58	--	--	2.05	2.15	2.10	--
Crystal 262	Approved	--	3.38	3.31	3.35	--	--	4.43	4.36	4.40	--
Crystal 269	Not Approved	--	4.20	3.90	4.05	--	--	4.60	4.38	4.49	--
Crystal 793	Not Approved	4.36	4.73	4.35	4.54	4.48	4.13	4.10	4.20	4.15	4.14
Crystal 913	Not Approved	3.94	4.23	4.19	4.21	4.12	4.10	3.73	3.91	3.82	3.91
Hilleshög HIL2317	Not Approved	4.76	4.71	4.44	4.58	4.64	4.57	5.13	4.84	4.99	4.85
Hilleshög HIL2366	Not Approved	3.98	3.92	3.99	3.96	3.96	5.01	5.00	5.02	5.01	5.01
Hilleshög HIL2386	Approved	4.20	3.51	3.91	3.71	3.87	4.30	4.54	4.23	4.39	4.36
Hilleshög HIL2389	Not Approved	3.99	3.92	4.45	4.19	4.12	4.85	4.69	4.51	4.60	4.68
Hilleshög HIL2441	Approved	--	3.62	3.89	3.76	--	--	4.01	3.85	3.93	--
Hilleshög HIL2442	Approved	--	3.70	3.90	3.80	--	--	4.39	4.10	4.25	--
Hilleshög HIL2487 (MA942)	Not Approved	--	4.18	4.29	4.24	--	--	4.57	4.74	4.66	--
Hilleshög HIL9920	Not Approved	4.70	4.58	4.42	4.50	4.57	4.75	4.92	5.15	5.04	4.94
Maribo MA717	Not Approved	4.31	3.92	4.10	4.01	4.11	4.68	5.05	5.04	5.05	4.92
Maribo MA943	Not Approved	--	4.04	4.18	4.11	--	--	4.28	4.44	4.36	--
SV 203	Not Approved	4.34	4.19	4.25	4.22	4.26	4.75	4.74	4.78	4.76	4.76
SV 265	Not Approved	4.17	3.96	3.86	3.91	4.00	4.30	4.46	4.65	4.56	4.47
SV 285	Not Approved	4.26	4.53	4.28	4.41	4.36	4.78	4.72	4.83	4.78	4.78
SX 1815	Not Approved	4.40	4.12	4.35	4.24	4.29	4.78	5.07	4.74	4.91	4.86
SX 1818	Not Approved	4.41	4.16	4.06	4.11	4.21	4.86	4.72	4.53	4.63	4.70
SX 1898	Not Approved	4.34	4.12	4.15	4.14	4.20	4.76	4.72	4.88	4.80	4.79
Approval Criteria for New Varieties					**3.82**					**5.00**	
Criteria to Maintain Approval						**4.12**					**5.30**

Rhizoctonia approval criteria include: 1) Cercospora rating two-year mean must not exceed 5.00 and 2) Rhizoctonia root rating two-year mean <= 3.82.

Created 11/01/2023

Three years of data may be considered for initial approval.
To maintain Rhizoctonia approval, criteria include: 1) Cercospora three-year mean must not exceed 5.30 and 2) Rhizoctonia rating three-year mean <= 4.12.
Previously approved varieties not meeting current approval standards may be sold in 2024.
* Rhizoctonia ratings adjusted to 2009 basis
Cercospora ratings adjusted to 1982 basis

Table 25. 2023 Aphanomyces Ratings for Official Trial Entries

KWS (Shakopee, MN)

			Unadju				Adjusted ++									
Chk++	Code	Description	Perl NA	Clim NA	Shak[Z] 8/29	Glyn NA	Perl NA	Clim NA	Shak[Z] 8/29	Glyn NA	2023	2 Yr	3 Yr	2022	2021	Trial Yrs
	550	BTS 8018	--	--	3.17	--	--	--	3.95	--	3.95	3.97	4.16	4.00	4.52	4
	558	BTS 8034	--	--	3.05	--	--	--	3.80	--	3.80	3.84	3.64	3.89	3.24	4
	538	BTS 8156	--	--	3.19	--	--	--	3.97	--	3.97	4.09	3.94	4.21	3.64	3
	540	BTS 8205	--	--	2.95	--	--	--	3.67	--	3.67	3.68	--	3.69	--	2
	551	BTS 8217	--	--	3.49	--	--	--	4.35	--	4.35	4.21	--	4.07	--	2
	527	BTS 8226	--	--	2.99	--	--	--	3.72	--	3.72	3.76	--	3.79	--	2
	561	BTS 8242	--	--	3.41	--	--	--	4.25	--	4.25	4.36	--	4.47	--	2
	533	BTS 8270	--	--	3.13	--	--	--	3.90	--	3.90	3.88	--	3.87	--	2
	535	BTS 8303	--	--	2.56	--	--	--	3.19	--	3.19	--	--	--	--	1
	508	BTS 8311	--	--	3.42	--	--	--	4.26	--	4.26	--	--	--	--	1
	545	BTS 8328	--	--	2.81	--	--	--	3.50	--	3.50	--	--	--	--	1
	517	BTS 8341	--	--	4.30	--	--	--	5.36	--	5.36	--	--	--	--	1
	505	BTS 8349	--	--	3.67	--	--	--	4.57	--	4.57	--	--	--	--	1
	524	BTS 8359	--	--	2.95	--	--	--	3.67	--	3.67	--	--	--	--	1
	546	BTS 8365	--	--	2.91	--	--	--	3.62	--	3.62	--	--	--	--	1
	528	BTS 8927	--	--	2.62	--	--	--	3.26	--	3.26	3.63	3.93	4.00	4.51	5
	521	Crystal 022	--	--	2.94	--	--	--	3.66	--	3.66	3.84	4.16	4.03	4.79	4
	510	Crystal 130	--	--	3.21	--	--	--	4.00	--	4.00	3.78	3.93	3.57	4.23	3
	552	Crystal 137	--	--	3.38	--	--	--	4.21	--	4.21	4.23	3.86	4.25	3.13	3
	502	Crystal 138	--	--	3.26	--	--	--	4.06	--	4.06	3.97	4.04	3.87	4.19	3
	529	Crystal 260	--	--	3.08	--	--	--	3.84	--	3.84	3.86	--	3.89	--	2
	555	Crystal 262	--	--	3.70	--	--	--	4.61	--	4.61	4.01	--	3.42	--	2
	557	Crystal 269	--	--	2.91	--	--	--	3.62	--	3.62	3.55	--	3.48	--	2
	534	Crystal 360	--	--	3.10	--	--	--	3.86	--	3.86	--	--	--	--	1
	519	Crystal 361	--	--	2.77	--	--	--	3.45	--	3.45	--	--	--	--	1
	556	Crystal 363	--	--	3.08	--	--	--	3.84	--	3.84	--	--	--	--	1
	506	Crystal 364	--	--	3.04	--	--	--	3.79	--	3.79	--	--	--	--	1
	523	Crystal 367	--	--	3.19	--	--	--	3.97	--	3.97	--	--	--	--	1
	531	Crystal 368	--	--	2.87	--	--	--	3.57	--	3.57	--	--	--	--	1
	513	Crystal 369	--	--	3.23	--	--	--	4.02	--	4.02	--	--	--	--	1
	514	Crystal 371	--	--	2.77	--	--	--	3.45	--	3.45	--	--	--	--	1
	509	Crystal 793	--	--	3.46	--	--	--	4.31	--	4.31	4.07	3.96	3.82	3.74	7
	547	Crystal 912	--	--	2.74	--	--	--	3.41	--	3.41	3.43	3.60	3.44	3.95	5
	549	Crystal 913	--	--	3.25	--	--	--	4.05	--	4.05	3.92	4.08	3.79	4.39	5
	553	Hilleshög HIL2317	--	--	4.19	--	--	--	5.22	--	5.22	4.56	4.71	3.91	5.01	5
	520	Hilleshög HIL2366	--	--	3.76	--	--	--	4.68	--	4.68	4.50	4.94	4.32	5.81	4
	511	Hilleshög HIL2368	--	--	4.03	--	--	--	5.02	--	5.02	4.83	4.97	4.63	5.25	4
	542	Hilleshög HIL2386	--	--	3.38	--	--	--	4.21	--	4.21	4.26	4.83	4.31	5.98	3
	522	Hilleshög HIL2389	--	--	4.35	--	--	--	5.42	--	5.42	4.60	4.35	3.78	3.86	3
	541	Hilleshög HIL2441	--	--	3.36	--	--	--	4.18	--	4.18	4.05	--	3.91	--	2
	526	Hilleshög HIL2442	--	--	3.80	--	--	--	4.73	--	4.73	4.78	--	4.83	--	2
	559	Hilleshög HIL2477	--	--	4.26	--	--	--	5.31	--	5.31	--	--	--	--	1
	516	Hilleshög HIL2478	--	--	3.52	--	--	--	4.38	--	4.38	--	--	--	--	1
	512	Hilleshög HIL2479	--	--	3.52	--	--	--	4.38	--	4.38	--	--	--	--	1
	501	Hilleshög HIL2480	--	--	3.45	--	--	--	4.30	--	4.30	--	--	--	--	1
	536	Hilleshög HIL2487 (MA942)	--	--	3.26	--	--	--	4.06	--	4.06	4.13	--	4.20	--	2
	507	Hilleshög HIL9920	--	--	4.41	--	--	--	5.49	--	5.49	4.91	4.82	4.33	4.65	7
	504	Maribo MA717	--	--	3.70	--	--	--	4.61	--	4.61	4.50	5.25	4.39	6.75	7
	539	Maribo MA902	--	--	4.63	--	--	--	5.77	--	5.77	5.18	5.77	4.59	6.96	5
	562	Maribo MA943	--	--	3.85	--	--	--	4.80	--	4.80	4.50	--	4.21	--	2
	518	Maribo MA945	--	--	3.47	--	--	--	4.32	--	4.32	--	--	--	--	1
	525	Maribo MA946	--	--	3.79	--	--	--	4.72	--	4.72	--	--	--	--	1
	543	SV 203	--	--	5.74	--	--	--	7.15	--	7.15	5.70	5.25	4.24	4.35	4
	548	SV 231	--	--	5.02	--	--	--	6.25	--	6.25	--	--	--	--	1
	532	SV 232	--	--	5.12	--	--	--	6.38	--	6.38	--	--	--	--	1
	503	SV 265	--	--	6.00	--	--	--	7.47	--	7.47	5.89	5.58	4.30	4.95	8
	515	SV 285	--	--	5.93	--	--	--	7.39	--	7.39	5.87	5.41	4.35	4.48	6
	554	SX 1815	--	--	4.94	--	--	--	6.15	--	6.15	5.22	4.88	4.28	4.19	3
	530	SX 1818	--	--	5.69	--	--	--	7.09	--	7.09	5.95	5.82	4.82	5.56	3
	560	SX 1835	--	--	4.81	--	--	--	5.99	--	5.99	--	--	--	--	1
	544	SX 1836	--	--	5.41	--	--	--	6.74	--	6.74	--	--	--	--	1
	537	SX 1898	--	--	5.38	--	--	--	6.70	--	6.70	5.47	5.31	4.25	4.97	5
1	1001	AP CK#32 CRYS981	--	--	3.29	--	--	--	4.10	--	4.10	3.97	4.01	3.83	4.09	15
1	1002	AP CK#43 BTS80RR32	--	--	4.15	--	--	--	5.17	--	5.17	4.98	4.97	4.79	4.94	14
1	1003	AP CK#44 SEEDVISION RR	--	--	4.54	--	--	--	5.65	--	5.65	5.59	5.11	5.53	4.14	15
1	1004	AP CK#45 CRYS986	--	--	3.22	--	--	--	4.01	--	4.01	4.13	4.61	4.25	5.57	15
1	1005	AP CK#51 CRYS246	--	--	3.68	--	--	--	4.58	--	4.58	4.69	4.63	4.81	4.50	12
1	1006	AP CK#52 HILL4094RR	--	--	4.05	--	--	--	5.04	--	5.04	5.01	4.99	4.98	4.94	16
1	1007	AP CK#55 CRYS247	--	--	3.58	--	--	--	4.46	--	4.46	4.69	4.70	4.91	4.73	12
1	1008	AP CK#56 BTS8363	--	--	4.04	--	--	--	5.03	--	5.03	5.00	5.17	4.98	5.49	11
1	1009	AP CK#57 CRYS578	--	--	3.48	--	--	--	4.33	--	4.33	4.45	4.61	4.56	4.95	9
1	1010	AP CK#58 CRYS572	--	--	3.72	--	--	--	4.63	--	4.63	4.56	4.64	4.49	4.79	9
1	1011	AP CK#59 BTS8606	--	--	3.56	--	--	--	4.43	--	4.43	4.36	4.60	4.29	5.06	8
1	1012	AP CK#61 HIL9708	--	--	3.96	--	--	--	4.93	--	4.93	4.69	5.24	4.45	6.34	9
	1013	Crystal 684 (Filler)	--	--	NA	--	--	--	NA	--	--	--	--	3.81	3.60	8

		Unadj. Shak	Adj. Shak	Adj. 2023
12	Check Mean	3.77	4.70	4.70
	Trial Mean	3.72	4.63	4.63
	Coeff. of Var. (%)	13.2		
	Mean LSD (0.05)	0.62		
	Mean LSD (0.01)	0.82		
	Sig Lvl	0.01		
	Adjustment Factor		1.245	

[Z] Trial mean and statistics for Shakopee include four extra filler entries (not shown)

++ Ratings adjusted to 2003 basis. (2000-2002 Aph nurseries). Ratings adjusted on the basis of checks.
(1=healthy, 9=severe damage).

Perley (Perl), Climax (Clim), and Glyndon (Glyn) not rated due to lack of Aphanomyces pressure

Ratings in green font indicate good resistance.

Ratings in red font indicate a level of concern.

Created 10/27/2023

Table 26. 2023 Cercospora Ratings for Official Trial Entries

KWS (Randolph, MN) - BSDF (Saginaw, MI) - NDSU (Foxhome, MN) - AC North (East Grand Forks, MN)

			Unadj				Adjusted++									
Chk ++	Code	Description	Randolph Avg 4 Dates+	BSDF Avg 5 Dates+	Foxhome Avg 4 Dates+	EGF Avg 4 Dates+	Randolph Avg 4 Dates+	BSDF Avg 5 Dates+	Foxhome Avg 4 Dates+	EGF Avg 4 Dates+	2023 3 loc[z]	2 Yr	3 Yr	2022	2021	Trial Yrs
	550	BTS 8018	1.81	2.02	2.97	1.34	2.80	2.41	3.33	1.53	2.42	2.23	2.25	2.03	2.31	4
	558	BTS 8034	2.10	2.49	2.68	1.45	3.25	2.97	3.00	1.65	2.54	2.41	2.46	2.28	2.56	4
	538	BTS 8156	2.21	2.27	2.90	1.45	3.42	2.71	3.25	1.65	2.53	2.48	2.48	2.43	2.48	3
	540	BTS 8205	2.61	3.62	4.51	4.12	4.04	4.31	5.05	4.69	4.69	4.48	--	4.27	--	2
	551	BTS 8217	2.06	2.19	2.35	1.37	3.19	2.61	2.63	1.56	2.27	2.26	--	2.25	--	2
	527	BTS 8226	1.60	2.26	2.57	1.25	2.48	2.69	2.88	1.42	2.33	2.17	--	2.00	--	2
	561	BTS 8242	2.69	3.61	4.19	3.90	4.17	4.30	4.69	4.44	4.48	4.41	--	4.35	--	2
	533	BTS 8270	1.75	2.32	2.55	1.46	2.71	2.77	2.86	1.66	2.43	2.20	--	1.97	--	2
	535	BTS 8303	2.72	3.35	4.63	3.69	4.21	3.99	5.19	4.20	4.46	--	--	--	--	1
	508	BTS 8311	1.56	2.42	2.46	1.35	2.42	2.88	2.76	1.54	2.39	--	--	--	--	1
	545	BTS 8328	2.90	3.93	4.20	3.71	4.49	4.68	4.70	4.22	4.54	--	--	--	--	1
	517	BTS 8341	1.93	2.29	2.58	1.70	2.99	2.73	2.89	1.94	2.52	--	--	--	--	1
	505	BTS 8349	1.92	2.14	2.37	1.40	2.97	2.55	2.65	1.59	2.27	--	--	--	--	1
	524	BTS 8359	1.74	2.02	2.60	1.29	2.69	2.41	2.91	1.47	2.26	--	--	--	--	1
	546	BTS 8365	2.55	3.49	3.92	3.43	3.95	4.16	4.39	3.91	4.15	--	--	--	--	1
	528	BTS 8927	2.51	3.66	4.17	3.62	3.89	4.36	4.67	4.12	4.38	4.40	4.43	4.42	4.48	5
	521	Crystal 022	2.84	4.24	4.58	4.16	4.40	5.05	5.13	4.74	4.97	4.79	4.85	4.60	4.97	4
	510	Crystal 130	1.84	2.55	2.75	1.48	2.85	3.04	3.08	1.69	2.60	2.35	2.36	2.10	2.38	3
	552	Crystal 137	2.16	2.67	2.74	1.49	3.35	3.18	3.07	1.70	2.65	2.61	2.58	2.57	2.53	3
	502	Crystal 138	2.94	3.92	4.45	4.10	4.55	4.67	4.98	4.67	4.77	4.82	4.79	4.87	4.74	3
	529	Crystal 260	1.73	2.04	2.24	1.32	2.68	2.43	2.51	1.50	2.15	2.10	--	2.05	--	2
	555	Crystal 262	2.98	3.55	4.20	3.64	4.61	4.23	4.70	4.15	4.36	4.39	--	4.43	--	2
	557	Crystal 269	2.87	3.91	3.68	3.83	4.44	4.66	4.12	4.36	4.38	4.49	--	4.60	--	2
	534	Crystal 360	1.59	1.99	2.36	1.30	2.46	2.37	2.64	1.48	2.17	--	--	--	--	1
	519	Crystal 361	1.53	2.01	2.55	1.29	2.37	2.40	2.86	1.47	2.24	--	--	--	--	1
	556	Crystal 363	2.16	2.65	3.04	2.55	3.35	3.16	3.40	2.90	3.16	--	--	--	--	1
	506	Crystal 364	3.10	3.48	4.01	3.63	4.80	4.15	4.49	4.13	4.26	--	--	--	--	1
	523	Crystal 367	1.87	2.37	2.59	1.28	2.90	2.82	2.90	1.46	2.39	--	--	--	--	1
	531	Crystal 368	2.39	3.39	4.06	3.28	3.70	4.04	4.55	3.74	4.11	--	--	--	--	1
	513	Crystal 369	2.44	3.28	3.51	3.08	3.78	3.91	3.93	3.51	3.78	--	--	--	--	1
	514	Crystal 371	1.55	1.92	2.06	1.23	2.40	2.29	2.31	1.40	2.00	--	--	--	--	1
	509	Crystal 793	2.41	3.63	4.15	3.19	3.73	4.33	4.65	3.63	4.20	4.15	4.15	4.10	4.13	7
	547	Crystal 912	3.11	4.29	4.44	4.32	4.82	5.11	4.97	4.92	5.00	4.91	4.98	4.81	5.13	5
	549	Crystal 913	2.52	3.54	3.52	3.14	3.90	4.22	3.94	3.58	3.91	3.82	3.92	3.73	4.10	5
	553	Hilleshög HIL2317	3.20	3.98	4.34	4.32	4.96	4.74	4.86	4.92	4.84	4.99	4.85	5.13	4.57	5
	520	Hilleshög HIL2366	3.01	4.41	4.09	4.59	4.66	5.26	4.58	5.23	5.02	5.01	5.01	5.00	5.01	4
	511	Hilleshög HIL2368	2.85	3.60	3.65	4.26	4.41	4.29	4.09	4.85	4.41	4.48	4.54	4.56	4.66	4
	542	Hilleshög HIL2386	2.65	3.93	3.82	3.28	4.10	4.68	4.28	3.74	4.23	4.39	4.36	4.54	4.30	3
	522	Hilleshög HIL2389	3.31	4.02	4.04	3.69	5.13	4.79	4.52	4.20	4.51	4.60	4.68	4.69	4.85	3
	541	Hilleshög HIL2441	2.66	3.46	3.62	2.96	4.12	4.12	4.05	3.37	3.85	3.93	--	4.01	--	2
	526	Hilleshög HIL2442	2.87	4.17	3.39	3.10	4.44	4.97	3.80	3.53	4.10	4.24	--	4.39	--	2
	559	Hilleshög HIL2477	2.82	3.94	4.08	3.17	4.37	4.70	4.57	3.61	4.29	--	--	--	--	1
	516	Hilleshög HIL2478	3.46	4.50	4.40	4.21	5.36	5.36	4.93	4.79	5.03	--	--	--	--	1
	512	Hilleshög HIL2479	2.67	3.79	3.76	3.11	4.13	4.52	4.21	3.54	4.09	--	--	--	--	1
	501	Hilleshög HIL2480	2.68	3.82	3.51	3.10	4.15	4.55	3.93	3.53	4.00	--	--	--	--	1
	536	Hilleshög HIL2487 (MA942)	2.99	3.85	4.20	4.32	4.63	4.59	4.70	4.92	4.74	4.65	--	4.57	--	2
	507	Hilleshög HIL9920	2.95	4.52	4.47	4.43	4.57	5.39	5.01	5.04	5.15	5.04	4.94	4.92	4.75	7
	504	Maribo MA717	3.00	4.37	4.18	4.59	4.65	5.21	4.68	5.23	5.04	5.05	4.92	5.05	4.68	7
	539	Maribo MA902	3.00	4.13	3.66	4.35	4.65	4.92	4.10	4.95	4.66	4.80	4.75	4.95	4.63	5
	562	Maribo MA943	2.92	4.14	3.97	3.46	4.52	4.93	4.45	3.94	4.44	4.36	--	4.28	--	2
	518	Maribo MA945	2.89	3.46	4.35	4.26	4.48	4.12	4.87	4.85	4.62	--	--	--	--	1
	525	Maribo MA946	2.89	3.92	3.76	3.39	4.48	4.67	4.21	3.86	4.25	--	--	--	--	1
	543	SV 203	3.58	4.42	4.24	3.80	5.54	5.27	4.75	4.33	4.78	4.76	4.76	4.74	4.75	4
	548	SV 231	3.64	4.35	4.25	3.98	5.64	5.18	4.76	4.53	4.83	--	--	--	--	1
	532	SV 232	3.02	3.63	4.21	3.41	4.68	4.33	4.71	3.88	4.31	--	--	--	--	1
	503	SV 265	3.09	4.31	4.17	3.65	4.79	5.14	4.67	4.16	4.65	4.56	4.47	4.46	4.30	8
	515	SV 285	3.63	4.24	4.31	4.06	5.62	5.05	4.83	4.62	4.83	4.78	4.78	4.72	4.78	6
	554	SX 1815	3.34	4.33	4.23	3.79	5.17	5.16	4.74	4.32	4.74	4.91	4.86	5.07	4.78	3
	530	SX 1818	3.26	3.79	4.11	3.93	5.05	4.52	4.60	4.48	4.53	4.63	4.71	4.72	4.86	3
	560	SX 1835	3.43	4.12	3.97	3.76	5.31	4.91	4.45	4.28	4.55	--	--	--	--	1
	544	SX 1836	3.38	3.80	4.10	3.39	5.23	4.53	4.59	3.86	4.33	--	--	--	--	1
	537	SX 1898	3.64	4.50	4.28	3.94	5.64	5.36	4.79	4.49	4.88	4.80	4.79	4.72	4.76	5
1	1101	CR CK#19 CRYS808	3.35	4.44	4.81	4.50	5.19	5.29	5.39	5.12	5.27	5.31	5.25	5.36	5.14	6
1	1102	CR CK#24 HILL4012RR	3.27	4.42	4.86	5.19	5.06	5.27	5.44	5.91	5.54	5.28	5.23	5.02	5.12	18
1	1103	CR CK#41 CRYS981RR	3.24	4.41	4.41	4.32	5.02	5.26	4.94	4.92	5.04	5.16	5.09	5.28	4.95	15
1	1104	CR CK#43 CRYS246RR	3.45	3.55	4.62	3.90	5.34	4.23	5.17	4.44	4.62	4.72	4.81	4.82	4.98	12
1	1105	CR CK#44 BETA80RR32	3.80	4.52	4.56	4.23	5.88	5.39	5.11	4.82	5.10	5.19	5.15	5.28	5.06	14
1	1106	CR CK#45 HILL4448RR	3.07	4.96	4.48	5.11	4.75	5.91	5.02	5.82	5.58	5.44	5.38	5.31	5.25	12
1	1107	CR CK#47 HILL4094RR	2.86	3.34	3.74	4.07	4.43	3.98	4.19	4.63	4.27	4.17	4.22	4.07	4.31	16
1	1108	CR CK#48 MARI504	2.90	4.30	4.01	4.38	4.49	5.12	4.49	4.99	4.87	4.90	4.97	4.94	5.11	9
1	1109	CR CK#49 CRYS578RR	3.53	3.98	4.37	4.11	5.47	4.74	4.89	4.68	4.77	4.88	4.94	4.99	5.07	9
1	1110	CR CK#51 CRYS355RR	2.52	4.00	4.41	4.05	3.90	4.77	4.94	4.61	4.77	4.61	4.69	4.45	4.86	11
1	1111	CR CK#52 MARI717	2.85	3.91	4.01	4.34	4.41	4.66	4.49	4.94	4.70	4.71	4.74	4.72	4.79	7
1	1112	CR CK#53 CRYS684RR	3.17	3.56	4.28	3.49	4.91	4.24	4.79	3.97	4.34	4.46	4.49	4.59	4.54	8
	1113	CR CK MOD SUS #7	3.23	3.75	4.09	4.24	5.00	4.47	4.58	4.83	4.63	4.55	4.62	4.47	4.75	9
	1114	CR CK MOD SUS #8	3.20	4.23	4.62	4.56	4.96	5.04	5.17	5.19	5.14	4.92	4.99	4.71	5.13	5
12		Check Mean	3.17	4.12	4.38	4.31	4.91	4.91	4.91	4.91	4.91					
		Trial Mean	2.73	3.56	3.78	3.31	4.23	4.24	4.23	3.77	4.08					
		Coeff. of Var. (%)	7.1	7.58	7.7	7.6										
		Mean LSD (0.05)	0.25	0.42	0.37	0.30										
		Mean LSD (0.01)	0.33	0.56	0.49	0.39										
		Sig Lvl	0.01	0.01	0.01	0.01										
		Adj Factor					1.549	1.192	1.120	1.139						

Created 10/27/2023

[z] Randolph not used in calculating mean due to hail damage, causing rating to conclude in mid July
+ Average rating based upon multiple rating dates.
++ Ratings adjusted to 1982 basis (5.5 equivalent in 1978-81 CR nurseries). Ratings adjusted on the basis of checks.
(1= healthy, 9= severe damage)
Ratings in green font indicate good resistance.
Ratings in red font indicate a level of concern.

Table 27. 2023 Fusarium Ratings for Official Trial Entries

ACSC (North Moorhead, MN) - ACSC (Sabin, MN)

			Unadjusted		Adjusted++							
Chk ++	Code	Description	N Mhd 4Dates+	Sab 3Dates+	N Mhd 4Dates+	Sab 3Dates+	2023	2 Yr	3 Yr	2022	2021	Trial Yrs
	550	BTS 8018	2.19	3.47	2.68	3.73	3.20	3.09	3.13	2.98	3.22	4
	558	BTS 8034	1.85	2.95	2.26	3.17	2.72	2.44	2.53	2.16	2.71	4
	538	BTS 8156	2.21	2.70	2.71	2.90	2.80	2.55	2.61	2.30	2.72	3
	540	BTS 8205	2.33	3.11	2.85	3.34	3.10	2.97	--	2.85	--	2
	551	BTS 8217	2.27	2.95	2.78	3.17	2.97	2.76	--	2.54	--	2
	527	BTS 8226	2.97	3.79	3.64	4.07	3.85	3.66	--	3.47	--	2
	561	BTS 8242	2.83	4.14	3.46	4.44	3.95	3.69	--	3.42	--	2
	533	BTS 8270	2.60	3.48	3.18	3.74	3.46	3.26	--	3.06	--	2
	535	BTS 8303	2.22	3.45	2.72	3.70	3.21	--	--	--	--	1
	508	BTS 8311	3.09	3.76	3.78	4.04	3.91	--	--	--	--	1
	545	BTS 8328	2.99	4.10	3.66	4.40	4.03	--	--	--	--	1
	517	BTS 8341	3.96	3.88	4.85	4.17	4.51	--	--	--	--	1
	505	BTS 8349	1.98	3.02	2.42	3.24	2.83	--	--	--	--	1
	524	BTS 8359	2.53	3.61	3.10	3.88	3.49	--	--	--	--	1
	546	BTS 8365	2.29	3.77	2.80	4.05	3.43	--	--	--	--	1
	528	BTS 8927	2.23	3.20	2.73	3.44	3.08	3.10	3.40	3.11	4.00	5
	521	Crystal 022	2.37	3.68	2.90	3.95	3.43	3.32	3.38	3.22	3.50	4
	510	Crystal 130	2.63	3.61	3.22	3.88	3.55	3.38	3.33	3.22	3.22	3
	552	Crystal 137	1.95	2.96	2.39	3.18	2.78	2.57	2.46	2.35	2.25	3
	502	Crystal 138	2.69	3.93	3.29	4.22	3.76	3.46	3.55	3.16	3.75	3
	529	Crystal 260	2.42	3.53	2.96	3.79	3.38	3.22	--	3.06	--	2
	555	Crystal 262	2.68	4.08	3.28	4.38	3.83	3.55	--	3.27	--	2
	557	Crystal 269	2.91	4.34	3.56	4.66	4.11	3.74	--	3.36	--	2
	534	Crystal 360	2.69	3.48	3.29	3.74	3.51	--	--	--	--	1
	519	Crystal 361	2.55	3.12	3.12	3.35	3.24	--	--	--	--	1
	556	Crystal 363	2.88	3.67	3.53	3.94	3.73	--	--	--	--	1
	506	Crystal 364	2.23	3.26	2.73	3.50	3.12	--	--	--	--	1
	523	Crystal 367	2.10	2.64	2.57	2.83	2.70	--	--	--	--	1
	531	Crystal 368	2.86	3.99	3.50	4.28	3.89	--	--	--	--	1
	513	Crystal 369	2.26	3.46	2.77	3.71	3.24	--	--	--	--	1
	514	Crystal 371	2.34	3.61	2.86	3.88	3.37	--	--	--	--	1
	509	Crystal 793	2.35	3.66	2.88	3.93	3.40	3.22	3.08	3.03	2.80	7
	547	Crystal 912	2.71	4.03	3.32	4.33	3.82	3.74	3.86	3.66	4.11	5
	549	Crystal 913	2.40	3.55	2.94	3.81	3.37	3.25	3.39	3.13	3.68	5
	553	Hilleshög HIL2317	5.00	5.15	6.12	5.53	5.83	5.74	5.85	5.65	6.06	5
	520	Hilleshög HIL2366	3.90	5.00	4.77	5.37	5.07	4.95	4.85	4.83	4.65	4
	511	Hilleshög HIL2368	3.27	4.20	4.00	4.51	4.26	4.29	4.34	4.33	4.44	4
	542	Hilleshög HIL2386	2.91	4.11	3.56	4.41	3.99	3.86	3.99	3.73	4.26	3
	522	Hilleshög HIL2389	4.47	5.14	5.47	5.52	5.50	4.92	4.86	4.34	4.75	3
	541	Hilleshög HIL2441	3.30	3.89	4.04	4.18	4.11	4.05	--	4.00	--	2
	526	Hilleshög HIL2442	3.29	4.50	4.03	4.83	4.43	4.55	--	4.68	--	2
	559	Hilleshög HIL2477	5.09	5.64	6.23	6.06	6.14	--	--	--	--	1
	516	Hilleshög HIL2478	3.18	4.55	3.89	4.88	4.39	--	--	--	--	1
	512	Hilleshög HIL2479	3.41	4.37	4.17	4.69	4.43	--	--	--	--	1
	501	Hilleshög HIL2480	2.29	3.53	2.80	3.79	3.30	--	--	--	--	1
	536	Hilleshög HIL2487 (MA942)	3.70	4.57	4.53	4.91	4.72	4.86	--	5.01	--	2
	507	Hilleshög HIL9920	5.26	5.23	6.44	5.62	6.03	5.84	5.71	5.66	5.45	7
	504	Maribo MA717	3.43	4.52	4.20	4.85	4.53	4.70	4.84	4.87	5.11	7
	539	Maribo MA902	3.22	4.46	3.94	4.79	4.37	4.33	4.39	4.30	4.50	5
	562	Maribo MA943	3.47	4.51	4.25	4.84	4.55	4.36	--	4.18	--	2
	518	Maribo MA945	2.08	3.14	2.55	3.37	2.96	--	--	--	--	1
	525	Maribo MA946	2.87	3.90	3.51	4.19	3.85	--	--	--	--	1
	543	SV 203	4.19	4.91	5.13	5.27	5.20	5.38	5.58	5.55	5.99	4
	548	SV 231	3.53	3.81	4.32	4.09	4.21	--	--	--	--	1
	532	SV 232	4.32	4.74	5.29	5.09	5.19	--	--	--	--	1
	503	SV 265	4.65	5.73	5.69	6.15	5.92	6.00	5.89	6.08	5.65	8
	515	SV 285	5.21	4.91	6.38	5.27	5.82	5.65	5.85	5.47	6.26	6
	554	SX 1815	4.83	4.93	5.91	5.29	5.60	5.46	5.25	5.32	4.82	3
	530	SX 1818	3.77	4.25	4.62	4.56	4.59	4.56	4.80	4.54	5.26	3
	560	SX 1835	3.21	3.64	3.93	3.91	3.92	--	--	--	--	1
	544	SX 1836	4.43	4.79	5.42	5.14	5.28	--	--	--	--	1
	537	SX 1898	4.55	5.00	5.57	5.37	5.47	5.42	5.51	5.38	5.67	5
1	1201	FS CK #12 HILL4012RR	5.67	5.95	6.94	6.39	6.66	6.52	6.42	6.38	6.23	18
1	1202	FS CK #18 CRYS768RR	3.24	4.12	3.97	4.42	4.19	4.33	4.18	4.46	3.87	15
1	1203	FS CK #29 CRYS875RR	3.63	4.73	4.44	5.08	4.76	4.78	4.68	4.79	4.48	16
1	1204	FS CK #30 BTS8337	2.87	3.64	3.51	3.91	3.71	3.82	3.72	3.93	3.53	11
1	1205	FS CK #31 SXMarathon	4.21	4.75	5.15	5.10	5.13	5.07	5.29	5.01	5.72	9
1	1206	FS CK #32 CRYS574	2.23	2.98	2.73	3.20	2.96	2.69	2.68	2.41	2.67	9
1	1207	FS CK #33 SES375	4.41	4.76	5.40	5.11	5.25	5.34	5.58	5.43	6.05	7
1	1208	FS CK #34 SES265	4.43	5.42	5.42	5.82	5.62	5.61	5.74	5.59	6.02	8
1	1209	FS CK #35 SES203	4.78	4.96	5.85	5.33	5.59	5.57	5.71	5.55	5.99	4
1	1210	FS CK #36 SES285	4.88	4.70	5.97	5.05	5.51	5.49	5.75	5.47	6.26	6
10		Check Mean	4.04	4.60	4.94	4.94	4.94					
		Trial Mean	3.23	4.07	3.95	4.37	4.16					
		Coeff. of Var. (%)	16.0	10.6								
		Mean LSD (0.05)	0.67	0.54								
		Mean LSD (0.01)	0.88	0.71								
		Sig Lvl	0.01	0.01								
		Adj Factor			1.224	1.074						

+ Average rating based upon multiple rating dates.
++ Ratings adjusted to 2007 basis. (2005-2006 FS Nurseries). Ratings adjusted on the basis of checks.
(1= healthy, 9= severe damage)
Ratings in green font indicate good resistance.
Ratings in red font indicate a level of concern.

Created 10/27/2023

Table 28. 2023 Rhizoctonia Ratings for OVT Entries

BSDF (Saginaw, MI) - ACSC (NWROC)

			Unac				Adjusted ++									
Chk ++	Code	Description	BSDF 8/29	TSC-E NA	TSC-W NA	NWROC 8/7	BSDF 8/29	TSC-E NA	TSC-W NA	NWROC 8/7	2023	2 Yr	3 Yr	2022	2021	Years
	550	BTS 8018	5.85	---	---	3.43	4.07	---	---	4.05	4.06	4.00	3.94	3.93	3.83	4
	558	BTS 8034	6.32	---	---	3.20	4.40	---	---	3.78	4.09	4.29	4.15	4.49	3.88	4
	538	BTS 8156	6.12	---	---	3.04	4.26	---	---	3.59	3.93	4.08	3.99	4.24	3.81	3
	540	BTS 8205	5.68	---	---	3.04	3.95	---	---	3.59	3.77	3.80	--	3.82	--	2
	551	BTS 8217	5.85	---	---	3.15	4.07	---	---	3.72	3.90	4.02	--	4.14	--	2
	527	BTS 8226	5.51	---	---	3.15	3.83	---	---	3.72	3.78	3.76	--	3.74	--	2
	561	BTS 8242	5.93	---	---	3.40	4.12	---	---	4.02	4.07	4.04	--	4.00	--	2
	533	BTS 8270	5.89	---	---	2.75	4.10	---	---	3.25	3.67	4.00	--	4.33	--	2
	535	BTS 8303	5.45	---	---	3.41	3.79	---	---	4.03	3.91	--	--	--	--	1
	508	BTS 8311	5.79	---	---	3.54	4.03	---	---	4.18	4.11	--	--	--	--	1
	545	BTS 8328	5.83	---	---	3.57	4.06	---	---	4.22	4.14	--	--	--	--	1
	517	BTS 8341	6.50	---	---	3.58	4.52	---	---	4.23	4.38	--	--	--	--	1
	505	BTS 8349	6.11	---	---	3.71	4.25	---	---	4.39	4.32	--	--	--	--	1
	524	BTS 8359	5.90	---	---	3.43	4.10	---	---	4.05	4.08	--	--	--	--	1
	546	BTS 8365	5.77	---	---	2.84	4.01	---	---	3.36	3.69	--	--	--	--	1
	528	BTS 8927	5.78	---	---	3.34	4.02	---	---	3.95	3.98	4.06	3.93	4.13	3.68	5
	521	Crystal 022	5.80	---	---	3.10	4.03	---	---	3.66	3.85	3.98	3.83	4.10	3.53	4
	510	Crystal 130	5.42	---	---	3.05	3.77	---	---	3.61	3.69	3.88	3.78	4.08	3.57	3
	552	Crystal 137	6.35	---	---	3.04	4.42	---	---	3.59	4.01	4.09	3.91	4.18	3.53	3
	502	Crystal 138	5.80	---	---	3.04	4.03	---	---	3.59	3.81	3.81	3.71	3.81	3.52	3
	529	Crystal 260	5.70	---	---	2.50	3.96	---	---	2.95	3.46	3.58	--	3.70	--	2
	555	Crystal 262	5.27	---	---	2.50	3.67	---	---	2.95	3.31	3.35	--	3.38	--	2
	557	Crystal 269	6.06	---	---	3.04	4.22	---	---	3.59	3.90	4.05	--	4.20	--	2
	534	Crystal 360	5.72	---	---	3.47	3.98	---	---	4.10	4.04	--	--	--	--	1
	519	Crystal 361	5.71	---	---	2.63	3.97	---	---	3.11	3.54	--	--	--	--	1
	556	Crystal 363	5.95	---	---	3.48	4.14	---	---	4.11	4.13	--	--	--	--	1
	506	Crystal 364	5.97	---	---	2.90	4.15	---	---	3.43	3.79	--	--	--	--	1
	523	Crystal 367	5.84	---	---	3.24	4.06	---	---	3.83	3.95	--	--	--	--	1
	531	Crystal 368	5.92	---	---	3.57	4.12	---	---	4.22	4.17	--	--	--	--	1
	513	Crystal 369	5.93	---	---	3.25	4.12	---	---	3.84	3.98	--	--	--	--	1
	514	Crystal 371	5.84	---	---	3.11	4.06	---	---	3.68	3.87	--	--	--	--	1
	509	Crystal 793	6.23	---	---	3.69	4.33	---	---	4.36	4.35	4.54	4.48	4.73	4.36	7
	547	Crystal 912	5.69	---	---	2.58	3.96	---	---	3.05	3.50	3.39	3.52	3.28	3.77	5
	549	Crystal 913	6.19	---	---	3.44	4.31	---	---	4.07	4.19	4.21	4.12	4.23	3.94	5
	553	Hilleshög HIL2317	6.02	---	---	3.97	4.19	---	---	4.69	4.44	4.57	4.64	4.71	4.76	5
	520	Hilleshög HIL2366	5.99	---	---	3.22	4.17	---	---	3.81	3.99	3.95	3.96	3.92	3.98	4
	511	Hilleshög HIL2368	5.94	---	---	2.51	4.13	---	---	2.97	3.55	3.51	3.31	3.46	2.92	4
	542	Hilleshög HIL2386	5.99	---	---	3.09	4.17	---	---	3.65	3.91	3.71	3.87	3.51	4.20	3
	522	Hilleshög HIL2389	6.06	---	---	3.97	4.22	---	---	4.69	4.45	4.19	4.12	3.92	3.99	3
	541	Hilleshög HIL2441	5.75	---	---	3.20	4.00	---	---	3.78	3.89	3.75	--	3.62	--	2
	526	Hilleshög HIL2442	6.03	---	---	3.05	4.19	---	---	3.61	3.90	3.80	--	3.70	--	2
	559	Hilleshög HIL2477	6.01	---	---	3.85	4.18	---	---	4.55	4.37	--	--	--	--	1
	516	Hilleshög HIL2478	5.72	---	---	2.96	3.98	---	---	3.50	3.74	--	--	--	--	1
	512	Hilleshög HIL2479	5.57	---	---	2.53	3.87	---	---	2.99	3.43	--	--	--	--	1
	501	Hilleshög HIL2480	5.77	---	---	2.87	4.01	---	---	3.39	3.70	--	--	--	--	1
	536	Hilleshög HIL2487 (MA942)	6.18	---	---	3.62	4.30	---	---	4.28	4.29	4.24	--	4.18	--	2
	507	Hilleshög HIL9920	5.95	---	---	3.98	4.14	---	---	4.70	4.42	4.50	4.57	4.58	4.70	7
	504	Maribo MA717	6.28	---	---	3.25	4.37	---	---	3.84	4.10	4.01	4.11	3.92	4.31	7
	539	Maribo MA902	5.97	---	---	3.03	4.15	---	---	3.58	3.87	3.72	3.75	3.57	3.80	5
	562	Maribo MA943	6.05	---	---	3.51	4.21	---	---	4.15	4.18	4.11	--	4.04	--	2
	518	Maribo MA945	5.62	---	---	3.57	3.91	---	---	4.22	4.06	--	--	--	--	1
	525	Maribo MA946	5.85	---	---	3.29	4.07	---	---	3.89	3.98	--	--	--	--	1
	543	SV 203	6.12	---	---	3.59	4.26	---	---	4.24	4.25	4.22	4.26	4.19	4.34	4
	548	SV 231	5.95	---	---	2.74	4.14	---	---	3.24	3.69	--	--	--	--	1
	532	SV 232	6.03	---	---	3.59	4.19	---	---	4.24	4.22	--	--	--	--	1
	503	SV 265	5.63	---	---	3.22	3.92	---	---	3.81	3.86	3.91	4.00	3.96	4.17	8
	515	SV 285	6.08	---	---	3.66	4.23	---	---	4.33	4.28	4.40	4.36	4.53	4.26	6
	554	SX 1815	6.40	---	---	3.60	4.45	---	---	4.26	4.35	4.24	4.29	4.12	4.40	3
	530	SX 1818	5.90	---	---	3.39	4.10	---	---	4.01	4.06	4.11	4.21	4.16	4.41	3
	560	SX 1835	5.51	---	---	2.77	3.83	---	---	3.27	3.55	--	--	--	--	1
	544	SX 1836	6.02	---	---	3.39	4.19	---	---	4.01	4.10	--	--	--	--	1
	537	SX 1898	5.88	---	---	3.56	4.09	---	---	4.21	4.15	4.13	4.20	4.12	4.34	5
1	1301	RH CK#35 SES36812RR	6.40	---	---	3.82	4.45	---	---	4.52	4.48	4.37	4.28	4.25	4.11	16
1	1302	RH CK#47 SES36272RR	6.32	---	---	3.82	4.40	---	---	4.52	4.46	4.54	4.39	4.63	4.09	12
1	1303	RH CK#48 HILL4094RR	5.95	---	---	3.00	4.14	---	---	3.55	3.84	3.73	3.56	3.61	3.22	16
1	1304	RH CK#49 CRYS247	6.15	---	---	3.67	4.28	---	---	4.34	4.31	4.31	4.44	4.31	4.70	12
1	1305	RH CK#51 SXWinchester	6.20	---	---	3.98	4.31	---	---	4.70	4.51	4.53	4.48	4.55	4.37	11
1	1306	RH CK#52 CRYS573	6.18	---	---	3.51	4.30	---	---	4.15	4.22	4.37	4.34	4.52	4.29	9
1	1307	RH CK#53 BTS8500	6.12	---	---	3.58	4.26	---	---	4.23	4.24	4.32	4.27	4.39	4.18	9
1	1308	RH CK#54 CRYS574	6.18	---	---	3.81	4.30	---	---	4.50	4.40	4.34	4.25	4.28	4.08	9
1	1309	RH CK#55 CRYS803	6.49	---	---	3.74	4.51	---	---	4.42	4.47	4.56	4.70	4.66	4.96	6
1	1310	RH CK#56 MARI504	6.53	---	---	3.67	4.54	---	---	4.34	4.44	4.31	4.40	4.18	4.58	9
1	1311	RH CK#57 BTS8606	--	---	---	4.02	--	---	---	4.75	4.75	4.56	4.53	4.37	4.48	8
1	1312	RH CK#58 CRYS793	--	---	---	3.53	--	---	---	4.17	4.17	4.33	4.34	4.49	4.36	7
	1313	Crystal 684 (Filler)	--	---	---	3.28	--	---	---	3.88	3.88	3.99	3.94	4.11	3.82	8
	1314	Maribo MA109 (Filler)	--	---	---	2.99	--	---	---	3.53	3.53	--	--	--	--	10
12 *		Mean of Check Varieties	6.25			3.68	4.35			4.35	4.35					
		Trial Mean	5.95			3.31	4.14			3.91	4.03					
		Coeff. of Var. (%)	6.0			12.8										
		Mean LSD (0.05)	0.52			0.53										
		Mean LSD (0.01)	0.69			0.69										
		Sig Lvl	0.01			0.01										
		Adjustment Factor			0.696					1.182						

++ Ratings adjusted to 2009 basis (2007-2009) RH nurseries. Ratings adjusted on the basis of checks

Created 10/27/2023

* Only 10 checks used at BSDF due to constraints of trial layout.

TSC-E and TSC-W not rated due to inadequate Rhizoctonia infection levels.

(0= healthy, 7= severe damage)

Ratings in green font indicate good resistance.

Ratings in red font indicate a level of concern.

Table 29. Pesticides Applied to ACSC Official Trials

	Herbicide		Fungicide	
Location	Herbicide Used	Spray Dates	Fungicide Used	Spray Dates
Casselton	RU1, RU2	6/1,6/22	CR1, CR2, CR3, CR4	7/5, 7/17, 7/31, 8/15
Perley	RU1, RU2	6/6, 6/23	CR1, CR2, CR3, CR4, CR5	7/6, 7/17, 7/31, 8/15, 8/28
Halstad	RU1, RU2	6/2, 6/19	CR1, CR2, CR3, CR4, CR5	7/5, 7/17, 7/31, 8/15, 8/28
Reynolds	RU1, RU2, RU3	5/30, 6/23, 7/21	CR1, CR2, CR3, CR4, CR5	7/7, 7/17, 7/31, 8/15, 8/28
Climax	RU1, RU2	5/30, 6/29	CR1, CR2, CR3, CR4, CR5	7/7, 7/17, 7/31, 8/15, 8/28
Grand Forks	RU1, RU2	6/2, 6/29	CR1, CR2, CR3, CR4, CR5	7/6, 7/17, 7/31, 8/14, 8/28
Scandia	RU1, RU2	6/1, 6/28	CR1, CR2, CR3, CR4, CR5	7/7, 7/17, 7/31, 8/15, 8/28
East Grand Forks	RU1, RU2	5/31, 7/3	CR1, CR2, CR3, CR4, CR5	7/11, 7/18, 8/1, 8/17, 8/28
Stephen	RU1, RU2	5/31, 6/26	CR1, CR2, CR3, CR4, CR5	7/10, 7/19, 8/1, 8/17, 8/30
St. Thomas	RU1, RU2	6/5, 7/6	CR1, CR2, CR3, CR4, CR5	7/10, 7/18, 8/1, 8/17, 8/30
Bathgate	RU1, RU2	5/31, 6/28	CR1, CR2, CR3, CR4, CR5	7/10, 7/18, 8/1, 8/17, 8/30

Ground applications made by beet seed personnel from Crystal Technical Services Center. Created 11/28/2023

Counter 20G applied at 8.9 lbs./A at all locations.
AZteroid in-furrow (5.7 fl oz/A) was used at all locations.
Quadris (10 fl oz./A) was applied to 6-10 leaf beets at all locations

RU1 = Roundup PowerMax 3 (25 oz./A), ClassAct (2.5 gal./100 gal. of water).
RU2 = Roundp PowerMax 3 (21 oz./A), ClassAct (2.5 gal./100 gal. of water).
RU3 = Roundp PowerMax 3 (20 oz./A), ClassAct (2.5 gal./100 gal. of water).

CR1 = Insire XT + Manzate Max
CR2 = Agritin + Incognito
CR3 = Proline + Manzate Max
CR4 = Manzate Max
CR5 = Priaxor + Agritin