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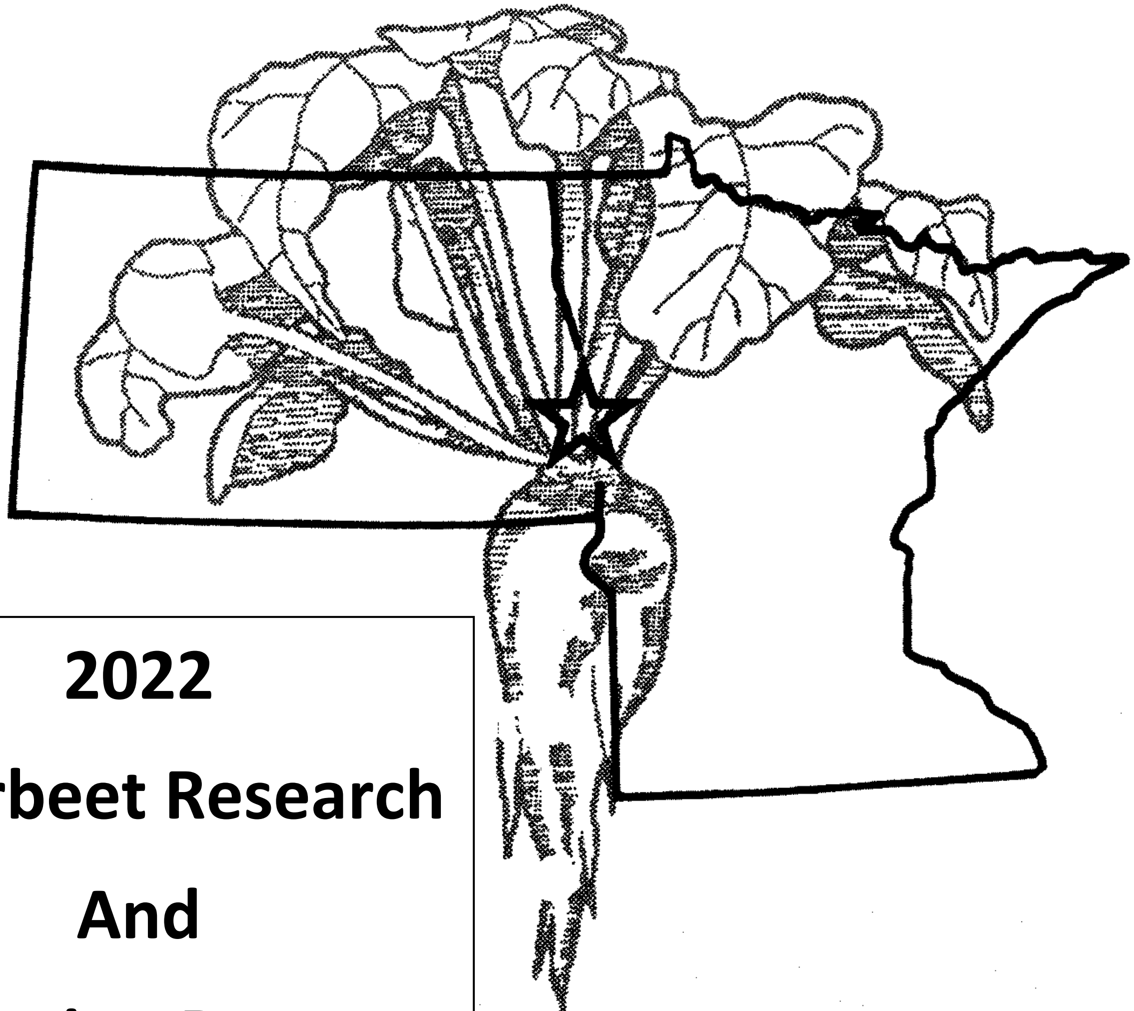

2022 Sugarbeet Research And Extension Reports

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 The contents of this booklet are not for publication or reprint without permission of the individual author.

* 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.

CONTENTS

WEED CONTROL

* Ethofumesate ……………………………………………………………………...6-11
Thomas J. Peters, Alexa L. Lystad and David Mettler

* Waterhemp Control from Soil Residual, Pre-emergence and Post-emergence Herbicides in 2022…...................................12-17
Thomas J. Peters, Alexa L. Lystad and David Mettler

* Sugarbeet Tolerance from Ultra Blazer……………………...18-23
Thomas J. Peters, Alexa L. Lystad, Emma Burt and David Mettler

* Ultra Blazer Section 18 Emergency Exemption and Supporting Experiments…..………………………………………...24-32
Thomas J Peters, Alexa L. Lystad, Emma Burt and David Mettler

* Reinventing Common Ragweed Control with Stinger HL in Sugarbeet …………………..……………………..................33-36
Thomas J Peters and Alexa L. Lystad

* Kochia Control in Sugarbeet and Crops in Sequence with Sugarbeet ………….………….………………………………...37-42
Thomas J. Peters and Alexa L. Lystad

*Turning Point Survey of Weed Control and Production Practices in
Sugarbeet in Minnesota and Eastern North Dakota in 2022……………………….……………………….…………….43-49
Thomas J Peters, Mohamed F. R. Khan, Mark A. Boetel and Alexa L. Lystad

* Spin-Aid Provides Selective Weed Control in Sugarbeet…………………..……………………………………………...50-54
Thomas J. Peters, Alexa L. Lystad and Adam Aberle

* Sugarbeet Tolerance to Complex Mixtures, Revisited in 2023…………..………………………….....................................55-59
Thomas J Peters, Alexa L. Lystad and Adam Aberle

* Complex Mixtures with Excalia……………………….…………………………………..…...................................60-62
Thomas J Peters, Alexa L. Lystad and Adam Aberle

SOIL MANAGEMENT PRACTICES

* Evaluation of Nitrogen Fertilizer Technologies and Fertilizer Timing for Sugarbeet Production ………..……….………...65-91
Daniel Kaiser, Mark Bloomquist and David Mettler

* Liquid Separated Dairy Manure as a Nutrient Source in a Sugarbeet Rotation …………………..………………..……….92-100
Melissa Wilson

SUGARBEET PHYSIOLOGY/STORAGE/PRODUCTION PRACTICES/ECONOMICS

* Preliminary Report on the Incidence of Postharvest Pathogens in Sugarbeet…………………………...…………………103-105
Shyam L. Kandel and Ela J. Montalvo

ENTOMOLOGY

***** Turning Point® Survey of Sugarbeet Insect Pest Problems and
Management Practices in Minnesota and Eastern North Dakota in
2022……..………108-116
Mark A. Boetel, Mohamed F.R. Khan, Thomas J. Peters, and Peter C. Hakk

***** Sugarbeet Root Maggot Fly Monitoring in the Red River Valley in 2022…………………………………………………117-119
Mark A. Boetel and Jacob J. Rikhus

***** Sugarbeet Root Maggot Forecast for the 2023 Growing Season………………………………………………………...120-121
Mark A. Boetel and Jacob J. Rikhus

*Sugarbeet Root Maggot Control by Using Multiple-Component Management Regimes……………………………..……122-129
Mark A. Boetel and Jacob J. Rikhus

*****Insecticide, Fungicide and Starter Fertilizer Combinations in Sugarbeet: An Evaluation
of Root Maggot Control Efficacy and Plant Safety……………………………………………………………..…………130-136
Mark A. Boetel and Jacob J. Rikhus

An Evaluation of Midac FC and Poncho Beta for Sugarbeet Root Maggot Control………………………………………...137-141
Mark A. Boetel and Jacob J. Rikhus

***** Experimental Insecticide Screening Trials to Identify Sugarbeet Root Maggot Control Alternatives………..…………...142-148
Mark A. Boetel and Jacob J. Rikhus

***** Springtail Control in Sugarbeet: Efficacy of Granular, Sprayable Liquid and Seed-Applied Insecticides ………..……...149-153
Mark A. Boetel and Jacob J. Rikhus

Entomology Appendix A. Research Site Agronomic and Rainfall Information………………………………………….154-156

Entomology Appendix B. 0 to 9 Scale for Rating Sugarbeet Root Maggot Feeding Injury……………………………………..157

PLANT PATHOLOGY

* Turning Point Survey of Fungicide Use in
in Minnesota and Eastern North Dakota in 2022 …………………………………………………………………………160-168
Peter C. Hakk, Mohamed F. R. Khan, Ashok K. Chanda, Mark A. Boetel, and Thomas J. Peters

* Evaluation of At-Planting Fungicide Treatments for Control of *Rhizoctonia Solani* on Sugarbeets in 2022 …………..….169-174
Austin K. Lien, Jeff Nielsen and Ashok K. Chanda

* Identification of Resistance-Breaking Variants of Beet Necrotic Yellow Vein Virus in Sugarbeets……………….…..…175-177
Vanitha Ramachandran, Eric Rivera Santiago, John Weiland and Melvin Bolton

* Evaluation of Fungicide Spray Programs to Manage Cercospora Leaf Spot Using
CR+ and Non-CR+ Sugarbeet Varieties ……………………………………….………………………………………….178-183
Austin K. Lien, Jeff Nielsen and Ashok K. Chanda

*Identification of New Genetic Sources from Sea Beet to Improve Identification of
New Genetic Cources to Improve Sugarbeet Resistance to Cercospora Leaf Spot…………..………………..……………184-190
Chenggen Chu, Muhammad Massub Tehseen, Rachael Claire Poore, Melvin D. Bolton, Mohamed F. R. Khan, Mike Metzger and Xuehui Li

* Sensitivity of *Cercospora Beticola* to Foliar Fungicides in 2022 …………………….……………………...……...…191-196
Gary Secor, Viviana Rivera, Melvin Bolton and Nathan Wyatt

*Preliminary Report of the Optimization of Fungicide Application Timings
for Management of Cercospora Leaf Spot in Sugarbeet CR+ Varieties……………………………………..……………197-201
Sunil Bhandari, Mohamed F. R. Khan and Peter C. Hakk

SUGARBEET VARIETIES/QUALITY TESTING

* Results of American Crystal Sugar Company's 2022 Coded
Official Variety Trials ………………………………………………………………………………………………….204-237
Jason Brantner and Deborah L Moomjian

WEED CONTROL

NOTES

ETHOFUMESATE

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Summary

1. Chemical properties of ethofumesate, including adsorptivity and water solubility, partially explain the inconsistent waterhemp control across environmental conditions.
2. Waterhemp control from ethofumesate is best following timely, adequate, and penetrating rainfall events.
3. Ethofumesate rate alone does not overcome sub-optimal environmental conditions.
4. The use of shallow tillage to incorporate ethofumesate in the top soil may improve the probability for waterhemp control.
5. Moisture in the soil solution is necessary for waterhemp control, even if ethofumesate moves into the soil during tillage.

Introduction

Ethofumesate or ‘Nortron’ was registered by Fisons Corporation in 1977 for control of small seeded broadleaves including common lambsquarters, waterhemp, and redroot pigweed control in sugarbeet (Edwards et al. 2005; Ekins and Cronin 1972). Ethofumesate is applied preplant incorporated (PPI) and preemergence (PRE) at use rates from 1.00 (2 pt/A) to 3.75 (7.5 pt/A) pound per acre (Kellogg 2011) and up to 0.38 (0.75 pt/A) pound per acre postemergence.

Weed control following PRE application requires timely and adequate precipitation to activate ethofumesate in the weed seedling layer due to low water solubility and strong adsorption to soil characteristics as compared to the chloroacetamide family of herbicides, dicamba, and trifluralin (Table 1; Shaner 2014; Schweitzer 1975). Ethofumesate rarely leaches in soil and provides up to 10 weeks of residual control to grass and broadleaf weed species (Ekins and Cronin 1972). Ethofumesate is absorbed through emerging roots and shoots when applied to soil (Eshel et al. 1978).

Table 1. Herbicides behavior in soil.

Common Name	Trade Name	Adsorptivity[a]	Water Solubility[b]
		K_{OC}	ppm[c]
acetochlor	Warrant	200	233
dimethenamid-p	Outlook	155	1,174
S-metolachlor	Dual Magnum	200	488
ethofumesate	Nortron	340	110
trifluralin	Treflan	7,000	0.3
dicamba	XtendiMax	2	4,500

[a]K value represents the ratio of herbicide bound to soil collides versus what is free in the water solution. The higher the K value, the greater the adsorption to soil colloids.
[b]Water solubility is a measure of the amount of chemical substance that can dissolve in water at a specific temperature. For example, milligrams per liter.
[c]ppm=Parts per million

Waterhemp control from ethofumesate has been an enigma (Merriam-Webster Dictionary definition: mysterious, puzzling, or difficult to understand) and it seems our interpretation of ethofumesate becomes more confusing with experiments in more environments. One of our first waterhemp experiments was near Herman, MN in 2014. We observed greater than 85% waterhemp control in July from ethofumesate alone or ethofumesate mixed with Dual Magnum PRE, but found ethofumesate did not provide season-long waterhemp control (Table 2). This outcome led to the development of a layered strategy in sugarbeet beginning with ethofumesate alone or ethofumesate mixtures with Dual Magnum PRE, followed by (fb) the split application of chloroacetamide herbicides at the V2 and V6 sugarbeet stage.

Table 2. Waterhemp control in response to herbicide treatment, Herman MN, 2014.

			Waterhemp Control			
Treatment[a]	**Application**	**Rate**	**Jun 23**	**Jul 2**	**Jul 10**	**Aug 27**
		---pt/A---	-----------------------	----------------------- %	-----------------------	-----------------------
Ethofumesate	PPI	6	78	90	86	74
Ethofumesate	PRE	6	88	88	86	70
Etho + Dual Magnum	PRE	3 + 0.5	99	99	97	94
Etho + Dual Magnum	PRE	4 + 0.5	98	97	97	94
Etho + Dual Magnum	PRE	3 + 1	98	100	100	98
Etho + Dual Magnum	PRE	4 + 1	100	100	100	98

[a]Treatments included repeat Roundup PowerMax applications POST at 28 fl oz/A followed by (fb) 28 fl oz/A fb 22 fl oz/A + Prefer 90 NIS at 0.25% v/v and N-Pak AMS at 2.5% v/v.

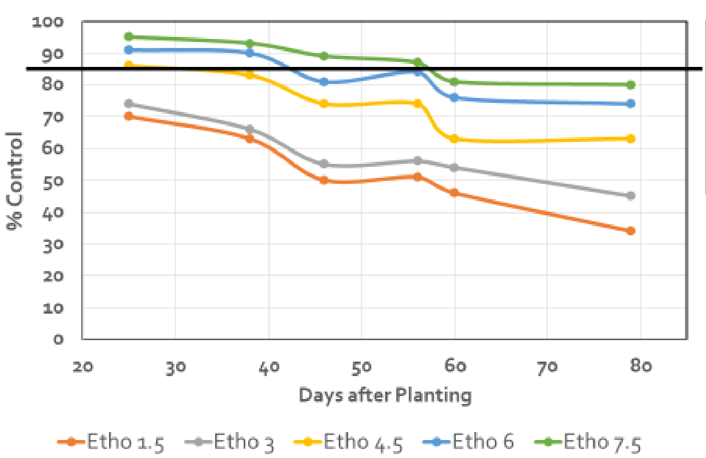
Ethofumesate alone or mixed with Dual Magnum PRE layered with chloroacetamide herbicides consistently controlled waterhemp in field experiments from 2015 to 2019. In general, sugarbeet were planted in May and received sufficient rainfall for activation of soil residual herbicides. However, our promising results did not reflect our historical knowledge, especially Dr. Dexter's research, which found incorporating ethofumesate improved the consistency of pigweed control from ethofumesate. Moreover, Dr. Dexter conducted several experiments over the years comparing preplant ethofumesate with preemergence ethofumesate (Table 3). Dr. Dexter's data suggests the importance of timely rainfall for activating ethofumesate. Finally, he conducted research on the appropriate depth to incorporate ethofumesate as well as comparing tillage equipment for optimal ethofumesate incorporation (Dexter et al., 1982).

Table 3. Comparing preplant incorporated and preemergence ethofumesate at 3.75 to 4.0 lb/A; 1973 to 1986.[a]

Nortron application	Redroot pigweed control at 4 of 7 locations	Redroot pigweed control at 3 of 7 locations
	---------------------------%	----------------------------
PPI	97	91
PRE	79	93
LSD (0.05)	**11**	**NS**

[a]Data taken from NDSU PLSC 350 class notes.

Growers frequently inquired about the maximum ethofumesate rate one can apply without injury to nurse crops. An experiment, first established in 2020, considered waterhemp control in response to ethofumesate rate (Figure 1 and Table 4). The experiment was established near Blomkest and at the ACS Technical Center, Moorhead, MN in 2020. Spring barley was drilled perpendicular to plots sprayed with ethofumesate at 1.5 to 7.5 pt/A. The primary objective was to find the threshold between spring barley safety and waterhemp control. Our second objective was to determine waterhemp control from ethofumesate at various application rates.



	Days after planting					
	25	38	46	56	60	79
Etho 1.5	70	63	50	51	46	34
Etho 3	74	66	55	56	54	45
Etho 4.5	86	83	74	74	63	63
Etho 6	91	90	81	84	76	74
Etho 7.5	95	93	89	87	81	80

Calendar date	Rainfall (inch)	Total Rainfall (inch)
May 9	0.7	0.7
May 26	1.7	2.4
June 10	0.3	2.7
June 25	1.3	4.0
July 10	3.8	7.8

Figure 1. Waterhemp control in response to ethofumesate PRE at 1.5 to 7.5 pt/A, Blomkest MN, 2020.

Our working hypothesis was ethofumesate provides greater than 85% waterhemp control for less than 30 days at 1.5, 3.0 and 4.5 pt/A and greater than 85% waterhemp control for more than 30 days at 6.0 and 7.5 pt/A. That is, complete waterhemp control but for short duration at rates less than 4.5 pt/A. To our surprise, the 1.5 and 3.0 pt/A rates did not accomplish 85% control at either Moorhead or Blomkest. The Moorhead experiment was completely overgrown with waterhemp by July 4, 2020 (Table 4). We attributed the Moorhead results to less than optimal results from ethofumesate in a season where ethofumesate activation by rainfall was compromised by below normal rainfall after planting.

Table 4. Waterhemp control in response to ethofumesate rate, Moorhead MN, 2020

		Waterhemp Control		
Herbicide	**Rate**	**May 26**	**June 15**	**June 28**
	--pt/A--	----------------------------------	%	----------------------------------
Ethofumesate	0	8 e	0 d	3 d
Ethofumesate	1.5	38 d	35 c	13 cd
Ethofumesate	3	50 c	51 b	18 c
Ethofumesate	4.5	73 a	68 a	33 b
Ethofumesate	6.0	63 b	70 a	58 a
Ethofumesate	7.5	65 ab	76 a	53 a
LSD (0.20)		**9**	**9**	**14**

This experiment was repeated at two locations in 2021, a location near Hector International Airport, Fargo, ND and a second location at the ACS Technical Center, Moorhead, MN. We elected to include both preplant incorporation and preemergence application in the experimental design in 2021 in response to previous year results with below normal rainfall. We also elected to conduct the experiment at 2, 4, 6, 8, 10 and 12 pt/A ethofumesate. Unfortunately, 2021 was equally as dry as 2020. Conditions were so poor that the experiment at Moorhead was abandoned due to erratic emergence of spring barley. We observed very poor overall control of waterhemp at Fargo location. However, we observed that waterhemp escapes were either small or large plant, depending on treatment, suggesting control of either early or late emerging waterhemp. Ethofumesate PPI, averaged across treatments, provided no control of early emerging waterhemp, but 56% control of late emerging waterhemp (Figure 2). Conversely, ethofumesate PRE, averaged across treatments, provided 55% control of early emerging waterhemp, but only 28% control of late emerging waterhemp.

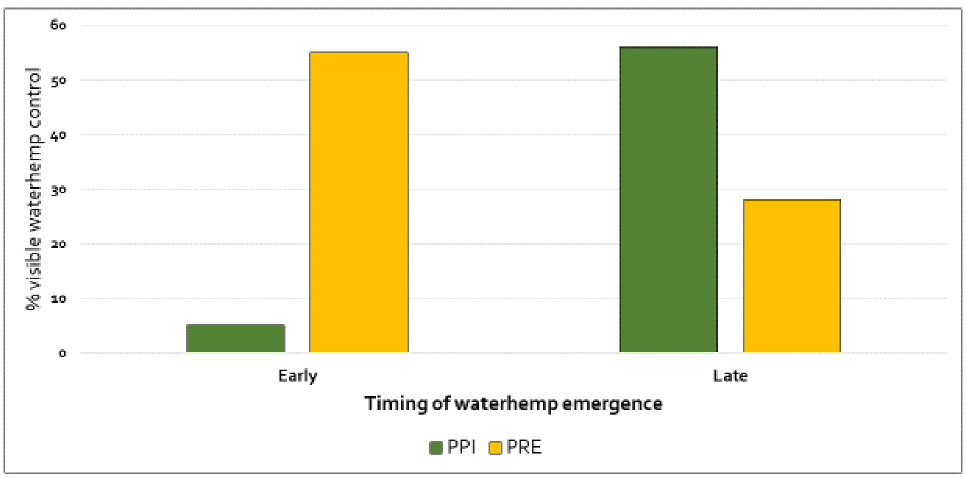


Figure 2. Early and late emerging waterhemp control in response to ethofumesate PPI or PRE, Fargo ND, 2021.

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 3). However, ethofumesate moved into the soil solution following rain events in June and was partially effective at controlling later emerging waterhemp. Ethofumesate PRE, which likely was bound to the soil surface, may have moved into the soil following rainfall events on May 20 and June 7, providing some early season control. However, degradation likely reduced control of late emerging waterhemp.

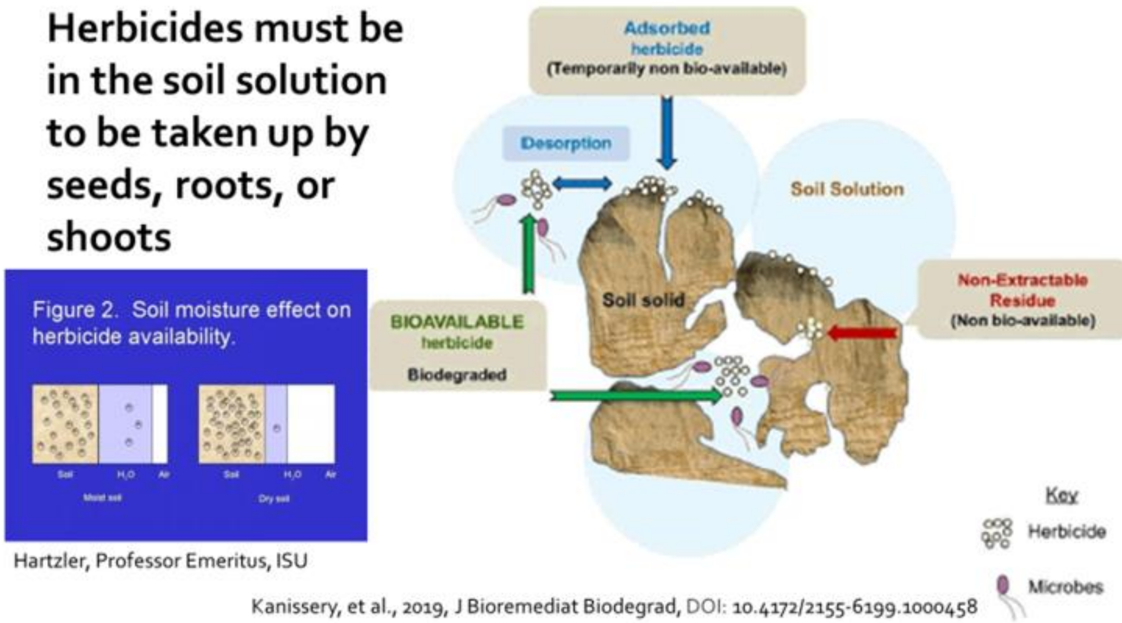


Figure 3. Illustration depicting ethofumesate bound to soil colloids when soil water content is low and in the soil solution when the soil water content is greater.

We believe soil moisture is a predictor of ethofumesate performance and at least partially explains the inconsistent results growers have experienced when ethofumesate has been applied preemergence in some fields in 2021 (and 2022). Likewise, waterhemp control from ethofumesate has been inconsistent even with effective incorporation, when soil moisture levels were sub-optimal such as conditions in some geographies in 2021.

Our working hypothesis is that 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. Ethofumesate rate does not overcome challenges caused by a dry spring. Finally, incorporating ethofumesate might be an effective way for improving waterhemp control, provided ethofumesate is not incorporated too deep, thereby diluting concentration.

The objective of this 2022 experiment was to 1) demonstrate crop safety to nurse crop barley and 2) determine the duration of waterhemp control from ethofumesate.

Materials and Methods

An experiment was conducted near Moorhead, MN in 2022. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on May 25 at Moorhead, MN in 2022. Sugarbeet was seeded in 22-inch rows at approximately 62,000 seeds per acre with 4.6 inch spacing between seeds. Herbicide treatments are found in Table 5.

Treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 40 feet in length in 2022. Ethofumesate applied preplant was incorporated into soil using a Kongskilde s-tine field cultivator with rolling baskets set approximately 2-inch deep and operated at approximately 5 mph.

Table 5. Herbicide treatment, application timing, and rate, Moorhead, MN, 2022.

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

Visible waterhemp control (0 to 100% control, 0% indicating no control, and 100% indicating complete control) was collected approximately 10 days after treatment (DAT). Experimental design was randomized complete block design with four replications in a factorial arrangement, with factors being herbicide rate and application timing. Data were analyzed with the ANOVA procedure of ARM, version 2022.5 software package.

Results and Discussion

Waterhemp control was evaluated on approximately ten-day intervals from June 16 to August 3, 2022. Figure 4 demonstrates waterhemp control × ethofumesate rate, averaged across application type, since waterhemp control from ethofumesate PPI (preplant incorporated) did not interact with ethofumesate PRE (P-Value = 0.8926, 0.7840, 0.6326, 0.4246, 0.2129 and 0.3762, approximately 20, 30, 40, 50, 60, and 70 DAP (days after planting) evaluation, respectively). Cumulative rainfall was 0.9, 2.6, and 4.5 inches, 14, 30 and 45 DAP and ethofumesate application, in 2022, which was enough to activate the herbicide, regardless of application method, and explains the lack of interaction. However, waterhemp control from ethofumesate at labeled rates failed to reach 85% control.

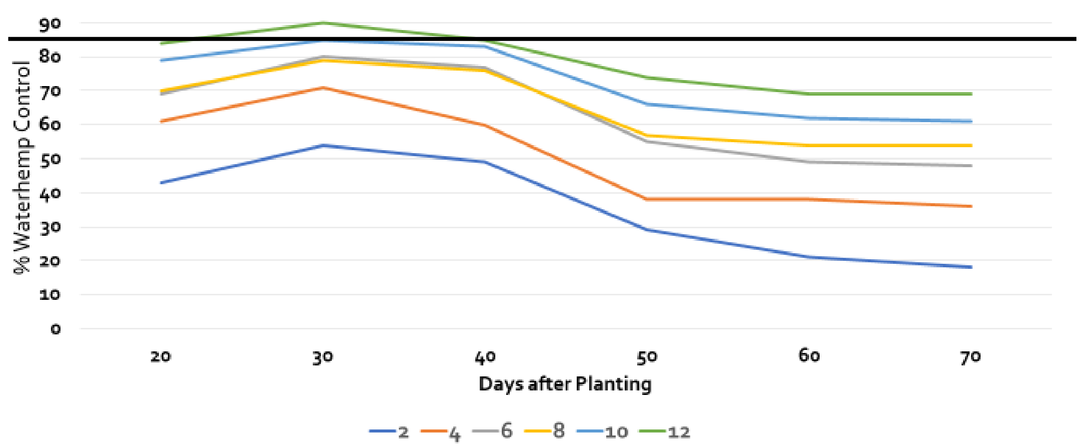


Figure 4. Waterhemp control in response to ethofumesate, averaged across PPI and PRE, Moorhead MN, 2022.

Ethofumesate PPI or PRE is a component in the waterhemp control strategy which includes PRE fb EPOST fb POST application of soil residual herbicides. Sugarbeet reach the 2-lf stage between 14 and 28 DAP, depending on planting date. Ekins and Cronin (1972) reported ethofumesate provides up to 10 weeks of residual broadleaf control. However, Ekins and Cronin did not research waterhemp control. Our 2022 result suggests no more than 6-weeks of waterhemp control (Figure 5) which seems to align with results from previous years.

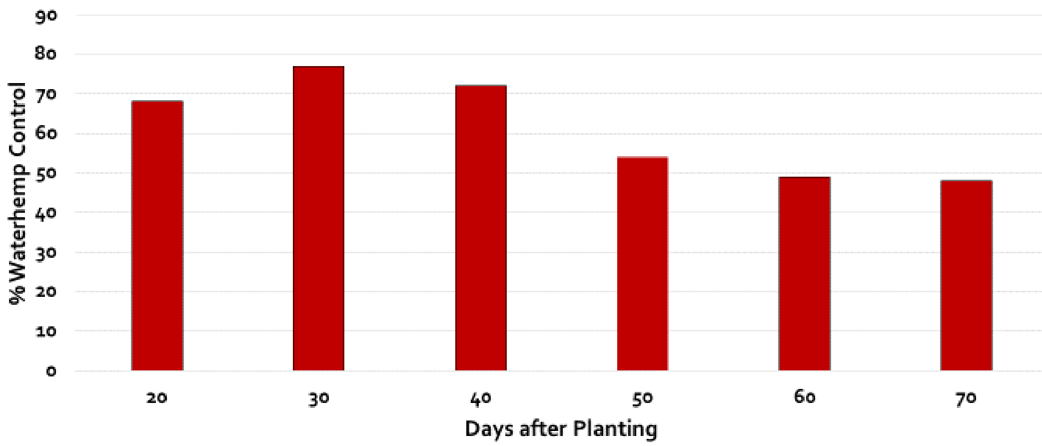


Figure 5. Waterhemp control in response to ethofumesate, averaged across ethofumesate rate and application type, Moorhead MN, 2022

Conclusion

Implementing the layered soil residual strategy is our best opportunity for season-long waterhemp control in sugarbeet. Our best opportunity for a clean start has been an early spring planting date along with an application of ethofumesate alone PRE or ethofumesate mixed with Dual Magnum PRE fb ample rainfall for activation. 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, thus 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.

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WATERHEMP CONTROL FROM SOIL RESIDUAL PREEMERGENCE AND POSTEMERGENCE HERBICIDES IN 2022

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Summary

1. Layering soil residual herbicides, beginning with preemergence (PRE) herbicide at planting, is our most effective strategy for controlling waterhemp in sugarbeet.
2. Differences in waterhemp control may occur, especially when rainfall is absent or not timely.
3. We do not completely understand the environmental conditions where ethofumesate fails to provide waterhemp control or why lack of control occurs.
4. Roundup PowerMax3 mixed with Ultra Blazer improved waterhemp control when soil residual herbicides failed due to lack of rainfall for activation.
5. Ultra Blazer mixed with Roundup PowerMax3 causes significant sugarbeet growth reduction injury which may cause loss of root yield compared with our soil residual waterhemp control standards, despite providing very good waterhemp control.

Introduction

Waterhemp control is our most important weed management challenge in sugarbeet according to the annual growers survey. Waterhemp is both common and troublesome in fields planted to sugarbeet for multiple reasons including full-season germination and emergence, prolific seed production, genetic diversity, and herbicide resistance. To date, waterhemp has shown resistance to herbicides from six classes, including Group 5 (e.g., triazines like atrazine), Group 2 (e.g., ALS-inhibiting herbicides like Pursuit), Group 14 (e.g., PPO-inhibiting herbicides like Ultra Blazer and Flexstar), Group 9 (e.g., glyphosate), Group 27 (e.g., HPPD-inhibiting herbicides like Callisto and Laudis), and Group 4 (e.g., 2,4-D).

The foundation of the waterhemp control program in sugarbeet is layered use of chloroacetamide (Group 15) herbicides PRE, early postemergence (EPOST), and POST, alone or in combination with glyphosate and ethofumesate, in sugarbeet (Figure 1). The goal is to have layered residual herbicides in the soil from planting through canopy closure, in late June or early July, to control waterhemp emergence.

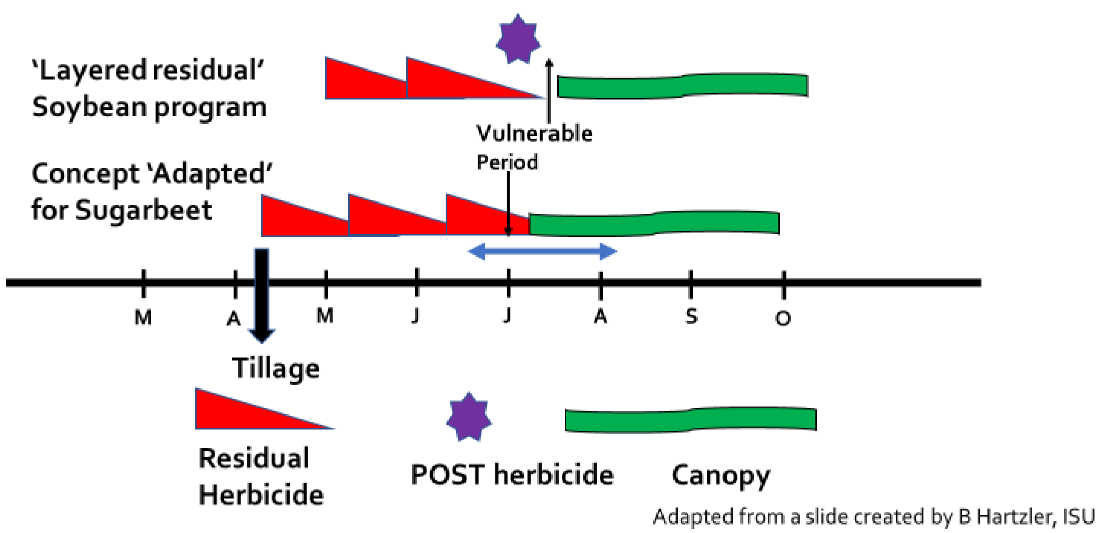

Figure 1. A demonstration of layered soil residual herbicides creating a herbicide barrier in soil from planting through canopy closure.

Calendar year 2022 created some unique challenges for sugarbeet growers. First, the spring was wet, resulting in average planting dates approximately 21 days later than the 20-year averages. Second, June and July rainfall were below normal in areas, compromising activation of soil residual herbicides (Figure 2).

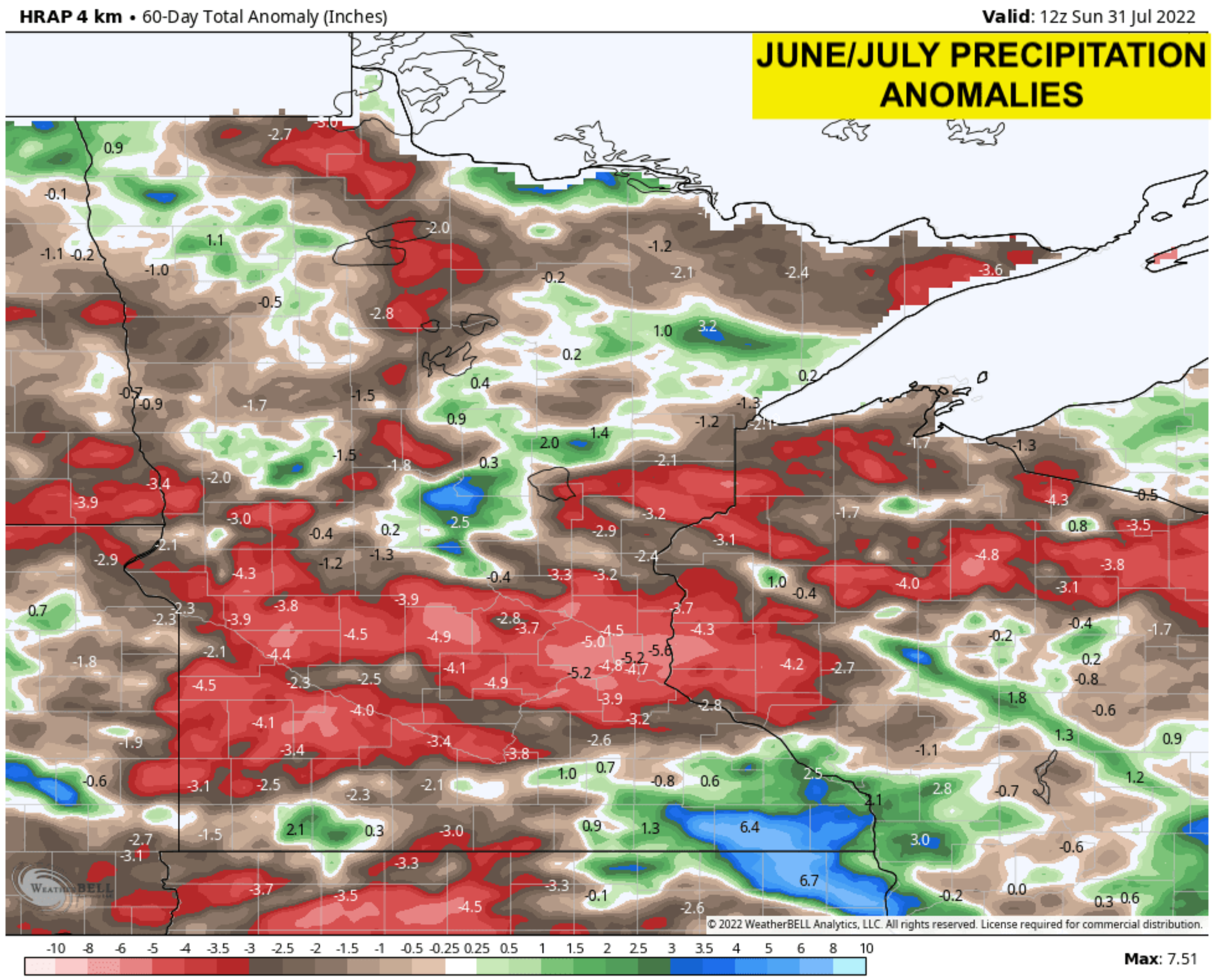

Figure 2. June and July, 2022 precipitation anomalies, Bring Me the News, Meteorologist Sven Sundgaard https://bringmethenews.com/minnesota-weather/july-2022-in-minnesota-was-hotter-windier-and-drier-than-normal.

The objectives of these experiments were 1) to demonstrate a weed control system for waterhemp control in sugarbeet, 2) to reinforce previous waterhemp control messages and practices for audiences with experience in waterhemp control, and 3) to examine differences in waterhemp control across experiments and investigate factors contributing to control.

Materials and Methods

Experiments were conducted near Blomkest, Moorhead, and Sabin, MN in 2022. 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 27 at Blomkest, May 25 at Moorhead, and May 19 at Sabin in 2022. Sugarbeet was seeded in 22-inch rows at approximately 62,000 seeds per acre with 4.6 inch spacing between seeds. Treatments were applied with a bicycle sprayer in 17 gpa spray solution through XR8002 flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 40 feet in length.

Table 1. Herbicide treatment, rate, and application timing, Blomkest, Moorhead, and Sabin MN, 2022.

Herbicide Treatment PRE	Residual Herbicide Treatment POST[a]	Rate (fl oz/A)	Sugarbeet stage (lvs)
No	PowerMax3 + etho / PowerMax3 + Ultra Blazer[b]	25 + 6 / 25 + 16	2 / 6-8
No	Outlook / Outlook	12 / 12	2 / 6-8
No	Warrant / Warrant	48 / 48	2 / 6-8
No	Outlook / Warrant	12 / 48	2 / 6-8
No	Outlook / Warrant	12 / 64	2 / 6-8
Yes[c]	PowerMax3 + etho / PowerMax3 + Ultra Blazer	25 + 6 / 25 + 16	PRE/2 / 6-8
Yes	Outlook / Outlook	12 / 12	PRE/2 / 6-8
Yes	Warrant / Warrant	48 / 48	PRE/2 / 6-8
Yes	Outlook / Warrant	12 / 48	PRE/2 / 6-8
Yes	Outlook / Warrant	12 / 64	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 every POST application that did not contain Ultra Blazer.
[b]Ultra Blazer applied with Roundup PowerMax 3 at 25 fl oz/A + Prefer 90 NIS at 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.
[c]Ethofumesate + Dual Magnum at 2+0.5 pt/A PRE at Bloomkest and Sabin or ethofumesate at 6 pt/A PRE at Moorhead.

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 7 and 14 days (+/- 3 days) following the 6-8 leaf application. Visible waterhemp control was evaluated using a 0 to 100% scale (0% indicating no control and 100% indicating complete weed control) and was collected 59, 90, and 94 days after planting. Experimental design was randomized complete block with four replications in a factorial treatment arrangement, factors being PRE and POST herbicide treatments. Data were analyzed with the ANOVA procedure of ARM, version 2022.5 software package.

At harvest, sugarbeet was defoliated and harvested mechanically from the center two rows of each plot and weighed at Moorhead and Sabin, MN. An approximate 30-pound sample was collected from each plot and analyzed for sucrose content and sugar loss to molasses by American Crystal Sugar Company (East Grand Forks, ND).

Results

Experiments at Blomkest and Moorhead, MN were planted later than average due to continuous spring rainfall in 2022. As a result, sugarbeet stands were variable at both locations. At Moorhead, experiments were planted into a cloddy seedbed. It was extremely dry at planting at Blomkest. In addition, excessively strong winds on June 21 partially defoliated sugarbeet. Timely rainfall events were measured at Moorhead in June and July following herbicide applications and in July at Sabin, MN; however, rainfall was much less at the Blomkest location (Table 2).

Table 2. Cumulative rainfall the first 10 days following herbicide application, across locations, 2022.

Herbicide Treatment	Moorhead, MN[a]	Sabin, MN	Blomkest, MN[b]
	----------	----inch----	----------
PRE Application	1.0	0.5	0.9
EPOST Application	1.7	0.4	0.0
POST Application	1.8	2.4	0.5
Total:	**4.5**	**3.3**	**1.4**

[a]Moorhead and Sabin precipitation data collected from nearby weather stations operated by North Dakota Agricultural Weather Network (NDAWN)
[b]Blomkest precipitation data collected using weather station instrumentation by Campbell Scientific.

Sugarbeet injury from soil residual herbicides ranged from 0% to 29% across evaluations and experiments (Table 3). Sugarbeet injury from soil residual herbicides tended to be greatest at Sabin and was less at Bloomkest and Moorhead. Assessment of sugarbeet injury at Bloomkest was complicated by erratic stands due to dry conditions and strong winds, which partially defoliated sugarbeet. At Sabin, sugarbeet injury from soil residual herbicides was observed 7 days after treatment (DAT) and remained visible 14 DAT, especially from PRE / EPOST / POST treatments.

Sugarbeet injury from Ultra Blazer + Roundup PowerMax3 POST ranged from 35% to 53% across locations and was greater than sugarbeet injury from soil residual herbicides POST (Table 3). Applying ethofumesate or ethofumesate + Dual Magnum PRE did not impact sugarbeet injury from Roundup PowerMax3 + ethofumesate followed by (fb) Roundup PowerMax3 + Ultra Blazer. Sugarbeet injury from Ultra Blazer declined numerically between the first and second evaluation.

Table 3. Sugarbeet visible injury in response to PRE and POST treatment, across locations, 2022.[a]

Herbicide Treatment PRE[c]	Herbicide Treatment POST[d]	Rate	Sugarbeet Injury[b] Sabin, MN 7 DAT	Sabin, MN 17 DAT	Moorhead, MN 10 DAT	Moorhead, MN 15 DAT	Blomkest, MN 9 DAT	Blomkest, MN 18 DAT
		-fl oz/A-	--------%					---------
No	PowerMax3 + etho / PowerMax3 + Ultra Blazer[e]	25 + 6 / 25 + 16	44 d	38 d	50 c	34 b	53 b	46 b
No	Outlook / Outlook	12 / 12	11 a	4 a	0 a	0 a	0 a	6 a
No	Warrant / Warrant	48 / 48	9 a	0 a	0 a	3 a	0 a	11 a
No	Outlook / Warrant	12 / 48	29 c	14 bc	0 a	5 a	0 a	5 a
No	Outlook / Warrant	12 / 64	9 a	3 a	16 b	4 a	0 a	0 a
Yes	PowerMax3 + etho / PowerMax3 + Ultra Blazer	25 + 6 / 25 + 16	50 d	35 d	50 c	48 b	48 b	41 b
Yes	Outlook / Outlook	12 / 12	13 ab	8 ab	0 a	0 a	0 a	5 a
Yes	Warrant / Warrant	48 / 48	20 abc	20 c	11 b	5 a	0 a	3 a
Yes	Outlook / Warrant	12 / 48	24 bc	15 bc	0 a	5 a	0 a	4 a
Yes	Outlook / Warrant	12 / 64	19 abc	4 a	8 a	0 a	0 a	8 a
LSD (0.10)			**12**	**8**	**9**	**8**	**5**	**11**

[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]Sugarbeet injury evaluations were approximately 7 and 14 days after application C, Ultra Blazer.
[c]Ethofumesate + Dual Magnum PRE at 2 + 0.5 pt/A at Blomkest and Sabin. Ethofumesate PRE at 6 pt/A at Moorhead.
[d]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 every POST application that did not contain Ultra Blazer.
[e]Ultra Blazer applied with Roundup PowerMax 3 at 25 fl oz/A + Prefer 90 NIS at 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.

Waterhemp (with some redroot pigweed) control ranged from 36% to 96% across treatments and locations (Table 4). The average control across all treatments was 52%, 93% and 95% for Blomkest, Moorhead and Sabin, respectively. At Sabin, repeat Warrant applications or Outlook fb Warrant tended to provide waterhemp control greater than repeat Outlook applications. Addition of ethofumesate mixtures with Dual Magnum PRE did not improve waterhemp control. Waterhemp control was greatest from Roundup PowerMax3 mixtures with soil residual herbicides at Sabin compared with other locations.

Waterhemp control from soil residual herbicides applied POST which contained Warrant, or Outlook followed by Warrant, provided similar waterhemp control at Moorhead and Sabin. PRE herbicides followed by POST herbicides tended to provide waterhemp control similar to POST treatments alone. The exception was at Moorhead where the absence of PRE herbicides resulted in reduced waterhemp control from repeat POST Outlook applications.

Ultra Blazer mixed with Roundup PowerMax3 following ethofumesate PRE provided or tended to provide waterhemp control similar to soil residual herbicides POST. However, control was less when Ultra Blazer and Roundup PowerMax3 were applied without PRE ethofumesate.

Table 4. Waterhemp control in response to PRE and POST treatment, across location, 2022.[a]

Etho or Etho+DM PRE[b]	Soil Residual Treatment POST[c]	Rate	Waterhemp Control Blomkest, MN 59 DAP[d]	Moorhead, MN 90 DAP	Sabin, MN 94 DAP
		--fl oz/A--	-------------------------%----------------------		
No	PowerMax3 + etho / PowerMax3 + Ultra Blazer[e]	25 + 6 / 25 + 16	63 ab	63 c	84 c
No	Outlook / Outlook	12 / 12	36 e	89 b	97 ab
No	Warrant / Warrant	48 / 48	54 bc	99 a	98 ab
No	Outlook / Warrant	12 / 48	43 de	96 ab	98 ab
No	Outlook / Warrant	12 / 64	54 bc	99 a	99 a
Yes	PowerMax3 + etho / PowerMax3 + Ultra Blazer	25 + 6 / 25 + 16	71 a	98 a	90 bc
Yes	Outlook / Outlook	12 / 12	43 de	99 a	98 ab
Yes	Warrant / Warrant	48 / 48	49 cd	99 a	99 a
Yes	Outlook / Warrant	12 / 48	56 bc	93 ab	92 ab
Yes	Outlook / Warrant	12 / 64	49 cd	99 a	96 ab
LSD (0.10)			**9**	**9**	**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]Ethofumesate + Dual Magnum PRE at 2 + 0.5 pt/A at Blomkest and Sabin. Ethofumesate PRE at 6 pt/A PRE at Moorhead.
[c]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 every POST application that did not contain Ultra Blazer.
[d]DAP=Days after plant
[e]Ultra Blazer applied with Roundup PowerMax3 at 25 fl oz/A + Prefer 90 NIS at 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.

Waterhemp control from PRE herbicides were inconsistent and unacceptable at Blomkest, MN. We credit trial inconsistency to variable weed pressure across the experiment due to dry conditions in June. An on-site rainfall collection device recorded 0.79 inches of rainfall May 30 or three days after PRE application (Table 5). This rainfall event should have been sufficient to activate ethofumesate and Dual Magnum PRE. However, sub-optimal weed control was observed on June 21 (data not included in this report) contributing to the overall lack of control, even from PRE herbicides at Blomkest. We believe the lack of early season waterhemp control from the PRE herbicides contributed to the lack of POST control from glyphosate, ethofumesate and soil residual herbicides.

Table 5. Hourly rainfall measurements, May 30, 2022, near Blomkest, MN.[a]

Hour	Rainfall (inch)
Midnight to 5:00AM	0.00
5:00AM to 7:00AM	0.04
8:00AM to 9:00AM	0.27
9:00AM to 10:00AM	0.17
10:00AM to noon	0.10
1:00PM to 5:00PM	0.01
6:00PM to 7:00PM	0.18
7:00PM to 8:00PM	0.02
8:00PM to midnight	0.00

[a] Blomkest precipitation data collected using weather station instrumentation by Campbell Scientific.

Sabin was also very dry in early June. However, in contrast to Blomkest, we do not believe there was waterhemp seed germination and emergence throughout May and the first half of June at Sabin, MN. We did have sufficient moisture for sugarbeet emergence and observed uniform stands. Soil residual herbicides were activated by late June and July rainfall, resulting in excellent weed control. We are unsure if the PRE herbicide treatment was activated at Sabin; however, the POST herbicide treatments delivered effective control as compared with the control strips imbedded in the experiment.

Ultra Blazer mixed with Roundup PowerMax3 alone or following ethofumesate at 6 pt/A PRE reduced sugarbeet root yield and recoverable sucrose as compared with soil residual herbicides mixed with Roundup PowerMax3 (Table 6). Herbicide treatments did not affect % sucrose.

Ultra Blazer was mixed with Roundup PowerMax3 in 2022. Roundup PowerMax3 was a new glyphosate formulation, containing 5.88 pounds of glyphosate per gallon as compared with 4.6 pounds of glyphosate per gallon in Roundup PowerMax. The experiments did not contain either the Roundup PowerMax3 alone treatment or Roundup PowerMax plus Ultra Blazer treatment.

Table 6. Root yield, % sucrose and recoverable sucrose in response to herbicide treatment, Moorhead MN, 2022.[a]

Etho PRE[b]	Soil Residual Treatment POST[c]	Rate	Root Yield	Sucrose	Recoverable sucrose/A
		--fl oz/A--	---TPA[d]---	---%---	----lb/A----
No	PowerMax3 + etho / PowerMax3 + Ultra Blazer[e]	25 + 6 / 25 + 16	21.2 c	14.9	5,658 c
No	Outlook / Outlook	12 / 12	26.5 ab	15.1	7,147 ab
No	Warrant / Warrant	48 / 48	27.5 a	14.7	6,900 ab
No	Outlook / Warrant	12 / 48	29.1 a	15	7,838 a
No	Outlook / Warrant	12 / 64	28.4 a	15.2	7,237 ab
Yes	PowerMax3 + etho / PowerMax3 + Ultra Blazer	25 + 6 / 25 + 16	24.0 b	14.9	6,280 bc
Yes	Outlook / Outlook	12 / 12	26.8 a	15.1	7,236 ab
Yes	Warrant / Warrant	48 / 48	28.5 a	15.3	7,895 a
Yes	Outlook / Warrant	12 / 48	27.2 a	14.8	7,124 ab
Yes	Outlook / Warrant	12 / 64	28.1 a	15.1	7,683 a
LSD (0.10)			**2.7**	**NS**	**1,031**

[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]Ethofumesate at 6 pt/A PRE applied at Moorhead.
[c]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 every POST application that did not contain Ultra Blazer.
[d]TPA=Tons per acre.
[e]Ultra Blazer applied with Roundup PowerMax3 at 25 fl oz/A + Prefer 90 NIS at 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.

Our best research practices are not to harvest weed control experiments. In this situation, however, we felt that quantifying yield from sugarbeet treated with Ultra Blazer in a waterhemp rich environment would enable us to demonstrate that weed control from Ultra Blazer might off-set sugarbeet injury.

Conclusion

Rainfall is critical for achieving satisfactory waterhemp control from soil residual herbicides. Evaluating the impact of moisture on herbicide activity was not the primary objective for the experiment, but the observations around the relationship of moisture and herbicide activity became an important benefit from the experiment, especially considering the lack of waterhemp control experienced by many growers in Southern Minnesota Beet Sugar Coop and Minn-Dak Farmers Coop in 2022. This research reinforces that a strategy to layer soil residual herbicides, starting at planting, is our best program for controlling waterhemp in sugarbeet. Finally, this research demonstrated excellent sugarbeet safety from the chloroacetamide herbicides, that the three chloroacetamide herbicides available in sugarbeet are equally effective at providing waterhemp control, and that the differences in waterhemp control among chloroacetamide products are minor.

SUGARBEET TOLERANCE FROM ULTRA BLAZER

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Summary

1. Environmental conditions at application and adjuvants influence sugarbeet tolerance and waterhemp control.
2. Yield parameters support either repeat Ultra Blazer applications at 12 fl oz/A followed by (fb) 12 fl oz/A with non-ionic surfactant or Ultra Blazer at 16 fl oz/A with Crop Oil Concentrate (COC).
3. Greater sugarbeet injury was observed from Ultra Blazer mixtures with Roundup PowerMax3 in 2022 than with Roundup PowerMax in previous years.
4. Acifluorfen use in sugarbeet requires a compromise between sugarbeet injury and waterhemp control.

Introduction

Ultra Blazer (acifluorfen) was repurposed into sugarbeet in 2019 and 2020 to replace Betamix (desmedipham & phenmedipham) and provide control of glyphosate-resistant (GR) waterhemp in sugarbeet. The Environmental Protection Agency (EPA) approved a request for a Section 18 emergency exemption for Ultra Blazer for control of escaped waterhemp in sugarbeet in Minnesota and eastern North Dakota in 2021 and 2022. The exemption allowed a single Ultra Blazer application at 16 fluid ounces per acre per year, either alone or mixed with Roundup PowerMax(3). 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.

Our 2022 Ultra Blazer Section 18 emergency exemption label provided flexibility and recommended Ultra Blazer at 16 fl oz/A either alone, with non-ionic surfactant at 0.125% v/v, or mixed with Roundup PowerMax3 and ammonium sulfate at 2.5% v/v, but without NIS, depending on situation (Table 1). However, our challenge has been to optimize waterhemp control without increasing sugarbeet injury. Sugarbeet must be greater than the 6-lf stage and waterhemp less than 4-inches (preferred) for selective control while reducing injury potential.

Table 1. Herbicide treatment, rate, and application timing, Ultra Blazer Section 18 emergency exemption, 2022.

Treatment	Rate (fl oz/A)	Sugarbeet Stage (lvs)
Ultra Blazer	16	>6
Ultra Blazer + Prefer 90 NIS	16 + 0.125% v/v	>6
Ultra Blazer + Roundup PowerMax + Amsol Liquid AMS	16 + 28 + 2.5 % v/v	>6

We have learned that sugarbeet injury increases when oil-based adjuvants or herbicides are mixed with Ultra Blazer. We have also learned that Ultra Blazer is more active on sugarbeet and waterhemp when the maximum day-time temperature is 85°F as compared with 75°F. The objective of this experiment was to determine sugarbeet visible injury, root yield, % sucrose, and recoverable sucrose from Ultra Blazer with adjuvants or mixtures with glyphosate.

Materials and Methods

Experiments conducted near Crookston, Hendrum, Nashua, Lake Lillian, and Murdock, MN in 2022 evaluated sugarbeet tolerance from Ultra Blazer alone or mixed with glyphosate (Roundup PowerMax3). 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. Treatments shown in Table 2 were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 40 feet in length. Environmental conditions at application are in Table 3.

Table 2. Herbicide treatment, herbicide rate, and application timing across locations in 2022.

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 + 7-day
Ultra Blazer + Crop Oil Concentrate	16 + 0.25%	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Prefer 90 NIS + Amsol Liquid AMS	25 + 16 + 0.25% + 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 3. Application information.

	Crookston	Hendrum	Murdock	Lake Lillian
Date	June 24	July 5	June 22	June 22
Time of Day	10:00 AM	1:00 PM	6:00 AM	4:00 PM
Air Temperature (F)	80	73	-	84
Relative Humidity (%)	57	67	29	29
Wind Velocity (mph)	15	4	6	9
Wind Direction	NNW	NNE	NW	W
Soil Temp. (F at 6”)	70	-	74	-
Soil Moisture	Fair	Dry	Dry	Dry
Cloud Cover (%)	100	100	10	10

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. All evaluations were a visual estimate of injury in the four treated rows compared to the adjacent, two-row, untreated strip.

At harvest, 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 2022.5 software package.

Results

Sugarbeet injury was evaluated multiple times throughout the growing season; however, only the evaluation of injury approximately 14 DAT is presented in Table 4. A very heavy rain event at Nashua, 6 days after planting, impacted sugarbeet stand and compromised the experimental area. We, therefore, elected to not present sugarbeet injury or yield data from Nashua, MN, due to variability.

Necrosis injury was evaluated as the percent of sugarbeet leaf area that was bronzed from Ultra Blazer application (Figure 1). Necrosis injury was greatest from repeat Ultra Blazer applications of 12 fl oz/A fb 12 fl oz/A as compared with a single application of 16 fl oz/A and was consistent across locations (Table 4). Application of Roundup PowerMax3 mixed with Ultra Blazer increased necrosis injury as compared with Ultra Blazer alone. Roundup PowerMax3 alone did not cause necrosis injury to sugarbeet. Visual necrosis was most severe at Hendrum and Lake Lillian, MN.

Sugarbeet growth reduction from Ultra Blazer at 16 fl oz/A plus NIS ranged from 5% to 21% across locations (Table 4). Comparatively, sugarbeet growth reduction either increased, decreased, or remained the same, depending on location, from Ultra Blazer plus crop oil concentrate or from repeat applications of Ultra Blazer plus non-ionic surfactant, with no definitive pattern of growth reduction injury observed. However, sugarbeet growth was consistently reduced from Ultra Blazer plus Roundup PowerMax3 across all locations, regardless of adjuvant use.

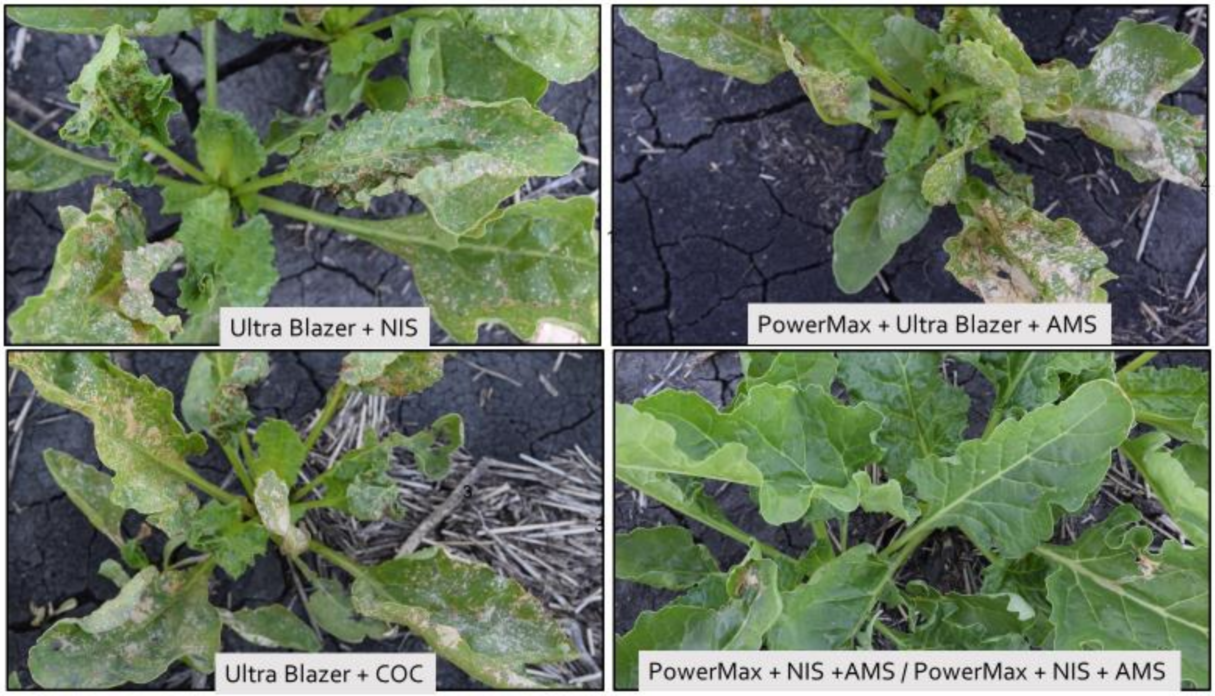

Figure 1. Sugarbeet necrosis injury symptoms in response to Ultra Blazer at 16 fl oz/A plus NIS or COC or mixed with Roundup PowerMax3 at 25 fl oz/A plus AMS as compared with repeat Roundup PowerMax3 at 25 fl oz/A plus NIS plus AMS, Hendrum, MN, 2022.

Table 4. Sugarbeet visible injury from herbicide treatments, across locations, 2022.[a]

		Sugarbeet Injury							
		Crookston		Hendrum		Murdock		Lake Lillian	
Herbicide Treatment	**Rate**	**Nec.[b]**	**GR**	**Nec.**	**GR**	**Nec.**	**GR**	**Nec.**	**GR**
	----fl oz/A----	---------------------------------%-------------------------------------							
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	2 a	21 b	33 b	19 b	0 a	5 a	8 b	12 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	24 b	17 ab	90 e	26 c	37 b	14 b	38 d	16 bc
Ultra Blazer + Crop oil concentrate	16 + 0.25%	2 a	14 a	46 c	29 c	2 a	13 b	8 b	12 ab
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	5 a	32 c	58 d	42 d	2 a	21 c	18 c	23 c
Roundup PowerMax3 + Ultra Blazer + Prefer 90 NIS + Amsol Liquid AMS	25 + 16 + 0.25% + 2.5% v/v	5 a	29 c	50 c	38 d	2 a	25 c	23 c	13 abc
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	0 a	12 a	0 a	5 a	0 a	0 a	0 a	4 a
LSD (0.10)		**5**	**6**	**8**	**7**	**3**	**6**	**6**	**10**

[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] Nec. = Visual necrosis and GR = growth reduction collected approximately 14 days after treatment (±3 days).

Sugarbeet injury from Ultra Blazer reduced sugarbeet stature (Figure 2). Stature reduction is greatest when Ultra Blazer is mixed with either oil-based adjuvants or herbicides and the air temperature is 85°F at or later in the day of application. However, sugarbeet rapidly recover from Ultra Blazer injury by producing new leaves (Figure 3).

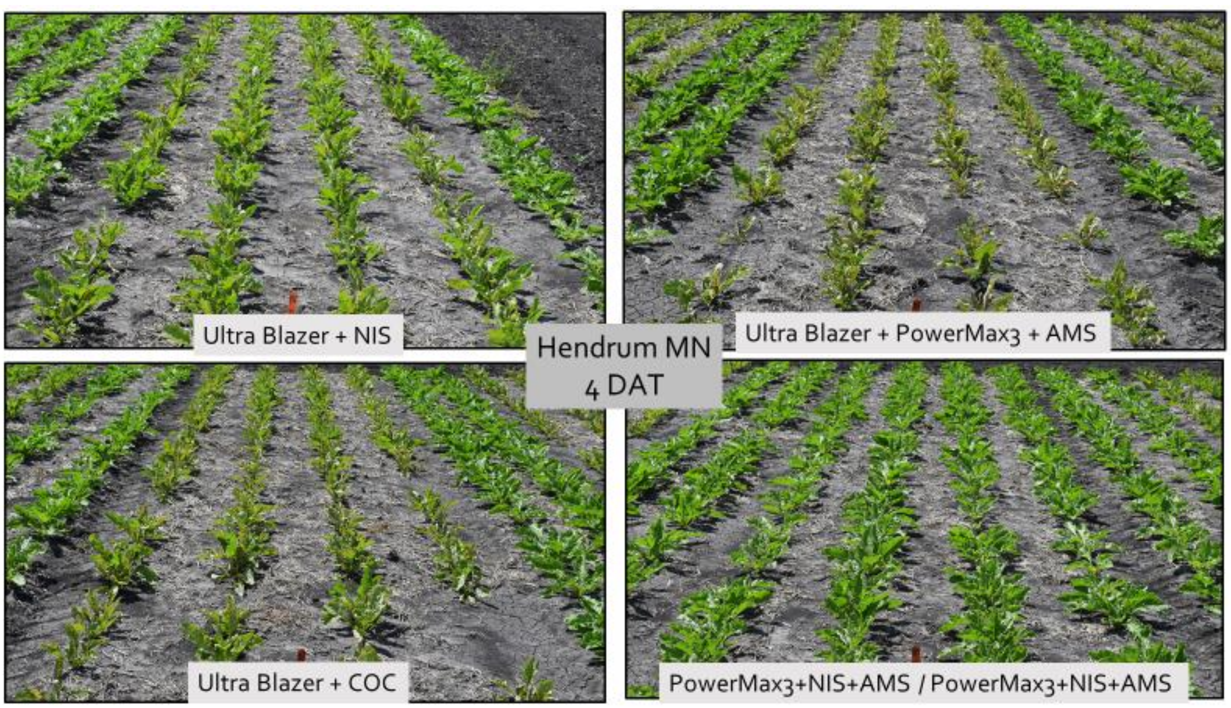

Figure 2. Sugarbeet injury in response to Ultra Blazer alone or mixed with Roundup PowerMax3 as compared with repeat Roundup PowerMax3 application, 4 DAT, Hendrum MN, 2022.

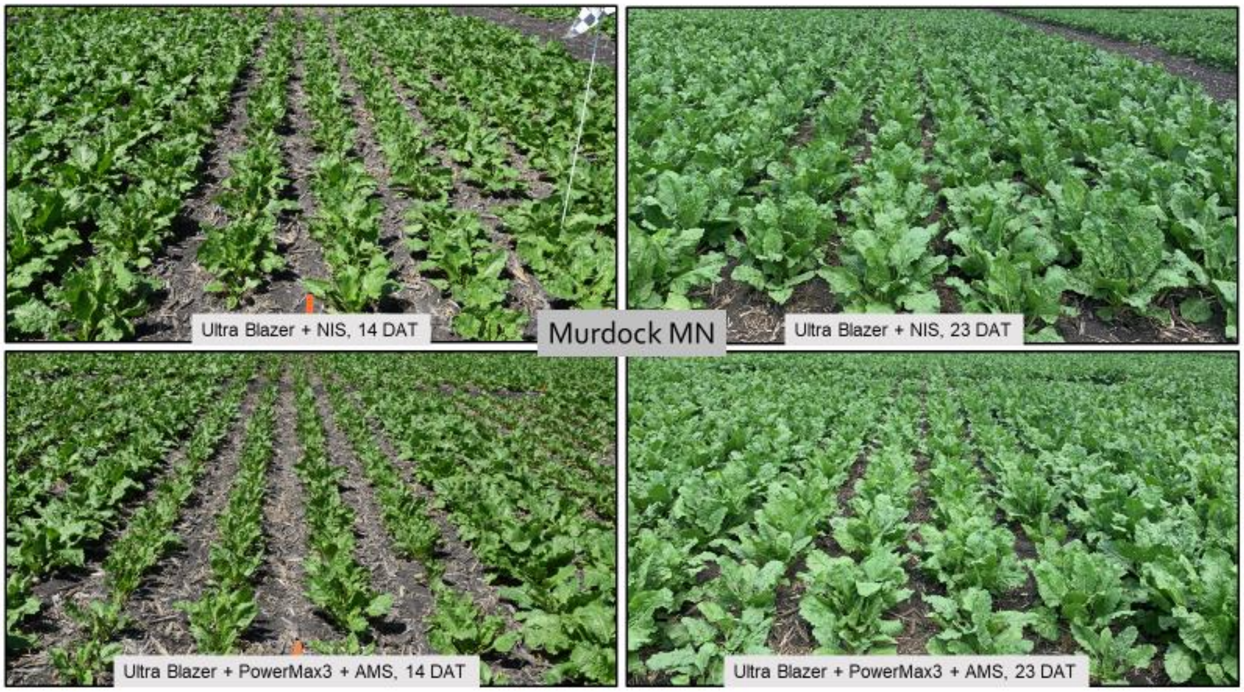

Figure 3. Sugarbeet regrowth following Ultra Blazer or Ultra Blazer mixtures with Roundup PowerMax3, Murdock, MN, 2022.

Not all yield parameters were significantly different at each individual location; however, we have elected to combine yield data and present differences across all locations in Table 5. Root yield and recoverable sucrose from a single application of Ultra Blazer plus NIS, Ultra Blazer plus COC, or repeat applications of Ultra Blazer plus NIS, generally were the same as the glyphosate control. Root yield and recoverable sucrose were less when Ultra Blazer was mixed with Roundup Powermax3 and Amsol or Amsol plus NIS. Ultra Blazer plus Roundup PowerMax3 consistently reduced root yield across locations compared with either product applied alone.

Table 5. Sugarbeet root yield, % sucrose, and recoverable sucrose in response to herbicide treatment across four locations, 2022.[a]

Herbicide Treatment	Rate	Root Yield	Sucrose	Recoverable Sucrose
	----------fl oz/A----------	-Ton/A-	--%--	---lb/A---
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	31.0 b	16.0	8,504 abc
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	31.7 ab	16.1	8,770 a
Ultra Blazer + Crop oil concentrate	16 + 0.25%	31.4 ab	16.0	8,606 ab
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	30.0 c	16.0	8,167 bc
Roundup PowerMax3 + Ultra Blazer + Prefer 90 NIS + Amsol Liquid AMS	25 + 16 + 0.25% + 2.5% v/v	29.4 c	16.0	7,974 c
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	32.8 a	16.1	8,963 a
P-Value (0.05)		**0.0040**	**NS**	**0.0123**

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

Roundup PowerMax3 contains the active ingredient glyphosate in the form of potassium salt at 5.88 pound per gallon as compared with potassium salt at 4.5 pounds per gallon in Roundup PowerMax. An increase in sugarbeet injury from Ultra Blazer mixtures with Roundup PowerMax was previously observed. However, we did not observe the magnitude of injury, nor did we observe loss in root yield and recoverable sucrose, from Ultra Blazer mixtures with Roundup Powermax (PowerMax vs. PowerMax3). Observations of increased phytotoxicity from Roundup PowerMax3 as compared with Roundup PowerMax tank mixed with other actives has been observed by other researchers (personal communication with Brett Miller, Syngenta).

Conclusion

The 2022 Ultra Blazer experiment was designed to determine if sugarbeet injury in response to Ultra Blazer could be reduced. Sugarbeet rapidly recovers from necrosis and growth reduction injury from Ultra Blazer plus NIS. The addition of COC with Ultra Blazer increases sugarbeet injury as compared with Ultra Blazer plus NIS; however, injury was less than Ultra Blazer mixtures with Roundup PowerMax3. A remedy to sugarbeet injury that may increase waterhemp control is applying split applications of Ultra Blazer at 12 fl oz/A plus NIS; however, we cannot avoid growth reduction or necrosis injury with split applications. Matter of fact, necrosis injury persists longer from repeat Ultra Blazer applications as compared with single applications; however, reduction in yield parameters did not occur. Ultra Blazer tank-mixtures with Roundup PowerMax3 and AMS or with AMS plus NIS caused significant sugarbeet injury that persisted and negatively impacted yield. We suggest utilizing single Ultra Blazer applications at 16 fl oz/A plus adjuvants or repeat applications of Ultra Blazer at 12 fl oz/A with NIS instead of Ultra Blazer mixtures with Roundup PowerMax3, unless there are significant waterhemp control challenges. Further research is needed to improve the tolerance of sugarbeet to these treatments in order to maintain yield parameters while optimizing waterhemp control.

ULTRA BLAZER SECTION 18 EMERGENCY EXEMPTION AND SUPPORTING EXPERIMENTS

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Summary

1. Ninety-three percent of respondents indicated the emergency exemption was beneficial for sugarbeet producers in Minnesota and North Dakota and contributed to overall weed management in 2022.
2. Eighty-nine percent of respondents indicated they would willingly support application for a 2023 emergency exemption in sugarbeet.
3. Roundup PowerMax3 mixed with Ultra Blazer reduced root yield as compared with repeat Roundup PowerMax3 applications or Ultra Blazer alone.
4. Apply Ultra Blazer at 20 gpa water carrier to optimize waterhemp control and/or use Turbo TeeJet Duo nozzles.

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 2022. The 2022 growing season was challenging for row crops producers, including sugarbeet producers, in Minnesota and North Dakota for several reasons. First, the calendar date for sugarbeet planting was delayed by cold and wet weather in April and early May. The average plant date was May 25, May 26, and May 19 for American Crystal Sugar Cooperative (ACS), Minn-Dak Farmers' Cooperative (MDFC), and Southern Minnesota Beet Sugar Cooperative (SMBSC) growers, respectively. Second, rainfall after planting to incorporate soil-residual herbicides commonly used for waterhemp control ranged from 1-inch to 5-inches below normal in June and July in the sugarbeet growing region south of Grand Forks, MN and into southwest and southcentral Minnesota. Lack of timely rainfall was widespread, especially in the SMBSC region. Finally, waterhemp emerging at or before sugarbeet emergence has historically caused the greatest loss of yield. Less than normal rainfall in April and May reduced the efficacy of preemergence (PRE), early postemergence (EPOST), and postemergence (POST) applied soil-residual herbicides. With the discontinuance of Betamix, there are currently no registered POST herbicides for effective waterhemp control that survives soil-residual herbicide treatments.

The exemption allowed a single Ultra Blazer application at 16 fluid ounces 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 of sugarbeet growers who applied Ultra Blazer. This report contains three 2022 program objectives: a) summarize results and user experiences from the 2022 Section 18 emergency exemption for use of Ultra Blazer in sugarbeet; b) summarize the crop tolerance experiment; and c) summarize the spray quality experiment.

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 10 to 20 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 April 28 through July 29, 2022.

Application of Ultra Blazer was targeted to air temperatures less than 85°F 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 85°F, 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).

Sugarbeet Tolerance

Experiments conducted near Crookston, Hendrum, Nashua, Lake Lillian, and Murdock, MN in 2022 evaluated sugarbeet tolerance from Ultra Blazer alone or mixed with glyphosate (Roundup PowerMax3). 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. 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 40 psi to the center four rows of six row plots 40 feet in length. Environmental conditions at application are in Table 2.

Table 1. Herbicide treatment, herbicide rate, and application timing across locations in 2022.

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 + 7-day
Ultra Blazer + Crop Oil Concentrate	16 + 0.25%	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	6-8 lf
Roundup PowerMax3 + Ultra Blazer + Prefer 90 NIS + Amsol Liquid AMS	25 + 16 + 0.25% + 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. Environmental application information.

	Crookston	Hendrum	Murdock	Lake Lillian
Date	June 24	July 5	June 22	June 22
Time of Day	10:00 AM	1:00 PM	6:00 AM	4:00 PM
Air Temperature (F)	80	73	-	84
Relative Humidity (%)	57	67	29	29
Wind Velocity (mph)	15	4	6	9
Wind Direction	NNW	NNE	NW	W
Soil Temp. (F at 6”)	70	-	74	-
Soil Moisture	Fair	Dry	Dry	Dry
Cloud Cover (%)	100	100	10	10

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. All evaluations were a visual estimate of injury in the four treated rows compared with the adjacent, two-row, untreated strip.

At harvest, 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 a randomized complete block with six replications. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2022.5 software package.

Waterhemp Control as Influenced by Carrrier Volume and Nozzle Selection

Experiments conducted near Blomkest and Moorhead, MN and Hickson, ND in 2022 evaluated sugarbeet tolerance, waterhemp control, and spray coverage from Ultra Blazer mixed with crop oil concentrate. 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. Treatments were applied with a bicycle sprayer in

15 or 20 gpa spray solution through various spray nozzles (Table 3) pressurized with CO_2 at 40 psi to the center four rows, of six row plots, 40 feet in length.

Table 3. Spray nozzles, nozzle size, spray pressure and resultant droplet size.

Nozzle	Size	Spray Pressure (psi)	Droplet Size
XR	XR 110002	40	F
AIXR	AIXR11002	40	C
Turbo TeeJet	TT11002	40	M
Turbo TeeJet Duo	2XTT11001	40	M

Water sensitive tape was attached to 12 tabs on a metal contraption and placed between rows three and four in rep 1 to simulate spray coverage to a 6-inch waterhemp plant. The contraption was removed from the plot after spraying and the water sensitive tape was transferred to a prepared template with coordinates matching the position on the contraption. The template was moved to a humidity-controlled environment for processing.

Figure 1. Water sensitive tape was attached to each tab on the contraption to simulate spray coverage on either sugarbeet or waterhemp.

Visible sugarbeet necrosis and growth reduction was evaluated approximately 7 and 14 DAT using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. Visible waterhemp control using a 0 to 100 scale (0 is no injury and 100 is complete control) was evaluated approximately 7, 14, 28, and 42 days after application. All evaluations were a visual estimate of injury or control from the four treated rows compared with the adjacent, two-row, untreated strip. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2022.5 software package.

Results

According to a survey of sugarbeet growers and agriculturalists, Ultra Blazer at 16 fl oz/A was applied to 43,397 sugarbeet acres in 2022 (totaling 5,425 gallons of Ultra Blazer). Eighty-nine percent or 38,484 acres were applied in Minnesota and 11% or 4,913 acres were applied in North Dakota.

Three observations standout from overseeing the emergency exemption and summarizing observations and agriculturist/producer critiques. First, waterhemp escapes rob yield in a low growing crop like sugarbeet and our producers understand this and are motivated to take action. Waterhemp interferes with sugarbeet yield, but even worse, produces significant quantities of seed that must be managed for four to six years. Our producers understand Ultra Blazer is a tool we would prefer not to use. Second, Ultra Blazer consistently causes sugarbeet injury and waterhemp control is inconsistent (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. Most growers are willing to accept the sugarbeet bronzing damage, provided waterhemp is controlled. It is becoming apparent that proper use of spray nozzles and selecting the appropriate carrier volume to ensure coverage improves the likelihood of success. Continued acifluorfen research must be focused on improving sugarbeet safety and waterhemp control. Finally, Roundup PowerMax3 mixed with Ultra Blazer caused more sugarbeet injury than was observed in the years Ms. Emma Burt conducted her research supporting her Masters of Science and in 2021, both in our producer fields and in our research. Our observations with Roundup PowerMax3 mixtures with Ultra Blazer will impact future recommendations.

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%)

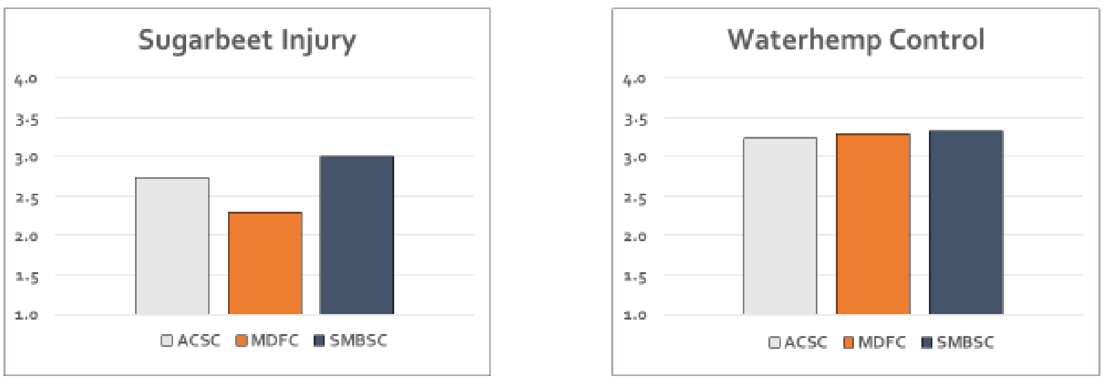

Figure 2. Results of producer and agriculturalist survey of sugarbeet injury and waterhemp control from Ultra Blazer Section 18 Emergency Exemption, Minnesota and North Dakota, 2022.

Sugarbeet Tolerance

Sugarbeet injury was evaluated multiple times throughout the growing season; however, only the evaluation of injury approximately 14 DAT is presented in Table 4. A very heavy rain event at Nashua, 6 days after planting, impacted sugarbeet stand and compromised the experimental area. We, therefore, elected to not present sugarbeet injury or yield data from Nashua, MN, due to variability.

Necrosis injury was evaluated as the percent of sugarbeet leaf area that was bronzed from Ultra Blazer application (Figure 3). Necrosis injury was greatest from repeat Ultra Blazer applications of 12 fl oz/A followed by (fb) 12 fl oz/A as compared with a single application of 16 fl oz/A and was consistent across locations (Table 4). Application of Roundup PowerMax3 mixed with Ultra Blazer increased necrosis injury as compared with Ultra Blazer alone. Roundup PowerMax3 alone did not cause necrosis injury to sugarbeet. Visual necrosis was most severe at Hendrum and Lake Lillian, MN.

Sugarbeet growth reduction from Ultra Blazer at 16 fl oz/A plus NIS ranged from 5% to 21% across locations (Table 4). Comparatively, sugarbeet growth reduction either increased, decreased, or remained the same, depending on location, from Ultra Blazer plus crop oil concentrate or from repeat applications of Ultra Blazer plus non-ionic surfactant, with no definitive pattern of growth reduction injury observed. However, sugarbeet growth was consistently reduced from Ultra Blazer plus Roundup PowerMax3 across all locations, regardless of adjuvant use.

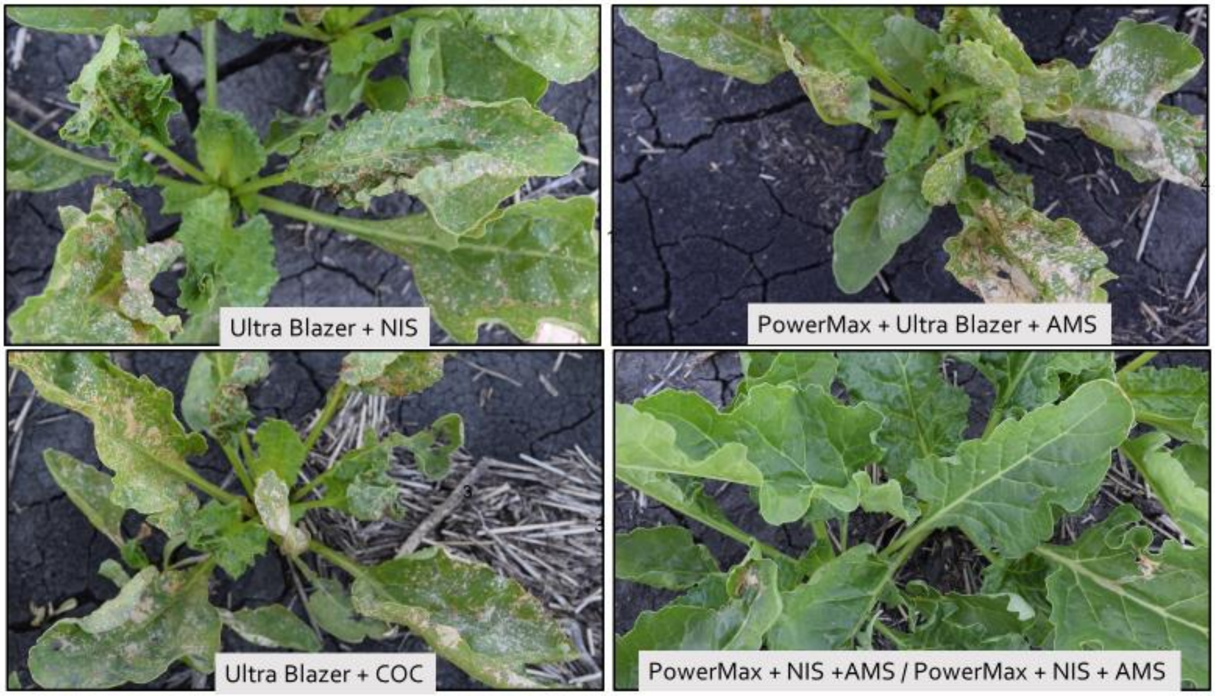

Figure 3. Sugarbeet necrosis injury symptoms in response to Ultra Blazer at 16 fl oz/A plus NIS or COC or mixed with Roundup PowerMax3 at 25 fl oz/A plus AMS as compared with repeat Roundup PowerMax3 at 25 fl oz/A plus NIS plus AMS, Hendrum, MN, 2022.

Table 4. Sugarbeet visible injury from herbicide treatments, across locations, 2022.[a]

		Sugarbeet Injury							
		Crookston		Hendrum		Murdock		Lake Lillian	
Herbicide Treatment	**Rate**	**Nec.**[b]	**GR**	**Nec.**	**GR**	**Nec.**	**GR**	**Nec.**	**GR**
	----fl oz/A----	--------	--------	--------	---%	--------	--------	--------	--------
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	2 a	21 b	33 b	19 b	0 a	5 a	8 b	12 ab
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	24 b	17 ab	90 e	26 c	37 b	14 b	38 d	16 bc
Ultra Blazer + Crop oil concentrate	16 + 0.25%	2 a	14 a	46 c	29 c	2 a	13 b	8 b	12 ab
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	5 a	32 c	58 d	42 d	2 a	21 c	18 c	23 c
Roundup PowerMax3 + Ultra Blazer + Prefer 90 NIS + Amsol Liquid AMS	25 + 16 + 0.25% + 2.5% v/v	5 a	29 c	50 c	38 d	2 a	25 c	23 c	13 abc
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	0 a	12 a	0 a	5 a	0 a	0 a	0 a	4 a
LSD (0.10)		**5**	**6**	**8**	**7**	**3**	**6**	**6**	**10**

[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] Nec. = Visual necrosis and GR = growth reduction collected approximately 14 days after treatment (±3 days).

Sugarbeet injury from Ultra Blazer reduced sugarbeet stature (Figure 4). Stature reduction is greatest when Ultra Blazer is mixed with either oil-based adjuvants or herbicides and the air temperature is 85°F at or later in the day of application. However, sugarbeet rapidly recover from Ultra Blazer injury by producing new leaves (Figure 5).

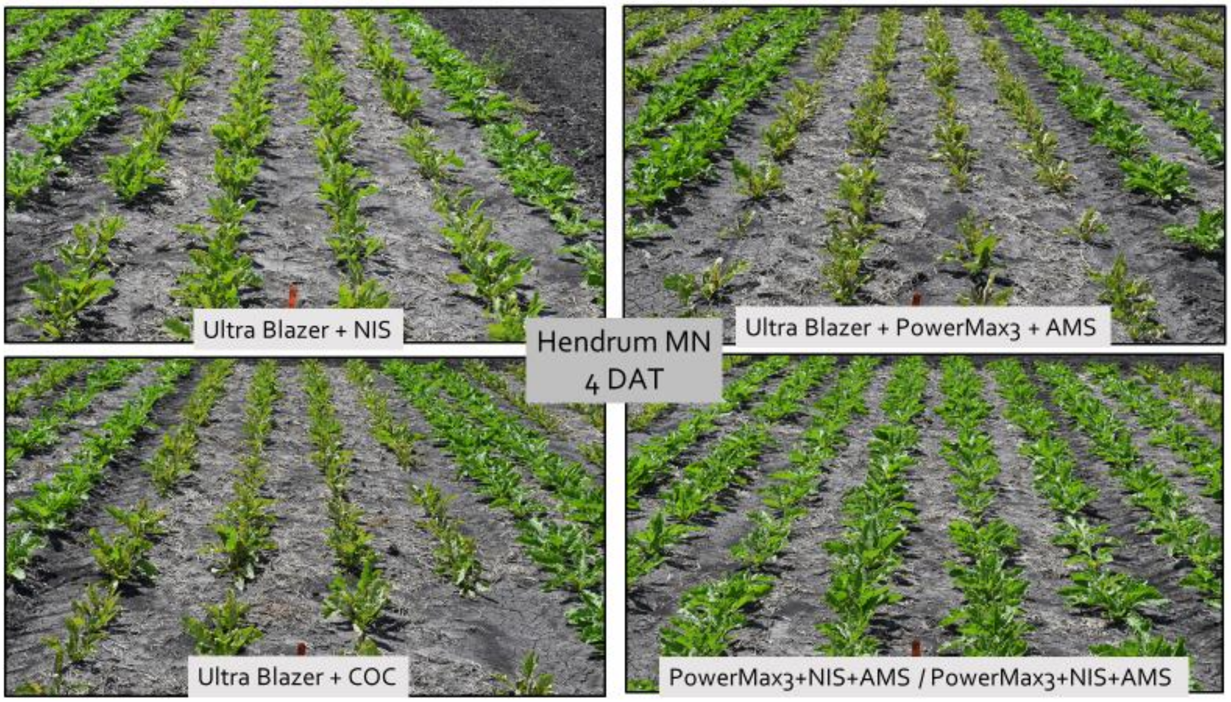

Figure 4. Sugarbeet injury in response to Ultra Blazer alone or mixed with Roundup PowerMax3 as compared with repeat Roundup PowerMax3 application, 4 DAT, Hendrum, MN, 2022.

Figure 5. Sugarbeet regrowth following Ultra Blazer or Ultra Blazer mixtures with Roundup PowerMax3, Murdock, MN, 2022.

Not all yield parameters were significantly different at each individual location; however, we have elected to combine yield data and present differences across all locations in Table 5. Root yield and recoverable sucrose from a single application of Ultra Blazer plus NIS, Ultra Blazer plus COC, or repeat applications of Ultra Blazer plus NIS, generally were the same as the glyphosate control. Root yield and recoverable sucrose were less when Ultra Blazer was mixed with Roundup Powermax3 and Amsol or Amsol plus NIS. Ultra Blazer plus Roundup PowerMax3 consistently reduced root yield across locations compared with either product applied alone.

Table 5. Sugarbeet root yield, % sucrose, and recoverable sucrose in response to herbicide treatment across four locations, 2022.[a]

Herbicide Treatment	Rate	Root Yield	Sucrose	Recoverable Sucrose
	----------fl oz/A----------	-Ton/A-	--%--	---lb/A---
Ultra Blazer + Prefer 90 NIS	16 + 0.25%	31.0 b	16.0	8,504 abc
Ultra Blazer + Prefer 90 NIS / Ultra Blazer + Prefer 90 NIS	12 + 0.125% / 12 + 0.125 %	31.7 ab	16.1	8,770 a
Ultra Blazer + Crop oil concentrate	16 + 0.25%	31.4 ab	16.0	8,606 ab
Roundup PowerMax3 + Ultra Blazer + Amsol Liquid AMS	25 + 16 + 2.5% v/v	30.0 c	16.0	8,167 bc
Roundup PowerMax3 + Ultra Blazer + Prefer 90 NIS + Amsol Liquid AMS	25 + 16 + 0.25% + 2.5% v/v	29.4 c	16.0	7,974 c
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	32.8 a	16.1	8,963 a
P-Value (0.05)		**0.0040**	**NS**	**0.0123**

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

Roundup PowerMax3 contains the active ingredient glyphosate in the form of potassium salt at 5.88 pound per gallon as compared with potassium salt at 4.5 pounds per gallon in Roundup PowerMax. An increase in sugarbeet injury from Ultra Blazer mixtures with Roundup PowerMax was previously observed. However, we did not observe the magnitude of injury, nor did we observe loss in root yield and recoverable sucrose, from Ultra Blazer mixtures with Roundup Powermax (PowerMax vs. PowerMax3). Observations of increased phytotoxicity from Roundup PowerMax3 as compared with Roundup PowerMax tank mixed with other actives has been observed by other researchers (personal communication with Brett Miller, Syngenta).

Waterhemp Control as Influenced by Carrrier Volume and Nozzle Selection

Waterhemp infestation was erratic at Hickson, making application and evaluation difficult. Application was delayed and waterhemp size was larger than desired at Blomkest, due to challenges with excessive winds. Thus, we elected to prioritize the Moorhead location. We observed necrosis/bronzing on sugarbeet from Ultra Blazer by day three and by day eight, necrosis ranged from 43% to 58% at 15 gpa and ranged from 50% to 66% at 20 gpa (Table 6). However, spray nozzle or spray volume did not influence necrosis or growth reduction from Ultra Blazer.

Table 6. Sugarbeet injury in response to Ultra Blazer + COC applied through various nozzles at 15 and 20 gpa water carrier, Moorhead, MN, 2022.[a]

	Necrosis				Growth Reduction			
	15 GPA		20 GPA		15 GPA		20 GPA	
Nozzle	8 DAT	12 DAT	8 DAT	12 DAT	8 DAT	12 DAT	8 DAT	12 DAT
	-------%-------		-------%-------		-------%-------		-------%-------	
XR	58	33	50	38	6	19	11	20
AIXR	43	23	55	23	5	8	10	8
Turbo TeeJet	58	28	59	30	15	15	10	13
Turbo TeeJet Duo	58	26	66	43	10	10	16	19
LSD (0.10)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

[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 from Ultra Blazer was influenced by spray nozzle and spray volume. In general, we observed greater waterhemp control when Ultra Blazer was applied through nozzles at 20 gpa as compared with 15 gpa (data not shown). Ultra Blazer through the Turbo TeeJet Duo consistently gave the best waterhemp control, presumably because it gave the best spray coverage over waterhemp (Table 7). Likewise, Ultra Blazer through AIXR nozzles consistently gave less waterhemp control.

Table 7. Waterhemp control in response to Ultra Blazer + COC applied through various nozzles, averaged across spray volume, Moorhead, MN, 2022.[a]

	Waterhemp control			
Nozzle	**8 DAT**	**12 DAT**	**28 DAT**	**42 DAT**
	--------------------------------------	%-------------------------------------		
XR	82	86 ab	70 b	60 b
AIXR	78	81 b	66 b	54 b
Turbo TeeJet	80	89 a	73 ab	59 b
Turbo TeeJet Duo	88	88 a	82 a	71 a
LSD (0.10)	**NS**	**6**	**9**	**11**

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

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.

Appendix. Survey

2022 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 2023?

   YES NO.

Write comments to provide additional details regarding your experiences.

____

____

____

REINVENTING COMMON RAGWEED CONTROL WITH STINGER HL IN SUGARBEET

Thomas J. Peters[1] and Alexa L. Lystad[2]

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Summary

1. Apply Stinger HL at 1.8 to 2.4 fl oz/A for control of common ragweed less than 2-inches.
2. Repeat Stinger HL applications at 1.8 followed by (fb) 1.8 fl oz/A on common ragweed less than 2-inches.
3. Apply Stinger HL at 2.4 fl oz/A for control of common ragweed greater than 2-inches but less than 4-inches.
4. Repeat Stinger HL applications at 1.8 fb 1.8 fl oz/A or 2.1 fb 2.1 fl oz/A on common ragweed greater than 2-inches but less than 4-inches.
5. Stinger HL maybe applied in mixtures with glyphosate, ethofumesate, and a chloroacetamide herbicide.

Introduction

Common ragweed is a troublesome summer annual broadleaf weed in sugarbeet in Minnesota and North Dakota. Growers attending the 2022 sugarbeet growers' seminars reported common ragweed as their second most troublesome weed following waterhemp. Past experiments investigating chemical control options reported targeting common ragweed less than 2-inches with repeat glyphosate plus clopyralid applications at 28 fl oz/A plus 4 fl oz/A, respectively, provided 92% control. Repeat applications of clopyralid plus glyphosate were more effective on both small (≤2 inches) and larger (≤4 inches) common ragweed; however, common ragweed 6-inches or greater were too large for POST control in sugarbeet. Recent greenhouse evaluation of common ragweed sourced from fields with weed control failures confirmed that the application of glyphosate alone is no longer an effective mode of action for common ragweed control. In addition, certain common ragweed populations from 2021 also demonstrated alarming tolerance to clopyralid; however, clopyralid eventually provided common ragweed suppression at 6 fl oz/A.

The objectives of this experiment were to 1) continue research focused on applications timed to common ragweed stage of growth and 2) identify appropriate Stinger HL use rates to improve common ragweed control.

Materials and Methods

Experiments were conducted on natural populations of common ragweed near Ada, MN in 2022. Plot area was located in a commercial sugarbeet field under conventional tillage. Sugarbeet was seeded 1.25 inches deep in 22-inch spaced rows at 62,000 seeds per acre on May 26. Herbicide treatments were applied June 9, 17, 22, and 27 (Table 1). All treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 40 feet in length in a field with moderate levels of glyphosate-resistant common ragweed.

Table 1. Application Information.

Application Code	A	B	C	D
Date	June 9	June 17	June 22	June 27
Time of Day	11:00 AM	2:00 PM	12:30 PM	9:45 AM
Air Temperature (F)	73	82	77	72
Relative Humidity (%)	32	36	50	53
Wind Velocity (mph)	2	3	6	4
Wind Direction	NNE	NNW	SW	SW
Soil Temp. (F at 6")	60	70	66	60
Soil Moisture	Dry	Dry	Fair	Fair
Cloud Cover (%)	0	100	80	0
Sugarbeet stage (avg)	2 lf	2-4 lf	6-8 lf	8 lf
Common Ragweed (avg)	1"	2"	3"	4"

Sugarbeet injury and weed control were evaluated on June 22 and 28 and July 8 and 16 with one additional weed control evaluation on July 26. All evaluations were a visual estimate of percent fresh weight reduction (0 to 100% control, 0% indicating no control, and 100% indicating complete control) in the four treated rows compared with the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2022.5 software package.

Results

Sugarbeet injury was negligible across the experiment; however, injury tended to be greater when herbicide treatments were applied to 6-8 or 8 leaf sugarbeet compared with applications made to 2- or 2-4 leaf sugarbeet (Table 2). Of the treatments applied to 2-leaf sugarbeet, repeat applications of Roundup PowerMax3 plus Stinger HL at 1.8 fl oz/A had the greatest injury at 11%. Likewise, sugarbeet injury was 15% and 13% from repeat applications of Roundup PowerMax3 plus Stinger HL at 1.5 and 1.8 fl oz/A at the 2-4 and 8-leaf sugarbeet stage, respectively.

Table 2. Sugarbeet injury across herbicide treatments, Ada, MN, 2022.[a]

Herbicide Treatment[b]	Rate	Common Ragweed	Sugarbeet	Sugarbeet Injury June 30	Sugarbeet Injury July 16
		----inches---	---lvs---	------------%-----------	
Stinger HL + Roundup PowerMax3	1.2 + 25	<2	2	0 a	0
Stinger HL + Roundup PowerMax3	1.8 + 25	<2	2	0 a	0
Stinger HL + Roundup PowerMax3	2.4 + 25	<2	2	0 a	0
Stinger HL + Roundup PowerMax3 / Stinger HL + Roundup PowerMax3	1.5 + 25 / 1.5 + 25	<2 / 10 days	2 / 6-8	4 ab	0
Stinger HL + Roundup PowerMax3 / Stinger HL + Roundup PowerMax3	1.8 + 25 / 1.8 + 25	<2 / 10 days	2 / 6-8	11 cd	0
Stinger HL + Roundup PowerMax3	1.2 + 25	2-4	2-4	6 abc	0
Stinger HL + Roundup PowerMax3	1.8 + 25	2-4	2-4	8 bc	0
Stinger HL + Roundup PowerMax3	2.4 + 25	2-4	2-4	11 cd	3
Stinger HL + Roundup PowerMax3 / Stinger HL + Roundup PowerMax3	1.5 + 25 / 1.5 + 25	2-4 / 10 days	2-4 / 8	15 d	0
Stinger HL + Roundup PowerMax3 / Stinger HL + Roundup PowerMax3	1.8 + 25 / 1.8 + 25	2-4 / 10 days	2-4 / 8	13 cd	0
LSD (0.05)				**7**	**NS**

[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]Roundup PowerMax3 plus Stinger HL treatments were applied with Amsol AMS at 2.5% v/v and Prefer 90 NIS at 0.25% v/v.

Trials conducted in 2014 (Peters and Carlson 2014) and 2018 (Peters and Lystad 2018) had greater sugarbeet injury from Stinger at 2 to 4 fl oz/A plus glyphosate when applied to 4-8 leaf sugarbeet compared with 2-4 leaf sugarbeet (data not presented). Additional trials conducted in 2009 and 2010 had greater sugarbeet injury from two sequential applications of Stinger at 4 fl oz/A compared with a single application of Stinger at 8 fl oz/A (data not presented).

The 2022 trial was similar in both regards with sugarbeet injury tending to be greater from two applications of Stinger HL compared with a single application and greater injury when applications were made to larger sugarbeet compared with smaller sugarbeet. However, there were no differences in sugarbeet injury across treatments at 19 days after the last application.

Common ragweed size impacted control from Stinger HL plus Roundup Powermax3. Herbicide treatments applied to less than 2-inch common ragweed provided greater control than the same treatments applied to 2-4-inch common ragweed (Table 3). On less than 2-inch common ragweed, sequential applications of Stinger HL at 1.8 fl oz/A + Roundup PowerMax3 provided up to 94% common ragweed control compared with a single application at up to 80%, 28 DAT (days after treatment). Similarly, a single application of Stinger HL at 1.8 fl oz/A + Roundup PowerMax3 to 2-4-inch common ragweed gave 63% control while two applications of Stinger HL at 1.8 fl oz/A + Roundup PowerMax3 gave 79% control, 28 DAT.

Table 3. Common ragweed control across herbicide treatments, Ada, MN, 2022.[a]

			Common Ragweed Control		
Herbicide Treatment[b]	**Rate**	**Common Ragweed**	**July 8 8 DAT[c]**	**July 16 18 DAT**	**July 26 28 DAT**
		----inches---	------------------%----------------		
Stinger HL + Roundup PowerMax3	1.2 + 25	<2	75 b	61 cd	60 cd
Stinger HL + Roundup PowerMax3	1.8 + 25	<2	91 a	83 b	80 b
Stinger HL + Roundup PowerMax3	2.4 + 25	<2	91 a	87 ab	88 a
Stinger HL + Roundup PowerMax3 / Stinger HL + Roundup PowerMax3	1.5 + 25 / 1.5 + 25	<2 / 10 days	91 a	91 ab	89 a
Stinger HL + Roundup PowerMax3 / Stinger HL + Roundup PowerMax3	1.8 + 25 / 1.8 + 25	<2 / 10 days	95 a	92 a	94 a
Stinger HL + Roundup PowerMax3	1.2 + 25	2-4	65 c	59 cd	54 c
Stinger HL + Roundup PowerMax3	1.8 + 25	2-4	68 bc	61 cd	63 c
Stinger HL + Roundup PowerMax3	2.4 + 25	2-4	71 c	67 c	65 c
Stinger HL + Roundup PowerMax3 / Stinger HL + Roundup PowerMax3	1.5 + 25 / 1.5 + 25	2-4 / 10 days	69 c	69 c	77 b
Stinger HL + Roundup PowerMax3 / Stinger HL + Roundup PowerMax3	1.8 + 25 / 1.8 + 25	2-4 / 10 days	70 bc	69 c	79 b
LSD (0.05)			**6**	**8**	**6**

[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]Roundup PowerMax3 plus Stinger HL treatments were applied with Amsol AMS at 2.5% v/v and Prefer 90 NIS at 0.25% v/v.
[c]DAT=Days after treatment.

Common ragweed control tended to increase as Stinger HL rate increased in both single and sequential applications across all common ragweed sizes. Single applications of Stinger HL at 1.8 fl oz/A or 2.4 fl oz/A plus Roundup PowerMax3 provided 80% and 88% control, respectively, on less than 2-inch common ragweed as compared with Stinger HL at 1.8 fl oz/A or 2.4 fl oz/A plus Roundup PowerMax3 at 63% or 65% control, respectively, on 2-4-inch common ragweed. Stinger HL at 1.2 fl oz/A plus Roundup PowerMax3 did not provide acceptable control, or greater than 90%, across all common ragweed sizes.

Acceptable control was achieved when herbicide applications were made on small common ragweed. Stinger HL rates should be 1.8 to 2.4 fl oz/A plus Roundup PowerMax3, applied to less than 2-inch common ragweed, to provide the best opportunity for greater than 90% control. Sequential applications increase the length of control across small and large common ragweed; however, two sequential applications of Stinger HL at 1.8 fl oz/A plus Roundup PowerMax3 on less than 2-inch common ragweed provided the greatest control. Common ragweed that is 2-4-inches or greater is too big for a POST herbicide program in sugarbeet to provide acceptable control.

Conclusion

Throughout the common ragweed experiments over the years, one message has stayed consistent, which is: Greatest common ragweed control is achieved when sprayed small. We must time our Stinger HL applications to ragweed size rather than sugarbeet stage for optimal common ragweed control. We recommend Stinger HL at 1.8 fl oz/A as the lowest rate applied for common ragweed control. For a single application, we recommend Stinger HL at 2.4 fl oz/A plus Roundup PowerMax3. For sequential applications, we recommend Stinger HL at 1.8 fl oz/A plus Roundup PowerMax3. It is difficult to achieve acceptable control when common ragweed is 2-4-inches. There are no herbicide options that will provide acceptable control for common ragweed that is 6-inches or greater.

If nurse crops are a concern, glyphosate and Stinger HL applications may need to be separated in order to control early emerged common ragweed while maintaining the nurse crop. Stinger HL may be tank-mixed with glyphosate, ethofumesate, and a chloroacetamide, while preserving sugarbeet tolerance.

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KOCHIA CONTROL IN SUGARBEET AND CROPS IN SEQUENCE WITH SUGARBEET

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Summary

1. Kochia, 1-inch to 2-inches tall, is easier to control with glyphosate than kochia 3- to 4-inches tall.
2. Ethofumesate preemergence (PRE) provides good to excellent kochia control when it is activated into the soil, before kochia germination and emergence.
3. Kochia control in the crop sequence is the most effective kochia control in fields to be planted to sugarbeet. However, the landscape is changing with the advent of Group 14 kochia resistant biotypes.
4. Glyphosate applied in relevant mixtures with adjuvants has resulted in the most consistent kochia control in sugarbeet.

Introduction

Glyphosate-resistant (GR) kochia is resurfacing as a weed control challenge in both sugarbeet fields and fields in sequence with sugarbeet in Minnesota, and eastern North Dakota. While waterhemp gets a lot of attention, 57% of respondents attending the Grafton sugarbeet growers' seminar identified kochia as their most important weed control challenge. Growers attending the Grand Forks and Wahpeton seminars called kochia their second most important weed control threat. The challenge with kochia is effective herbicides. There are very few effective kochia control herbicide options in sugarbeet. Conversely, herbicides are a major component of kochia control programs, especially with advent of strip tillage sugarbeet in the northern Red River Valley. Kochia typically emerges in April and May, but some kochia biotypes emerge as late as June (Beckie et al. 2018). Kochia is most severe when drought conditions reduce both sugarbeet stands and early season sugarbeet growth and development. Finally, kochia interferes with sugarbeet root yield by virtue of its rapid growth, resulting in sugarbeet interference due to its enormous growth potential.

The outcome of relying on herbicides, along with kochia's competitive characteristics and high genetic diversity, are population shifts and evolution of herbicide-resistant populations in many regions in Minnesota and eastern North Dakota. Kochia has evolved resistance to at least four herbicide sites of action. They are (ALS) inhibitors, synthetic auxins, photosystem II (PSII) inhibitors, and EPSP synthase inhibitors or glyphosate, which are also herbicides effective for kochia control in crops in sequence with sugarbeet.

Kochia control in crops in sequence with sugarbeet. Researchers from Colorado, Kansas, Nebraska, South Dakota, and Wyoming selected their favorite programs for kochia control in corn, soybean, sugarbeet, spring wheat and fallow in 2010 and 2011 (Sbatella et al., 2019). Overall, preferred programs were a combination of soil residual followed by (fb) POST herbicides applied singly or in repeat herbicide applications. Kochia control was arranged by crop and location across years (Figure 1). Herbicide programs approved for kochia control in corn or soybean demonstrated greater overall control with less variability across environments compared with herbicides for kochia control in fallow, wheat, or sugarbeet (Sbettala et al. 2019). The potential for a kochia control failure was relatively low in corn, regardless of the herbicide program evaluated, whereas in sugarbeet, there was no herbicide program evaluated that provided greater than 86% kochia control at any field location. The median kochia control was 40% in sugarbeet across all sites (Figure 1).

Effective, long-term kochia management in sugarbeet will likely depend on programs used across the sequence including corn, soybean, spring wheat, and spring barley. However, Brian Jenks at the North Central Research and Extension Center recently reported PPO (Group 14) resistant kochia (Figure 2). Furthermore, some kochia control herbicides create challenges as their crop rotation restrictions do not allow sugarbeet to be planted the following year. Corn, wheat, and to an extent, soybean, create dense canopies formed early in the growing season that compete with kochia. In contrast, sugarbeet is a poor competitor because of slow growth and development and relatively short stature.

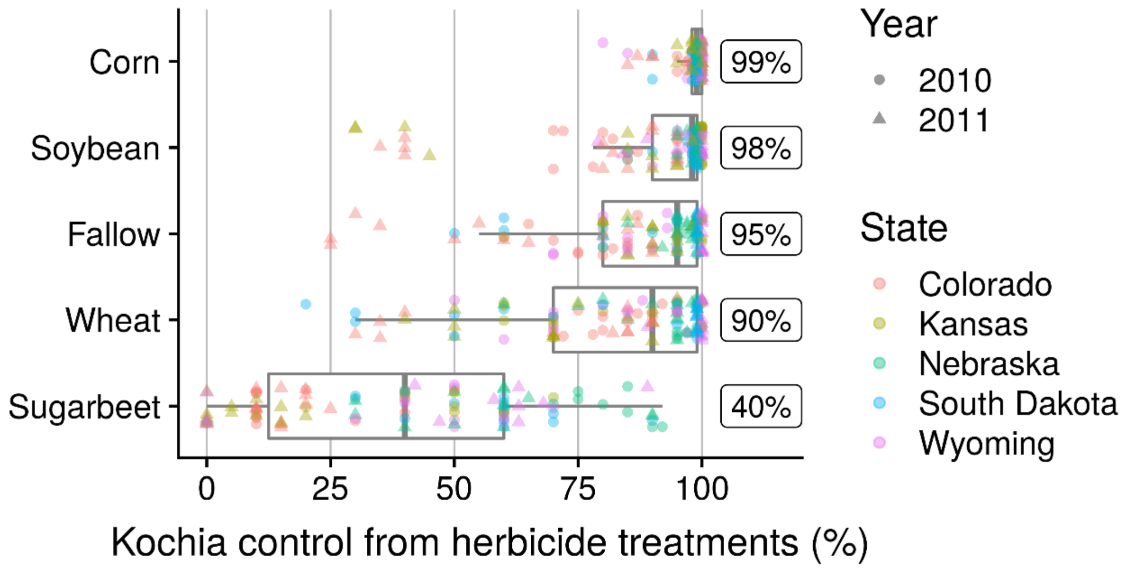

Figure 1. Kochia control, 30 days after final application of herbicide treatment, labeled for corn, soybean, fallow, wheat, and sugarbeet. Each point represents a plot in a field. Percentages are the median kochia control from herbicide treatments within each crop.

Figure 2. Control of 2- to 2.5-inch kochia with Sharpen at 1 and 2 fl oz/A with AMS and MSO, 13 DAT (image courtesy of Dr. Brian Jenks). Kochia biotypes were putative group 14 resistant biotypes collected from multiple western ND locations.

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

1. Spring
   a. Corn
      i. Verdict (16-18 fl oz) + atrazine[1] (0.38 to 0.5 lb) or Harness MAXX (2 qt) + atrazine (0.38 to 0.5 lb) PRE fb PowerMax + Status (5 fl oz) POST (requires RR corn)
      ii. Acuron[2] (1.25 qt) or Acuron Flexi (1.25 qt) fb Acuron (1.25 qt) or Acuron Flexi (1.25 qt) + PowerMax (requires RR corn)
      iii. Capreno (3 fl oz) + PowerMax + atrazine (0.38 to 0.5 lb) EPOST (V2 to V4 corn, (less than 3-inch kochia) (requires RR Corn)
   b. Soybean
      i. Authority Edge[3] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend or XtendFlex soybeans, Liberty requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans)
      ii. Fierce MTZ[4] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans)
      iii. Authority MTZ[5] (full rate for soil type) fb PowerMax + dicamba or Liberty (dicamba use requires Xtend soybeans, Liberty use requires Enlist, LibertyLink, LLGT27, or XtendFlex soybeans
   c. Spring Wheat
      i. Huskie FX[6] (full rate)
      ii. Starane NXT[7] (full rate)
      iii. Talinor[8] (full rate)

Kochia control in sugarbeet. Ethofumesate should be applied preplant incorporated (PPI) or PRE at 6 to 7.5 pt/A in sugarbeet fields when kochia, especially GR kochia, is a weed control challenge (Peters and Lueck 2016; Peters and Lystad 2021). Ethofumesate at less than 6 pt/A provided inconsistent kochia control, even when incorporated into the soil. Herbicide applications POST should be timed to kochia growth stage rather than sugarbeet growth stage. Kochia control POST is greatest in sugarbeet, even with glyphosate products, when it is less than 3-inches tall. The addition of Betamix improved kochia control from Roundup PowerMax + ethofumesate POST. However, Betamix rate must be carefully selected based on sugarbeet growth stage to ensure sugarbeet safety, especially when Betamix follows soil applied (PPI or PRE) ethofumesate.

Objectives

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

Material and Methods

Three kochia experiments were planned for 2022. Two field experiments were conducted on natural kochia populations that were a mixture of glyphosate susceptible and glyphosate resistant biotypes, one near Fairview, MT and a second near Manvel, ND in 2022. The third experiment was kochia planted in strips across sugarbeet near Horace, ND. The Manvel, ND experiment was terminated due to the late plant from an overland spring flood, causing a less than expected kochia infestation. Kochia at the Horace, ND location generally was glyphosate sensitive and was easily control with glyphosate.

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[1]Atrazine requires a second cropping season after herbicide application crop rotation restriction to sugarbeet.
[2]Acuron/Flexi requires an 18 month after application crop rotation restriction to sugarbeet.
[3] Authority Edge requires up to 36 months after application crop rotation restriction to sugarbeet.
[4] Fierce MTZ requires up to 18 months after application crop rotation restriction to sugarbeet.
[5] Authority MTZ requires up to 24 months after application crop rotation restriction to sugarbeet.
[6] Huskie FX requires a 9 month after application crop rotation restriction to sugarbeet.
[7] Starane NXT requires a 9 month after application crop rotation restriction to sugarbeet.
[8] Talinor requires a 15 month after application crop rotation restriction to sugarbeet.

Soil residual herbicides were applied after sugarbeet planting in a furrow irrigated field in 24-inch rows at Farview, MT. Treatments were applied through 8002 XR flat fan nozzles with a backpack sprayer with CO_2 at 40 psi to deliver 17 GPA. Experiments were conducted to evaluate ethofumesate PRE and POST applications of Betamix, Spin-Aid, Ultra Blazer, and ethofumesate at rates and timings to maximize kochia control and minimize sugarbeet injury.

Table 1. Herbicide treatment, rate, and application timing, Fairview, ND, 2022.

Treatment	Rate (fl oz/A)	SGBT (leaf stage)
Etho[1] / RU PowerMax3[2] / RU PowerMax3	64 / 25 / 25	PRE / 2 / 6
Etho / RU PowerMax3 / RU PowerMax3	96 / 25 / 25	PRE / 2 / 6
RU PowerMax3 + Etho[3] / RU PowerMax3 + Etho / RU PowerMax3 + Etho	25 + 4 / 25 + 4 / 20 + 4	2 / 6 / 10
RU PowerMax3 + Etho + Betamix / RU PowerMax3 + Etho + Betamix / RU PowerMax3 + Etho + Betamix	25 + 4 + 12 / 25 + 4 + 24 / 20 + 4 + 24	2 / 6 / 10
RU PowerMax3 + Etho + Spin-Aid / RU PowerMax3 + Etho + Spin-Aid / RU PowerMax3 + Etho + Spin-Aid	25 + 4 + 12 / 25 + 4 + 24 / 20 + 4 + 24	2 / 6 / 10
Etho / RU PowerMax3 / Ultra Blazer[4]	96 / 25 / 16	PRE / 2 / 6
Etho / Ultra Blazer[4] / Ultra Blazer[4]	96 / 12 / 12	PRE / 6 / 10
Etho / RU PowerMax3 / Ultra Blazer[5]	96 / 25 / 16	PRE / 2 / 6
Etho / RU PowerMax3 + Loyant / RU PowerMax3 + Loyant	96 / 25 + 0.28 / 25 + 0.28	PRE / 2 / 6
Etho / RU PowerMax3 + Loyant / RU PowerMax3 + Ultra Blazer[5]	96 / 25 + 0.28 / 25 + 16	PRE / 2 / 6

[1] etho = ethofumesate.

[2]Roundup PowerMax3 applied with Prefer 90 NIS at 0.25%v/v and Amsol Liquid AMS at 2.5% v/v.

[3]Roundup PowerMax3 + ethofumesate, Betamix, or Spin-Aid applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.

[4]Ultra Blazer applications applied with Prefer 90 non-ionic surfactant at 0.125% v/v.

[5]Ultra Blazer applications applied with Prefer 90 non-ionic surfactant at 0.25% v/v.

Visible sugarbeet growth reduction was evaluated using a 0% to 100% scale, (0 is no visible injury and 100 is complete loss of plant / stand) at the 2-lf sugarbeet stage and 7, 14, and 21 days after 2-lf stage application. Visual percent kochia control was evaluated using a 0% to 100% scale (0 is no control and 100 is complete control) at the 2-lf stage and 7, 14, 21 and 28 days after the 2-lf sugarbeet stage or when kochia was approximately 1-inch tall.

All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared with the adjacent untreated strip. Experimental design was randomized complete block with four replications. Data was analyzed with the ANOVA procedure of ARM, version 2022.7 software package.

Results and Discussion

Sugarbeet injury ranged from 0-29% in this experiment (Table 2). Increased injury was observed in treatments containing Ultra Blazer, either alone or in tank mixtures. Sugarbeet injury was negligible across all other herbicide treatments. Sugarbeet injury was greatest from Ultra Blazer followed by Ultra Blazer. We anticipated more growth reduction injury with treatments containing Loyant; however, injury was negligible. Environmental conditions may have influenced sugarbeet injury as air temperature at applications (71°F and 62°F) and relative humidity were less as compared with applications in eastern North Dakota and Minnesota.

Kochia control was exceptional across most treatments. The trial was conducted in a flood-irrigated production field. The utilization of irrigation likely ensured herbicide activation, which was observed in weed control evaluations.

Table 2. Visible kochia control in response to herbicide treatment, Fairview, ND, 2022.[1]

Treatment	Rate	Sugarbeet Injury		Kochia Control	
		14 DAAC[2]	21 DAAC	14 DAAC	21 DAAC
	---fl oz/A---	--------------------------%-------------------------			
Etho3 / RU PowerMax3[4] / RU PowerMax3	64 / 25 / 25	0 a	0 a	98 ab	98 a
Etho / RU PowerMax3 / RU PowerMax3	96 / 25 / 25	0 a	0 a	99 a	99 a
RU PowerMax3 + Etho[5] / RU PowerMax3 + Etho / RU PowerMax3 + Etho	25 + 4 / 25 + 4 / 20 + 4	8 b	0 a	99 a	98 a
RU PowerMax3 + Etho + Betamix / RU PowerMax3 + Etho + Betamix / RU PowerMax3 + Etho + Betamix	25 + 4 + 12 / 25 + 4 + 24 / 20 + 4 + 24	0 a	1 a	95 ab	98 a
RU PowerMax3 + Etho + Spin-Aid / RU PowerMax3 + Etho + Spin-Aid / RU PowerMax3 + Etho + Spin-Aid	25 + 4 + 12 / 25 + 4 + 24 / 20 + 4 + 24	5 ab	3 a	93 b	95 ab
Etho / RU PowerMax3 / Ultra Blazer[6]	96 / 25 / 16	20 c	0 a	93 b	93 ab
Etho / Ultra Blazer[4] / Ultra Blazer[6]	96 / 12 / 12	29 d	23 b	14 c	23 c
Etho / RU PowerMax3 / Ultra Blazer[7]	96 / 25 / 16	24 cd	1 a	96 ab	90 b
Etho / RU PowerMax3 + Loyant / RU PowerMax3 + Loyant	96 / 25 + 0.28 / 25 + 0.28	5 ab	1 a	96 ab	95 ab
Etho / RU PowerMax3 + Loyant / RU PowerMax3 + Ultra Blazer[7]	96 / 25 + 0.28 / 25 + 16	24 cd	1 a	98 ab	94 ab
LSD (0.10)		**6**	**4**	**5**	**7**

[1]Means within a rating timing that do not share any letter are significantly different by the LSD at the 10% level of significance.
[2]DAC= days after application C treatment.
[3]etho = ethofumesate.
[4]Roundup PowerMax3 applied with Prefer 90 NIS at 0.25%v/v and Amsol Liquid AMS at 2.5% v/v.
[5]Roundup PowerMax3 + ethofumesate, Betamix, or Spin-Aid applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[6]Ultra Blazer applications applied with Prefer 90 non-ionic surfactant at 0.125% v/v.
[7]Ultra Blazer applications applied with Prefer 90 non-ionic surfactant at 0.25% v/v.

A greenhouse experiment was conducted in the winter of 2022 evaluating kochia control from Ultra Blazer alone or mixed with Roundup PowerMax at various sizes (Peters and Lystad 2023). In summary, Ultra Blazer plus NIS applied to 2-inches or less kochia provided the greatest control (data not shown). Ultra Blazer plus Roundup PowerMax provided greater kochia control as compared with Ultra Blazer alone. Similarly, Ultra Blazer alone provided the least kochia control at 14 and 23% at 14 and 21 days after application C (DAAC), respectively, in the field experiment (Table 2). The use of Roundup PowerMax3, prior to Ultra Blazer application, increased kochia control from 23 to 90%; however, provided less kochia control as compared with the other treatments.

We observed Ultra Blazer does not have a technical fit for kochia control in sugarbeet since kochia germinates and emerges early in the season and sugarbeet must be greater than the 6-lf stage for application. This combination of weed size and sugarbeet growth stage explains the inconsistent kochia control we have observed from Ultra Blazer in previous experiments. The majority of kochia size in a production field, like at Fairview, ND, was greater than 2-inches at the 6-lf sugarbeet stage, resulting in unacceptable kochia control from Ultra Blazer applications.

Common lambsquarters was also evaluated in this experiment (data not shown). Treatments with ethofumesate PRE significantly improved common lambsquarters control compared with no PRE. Roundup PowerMax3 plus either Betamix or Spin-aid improved common lambsquarters control as compared with Roundup PowerMax3 alone. Ultra Blazer alone did not provide acceptable control on common lambsquarters.

Recommendations in sugarbeet
Ethofumesate at 6 pt/A or greater PRE followed by glyphosate alone or repeat glyphosate plus ethofumesate applications, beginning when kochia is less than 3-inches tall, provides the greatest kochia control in sugarbeet.

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TURNING POINT SURVEY OF WEED CONTROL AND PRODUCTION PRACTICES IN SUGARBEET IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2022

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The seventh annual weed control and production practices live polling questionnaire was conducted using Turning Point Technology at the 2023 winter Sugarbeet Grower Seminars. Responses are based on production practices from the 2022 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 207,360 acres reported by 246 respondents (Table 6) compared with 162,042 acres represented in 2021. The average sugarbeet acreage per respondent grown in 2022 was calculated from Table 6 at 843 acres compared with 965 acres in 2021.

Survey participants were asked a series of questions regarding their production practices used in sugarbeet in 2022. Growers were asked about their tillage practices for sugarbeet in 2022 (Table 7). Ninety-seven percent of all respondents indicated conventional tillage as their primary with 1% practicing strip tillage and 2% using no tillage. Across locations, 53% of respondents indicated wheat was the crop preceding sugarbeet (Table 8), 28% indicated corn (field or sweet), and 13% indicated soybean. Preceding crop varied by location with 81% of Grand Forks growers indicating wheat preceded sugarbeet and 84% 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 2022 (Table 9) which decreased from 82% in 2021. Cover crop species also varied widely by location with barley being used by 52% and 59% of growers at the Grand Forks and Wahpeton meeting, respectively, and oat being used by 50% of growers at the Willmar meeting.

Growers indicated weeds were their most serious production problem in sugarbeet for the second year in a row (Table 10) with 55% of participants in 2022 as compared with 32% of participants in 2021. In 2022, emergence or stand was the most serious problem overall for 18% of respondents. Cercospora leaf spot (CLS) was named as most serious overall by 8% of respondents across locations; however, was the most serious problem for 27% of participants in the Grafton location.

Waterhemp was named as the most serious weed problem in sugarbeet for the third year in a row by 73% of respondents in 2022 (Table 11) compared with 73% in 2021 and 54% in 2019. Fourteen percent of respondents indicated kochia, 6% said common ragweed, and 2% of respondents indicated common lambsquarters were their most serious weed problem in 2022. The increased presence of glyphosate-resistant waterhemp and kochia, along with a dry growing season in 2022, are likely the reasons for these weeds being named as the worst weeds. Troublesome weeds varied by location with 100%, 89%, and 88% 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 57% of responses.

Respondents to the survey indicated making 0 to 4 glyphosate applications in their 2022 sugarbeet crop (Table 12) with a calculated average of 2.08 applications per acre. The calculated average in 2021 was 1.99 applications per acre.

Glyphosate was most commonly applied with a chloroacetamide herbicide postemergence (lay-by) in 2022 with 49% of responses indicating this herbicide combination was used (Table 13). Glyphosate applied with a broadleaf herbicide postemergence was the second most common herbicide used in sugarbeet in 2022 with 31% of responses.

Glyphosate alone and glyphosate plus a grass herbicide were the third and fourth most common at 14% and 5% of the responses, respectively.

Preplant incorporated (PPI) or preemergence (PRE) herbicides were applied by 71% of survey respondents in 2022 (Table 14). Thirty-seven percent of Grafton survey participants applied a PPI or PRE herbicide compared with 31% in 2021. Conversely, 98% of Wahpeton survey participants applied a PPI or PRE herbicide in sugarbeet in 2022 compared with 90% in 2021. 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. The most commonly used soil-applied herbicide was *S*-metolachlor with 24% of all responses followed by a combination of *S*-metolachlor plus ethofumesate with 22% of responses that utilized a PPI or PRE. Of the growers who indicated using a soil-applied herbicide, 46% indicated excellent to good weed control from that herbicide (calculated from Table 15).

The application of soil-residual herbicides applied 'lay-by' to the 2022 sugarbeet crop was indicated by 79% of respondents (Table 16). *S*-metolachlor and Outlook were the most commonly applied lay-by herbicides with 36% of responses. The majority of growers responding at the Willmar meeting indicated using Outlook (78% of responses), while S-metolachlor was more commonly applied by growers of the Fargo (73% of responses) and Wahpeton (61% of responses) meetings.

The Environmental Protection Agency (EPA) approved a second request for a Section 18 emergency exemption for Ultra Blazer (acifluorfen) in 2022. This provided Minnesota and eastern North Dakota sugarbeet growers a postemergence herbicide to control glyphosate-resistant waterhemp in sugarbeet. The exemption allowed a single Ultra Blazer application at 16 fluid ounces 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. Twenty-three percent of respondents applied Ultra Blazer in 2022 as compared with 37% of respondents in 2021 (data not shown). Of the growers who used Ultra Blazer, 2% applied Ultra Blazer alone, 10% applied Ultra Blazer with NIS, and 6% tank mixed Ultra Blazer with glyphosate, NIS, and AMS.

Growers' were asked about additional POST weed control methods used in 2022 (Table 17). Hand-weeding and row-crop cultivation were the two most common practices with 40% of respondents hand-weeding and 24% of respondents implementing row-crop cultivation. Thirty-nine percent of respondents had some acres hand-weeded (calculated from Table 18). However, most respondents indicated less than ten percent of their acres were hand-weeded. Sixty-two 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, 7% reported row-crop cultivation on 100% of their acres.

Table 1. 2023 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2022.

County		Number of Responses	Percent of Responses
Cass		3	10
Clay		11	38
Norman[1]		10	35
Traill		5	17
	Total	29	100

[1]Includes Mahnomen County

Table 2. 2023 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2022.

County		Number of Responses	Percent of Responses
Grand Forks		4	8
Kittson		6	12
Marshall		6	12
Pembina		14	28
Walsh		19	38
Other		1	2
	Total	50	100

Table 3. 2023 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2022.

County		Number of Responses	Percent of Responses
Grand Forks		15	25
Marshall		4	6
Nelson		2	3
Polk		29	48
Traill		3	5
Walsh		3	5
Other		5	8
	Total	61	100

Table 4. 2023 Wahpeton Grower Seminar - Number of survey respondents by county growing sugarbeet in 2022.

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
	Total	42	100

Table 5. 2023 Willmar Grower Seminar - Number of survey respondents by county growing sugarbeet in 2022.

County	Number of Responses	Percent of Responses
Chippewa	30	40
Kandiyohi	7	9
Redwood	2	3
Renville	22	29
Stearns	1	1
Stevens	2	3
Swift	6	8
Other	5	7
Total	75	100

Table 6. Total sugarbeet acreage operated by respondents in 2022.

		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	23	0	0	4	22	26	17	4	13	4	10
Grafton	46	2	11	7	15	17	11	9	15	9	4
Grand Forks	63	3	10	6	7	29	16	16	13	0	0
Wahpeton[1]	41	0	12	0	0	22	0	24	0	42	0
Willmar	73	7	11	15	11	18	12	10	10	4	2
Total	246	3	10	8	10	22	11	13	10	10	2

[1]Acreage categories were <250, 250-500, 500-750, or >750.

Table 7. Tillage system used in sugarbeet in 2022.

Location	Responses	Conventional Tillage	Strip Tillage	No Tillage
		--------------------% of responses-----------------		
Fargo	23	100	0	0
Grafton	47	96	2	2
Grand Forks	62	96	2	2
Wahpeton	41	98	1	1
Willmar	73	97	3	0
Total	246	97	1	2

Table 8. Crop grown in 2021 that preceded sugarbeet in 2022.

		Previous Crop						
Location	Responses	Sweet Corn	Field Corn	Dry Bean	Potato	Soybean	Wheat	Other
		-------------------------------% of responses--------------------------------------						
Fargo	27	4	0	0	0	14	78	4
Grafton	44	0	0	9	9	2	80	0
Grand Forks	64	0	0	0	6	11	81	2
Wahpeton	41	0	21	0	0	24	55	0
Willmar	73	70	14	0	0	15	1	0
Total	250	24	4	2	3	13	53	1

Table 9. Nurse or cover crop used in sugarbeet in 2022.

Location	Responses	Spring Barley	Spring Oat	Winter Rye	Spring Wheat	Winter Wheat	Other[1]	None
		----------	----------	----------	% of responses	----------	----------	----------
Fargo	26	38	0	0	4	0	0	58
Grafton	42	36	5	2	22	2	0	33
Grand Forks	62	52	0	8	13	0	0	27
Wahpeton	41	59	0	17	4	0	0	20
Willmar	72	0	50	3	36	0	0	11
Total	243	33	16	6	19	1	0	25

[1]Includes Mustard and 'Other'.

Table 10. Most serious production problem in sugarbeet in 2022.

Location	Responses	CLS[1]	Rhizo-mania	Aph[2]	Rhizoc-tonia	Fusarium	Herbicide Injury	Root Maggot	Weeds	Stand[3]
		----------	----------	----------	----------	% of responses	----------	----------	----------	----------
Fargo	24	8	0	0	0	0	13	4	58	17
Grafton	42	27	2	2	7	0	0	7	43	12
Grand Forks	59	3	0	0	8	0	0	10	65	14
Wahpeton	40	3	0	0	27[4]	0	0	0	27	43
Willmar	76	5	3	1	12	0	0	0	67	12
Total	241	8	1	5	7	0	1	4	55	18

[1]Cercospora Leaf Spot
[2]Aphanomyces
[3]Emergence/Stand
[4]Includes all root diseases.

Table 11. Most serious weed problem in sugarbeet in 2022.

Location	Responses	grasses	colq[1]	cora	kochia	gira	rrpw	RR Canola	wahe	other
		----------	----------	----------	----------	% of responses	----------	----------	----------	----------
Fargo	25	0	0	8	0	0	0	4	88	0
Grafton	48	0	8	8	57	0	2	0	23	2
Grand Forks	62	0	2	12	12	2	2	0	70	0
Wahpeton	38	0	3	0	5	0	3	0	89	0
Willmar	69	0	0	0	0	0	0	0	100	0
Total	242	0	2	6	14	1	2	1	73	1

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

Table 12. Average number of glyphosate applications per acre in sugarbeet during 2022 season.

Location	Responses	0	1	2	3	4	5
		----------	----------	% of responses	----------	----------	----------
Fargo	24	4	25	58	13	0	0
Grafton	47	0	17	51	30	2	0
Grand Forks	62	0	15	66	19	0	0
Wahpeton	41	3	20	63	14	0	0
Willmar[1]	75	0	0	75	25	0	0
Total	249	1	12	65	21	1	0

Table 13. Herbicides used in a weed control systems approach in sugarbeet in 2022.

		Glyphosate Application Tank-Mixes					
Location	Responses	Gly Alone	Gly+Lay-by	Gly+Broadleaf	Gly+Grass	Other	None Used
		-------------------------------------% of responses-----------------------------------					
Fargo	31	3	52	36	6	3	0
Grafton	50	44	16	36	4	0	0
Grand Forks	72	12	29	51	4	3	1
Wahpeton	42	1	98	-[1]	0	1	0
Willmar	85	8	61	24	7	0	0
Total	280	14	49	31	5	1	0

[1]Most applications included both a lay-by and broadleaf herbicide.

Table 14. Preplant incorporated or preemergence herbicides used in sugarbeet in 2022.

		PPI or PRE Herbicides Applied					
Location	Responses	S-metolachlor	ethofumesate	Ro-Neet SB	S-metolachlor +ethofumesate	Other	None
		--------------------------------------% of responses-----------------------------------					
Fargo	34	35	41	3	6	6	9
Grafton	47	11	11	0	11	4	63
Grand Forks	62	27	13	0	7	3	50
Wahpeton	42	43	12	0	43	0	2
Willmar	76	16	29	0	37	2	16
Total	261	24	21	1	22	3	29

Table 15. Satisfaction in weed control from preplant incorporated and preemergence herbicides in 2022.

		PPI or PRE Weed Control Satisfaction					
Location	Responses	Excellent	Good	Fair	Poor	Unsure	None Used
		-----------------------------% of responses-------------------------					
Fargo	26	15	66	19	0	0	0
Grafton	43	2	35	5	0	0	58
Grand Forks	61	7	34	5	0	2	52
Wahpeton	42	0	50	50	0	0	0
Willmar	71	0	38	33	18	0	11
Total	243	4	42	22	5	0	27

Table 16. Soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2022.

		Lay-by Herbicides Applied			
Location	Responses	S-metolachlor	Outlook	Warrant	None
		--------------------------------------% of responses----------------------			
Fargo	26	73	19	0	8
Grafton	42	29	2	5	64
Grand Forks	64	52	12	2	34
Wahpeton	41	61	32	0	7
Willmar	86	5	78	16	1
Total	258	36	36	7	21

Table 17. Other POST weed control methods used in 2022.

Location	Responses	Rotary Hoe	Row-Cultivation	Hand Weeding	Other	None
		------------------------------------% of responses------------------------------				
Fargo	25	0	24	56	0	20
Grafton	53	9	23	40	0	28
Grand Forks	81	5	17	56	1	21
Wahpeton	40	25	0	0	12	63
Willmar	75	3	33	34	6	26
Total	274	4	24	40	2	30

Table 18. Percent of sugarbeet acres hand-weeded in 2022.

		% Acres Hand-Weeded				
Location	Responses	0	< 10	10-50	51-100	>100
		------------------------------------% of responses------------------------------				
Fargo	25	36	28	16	12	8
Grafton	48	35	48	13	4	0
Grand Forks	60	20	55	18	5	2
Wahpeton	40	98	2	0	0	0
Willmar	73	25	21	19	16	19
Total	242	61	18	12	2	7

Table 19. Percent of sugarbeet acres row-crop cultivated in 2022.

		% Acres Row-Cultivated				
Location	Responses	0	< 10	10-50	51-100	>100
		------------------------------------% of responses------------------------------				
Fargo	25	56	28	16	0	0
Grafton	46	63	22	9	0	6
Grand Forks	59	51	27	22	0	0
Wahpeton	40	95	5	0	0	0
Willmar	72	49	14	10	8	19
Total	246	38	33	14	8	7

SPIN-AID PROVIDES SELECTIVE WEED CONTROL IN SUGARBEET

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Summary

1. Kochia approximately 1-inch tall (dime-size), or 6- to 8-lvs, is controlled best with Spin-Aid.
2. Kochia control was greater when ethofumesate was mixed with Spin-Aid. In the field, we recommend Spin-Aid plus ethofumesate and Roundup PowerMAX3 at 4+25 fl oz/A, respectively, plus adjuvant.
3. Kochia control was greater from repeat Spin-Aid applications as compared with Spin-Aid singly.
4. Recommendations for kochia control with Spin-Aid are in the conclusions section of this document.

Introduction

Some might remember the herbicide, Betanal, or more affectionally, 'Blue Can.' Phenmedipham was registered in 1970 and sold under the trade name Betanal from 1970 through 1981. A pre-mix of phenmedipham and desmedipham (1:1 ratio) was registered in 1982 and was sold as Betamix. U.S. registration for Betamix was cancelled in 2014 (EPA 2014). Currently, there is no active phenmedipham registration in sugarbeet in the United States; however, Belchim Crop Protection has been marketing phenmedipham with the trade name 'Spin-Aid' on spinach and red beet for six years and has recently completed the acquisition of the registration from Bayer. Phenmedipham is marketed for use in sugarbeet in other world areas. I have evaluated phenmedipham alone and in mixtures in sugarbeet since 2016, including experiments for control of glyphosate resistant (GR) kochia and GR common ragweed and common lambsquarters in 2022. The objective of this greenhouse experiment was to evaluate sugarbeet tolerance and kochia control from single or repeat applications of Spin-Aid alone, Spin-Aid plus ethofumesate, or Spin-Aid plus ethofumesate and Roundup PowerMAX3.

Materials and Methods

Greenhouse experiments were conducted using a glyphosate sensitive kochia seed source collect at North Dakota State University (NDSU) field research facilities. Kochia was grown in a flat filled with PROMIX general purpose greenhouse media (Premier Horticulture, Inc., Quakertown, PA) to 1-inch and transplanted in 4 × 4-inch pots. Betaseed 8927 sugarbeet were grown in 4 × 4 pots with a 1:1 mixture of Wheatville silt loam from the Northwest Research and Outreach Center, Crookston and PROMIX greenhouse media to the 2-lf stage. Both kochia and sugarbeet were grown at 75°F to 81°F under natural light supplemented with a 16 h photoperiod of artificial light.

Herbicide treatments were applied using a spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet® 8002 even banding nozzle (TeeJet Technologies, Glendale Heights, IL) calibrated to deliver 15 gpa spray solution at 25 psi and 3 mph when kochia was 6- to 8-lf or 'dime' size in diameter (Figure 1) and when sugarbeet was at the 2- lf stage. Visible sugarbeet injury (0% to 100%, 100% indicating complete loss of stand) and kochia control (0% to 100%, 100% indicating complete control) were evaluated approximately 5, 14, and 21 days after treatment (DAT).

Spin-Aid rate screen

Herbicide treatment for control of 1-inch (dime size) kochia and tolerance of 2- lf sugarbeet were a single Spin-Aid application at 48, 72, 96 and 144 fl oz/A and Spin-Aid at 32, 48, and 64 fl oz/A followed by a repeat Spin-Aid application after six days at 32, 48, and 64 fl oz/A, respectfully. All Spin-Aid applications were with Noble methylated seed oil (MSO) (Winfield United, Arden Hills, MN) at 1.5 pt/A (Table 1). Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2022.5 software package.

Spin-Aid plus ethofumeste for kochia control; Sugarbeet tolerance from Spin-Aid plus ethofumesate and Roundup PowerMAX3

Herbicide treatments were a single Spin-Aid application at 64, 80, and 96 fl oz/A or Spin-Aid application at 24, 32, 40, and 48 fl oz/A followed by a repeat Spin-Aid application at 24, 32, 40 and 48 fl oz/A, respectively. Spin-Aid

Figure 1. One-inch (dime-size) kochia.

was mixed with ethofumesate and Noble MSO at 1.5 pt/A for kochia control or Spin-Aid with ethofumesate and Roundup PowerMAX3 plus Destiny HC high surfactant methylated seed oil (HSMOC) for sugarbeet tolerance evaluation (Table 2). We elected not to use PowerMAX3 in the kochia experiment since our kochia seed source was segregating for glyphosate resistance. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2022.5 software package.

Table 1. Spin-Aid rate and sugarbeet and kochia stage at application, greenhouse, 2023.

Herbicide treatment[a]	Rate	Sugarbeet stage	Kochia size
	(fl oz/A)	(Num of lvs)	(Num of lvs)
Spin-Aid	48	2-4 lvs	6-8 (dime size)
Spin-Aid	72	2-4 lvs	6-8 (dime size)
Spin-Aid	96	2-4 lvs	6-8 (dime size)
Spin-Aid	144	2-4 lvs	6-8 (dime size)
Spin-Aid / Spin-Aid	32/32	2-4 lvs / 6 days	6-8 (dime size) / 6 days
Spin-Aid / Spin-Aid	48/48	2-4 lvs / 6 days	6-8 (dime size) / 6 days
Spin-Aid / Spin-Aid	64/64	2-4 lvs / 6 days	6-8 (dime size) / 6 days
Non Treated Control	-	2-4 lvs	6-8 (dime size)

[a]Spin-Aid with Noble methylated seed oil (MSO) at 1.5 pt/A.

Table 2. Herbicide treatment and sugarbeet and kochia stage at application, greenhouse, 2023.

Herbicide treatment[a]	Rate	Sugarbeet stage	Kochia size
	(fl oz/A)	(Num of lvs)	(Num of leaves)
Spin-Aid + ethofumesate	64 +11	2-4 lvs	6-8 (dime size)
Spin-Aid + ethofumesate	80 + 13.8	2-4 lvs	6-8 (dime size)
Spin-Aid + ethofumesate	96 + 16.5	2-4 lvs	6-8 (dime size)
Spin-Aid + etho / Spin-Aid + etho	24 + 4.1 /24 + 4.1	2-4 lvs	6-8 (dime size)
Spin-Aid + etho / Spin-Aid + etho	32 + 5.5 /32 + 5.5	2-4 lvs / 7 days	6-8 (dime size) / 7 days
Spin-Aid + etho / Spin-Aid + etho	40 + 6.9 /40 + 6.9	2-4 lvs / 7 days	6-8 (dime size) / 7 days
Spin-Aid + etho / Spin-Aid + etho	48 + 8.3 /48 + 8.3	2-4 lvs / 7 days	6-8 (dime size) / 7 days
Non Treated Control	-	2-4 lvs	6-8 (dime size)

[a]Spin-Aid with Noble methylated seed oil (MSO) at 1.5 pt/A mixed with Spin-Aid for kochia control. Roundup PowerMAX at 25 fl oz/A and High Surfactant Methylated Oil Concentrate (HSMOC) at 1.5 pt/A was mixed with Spin-Aid and ethofumesate for sugarbeet tolerance evaluation.

Results and Discussion

Spin-Aid rate screen

Sugarbeet injury ranged from 18% to 49% from a single Spin-Aid application, 5 days after application A (DAAA). Injury was greatest from Spin-Aid alone at 144 fl oz/A (Table 3). Repeat Spin-Aid applications at 32 or 48 fl oz/A

Table 3. Sugarbeet injury and kochia control in response to herbicide treatment, greenhouse, 2023.

Herbicide treatment[a]	Rate	Sugarbeet injury			Kochia control		
		5 DAAA	10 DAAA	16 DAAA	10 DAAA	12 DAAA	20 DAAA
	--fl oz/A--	------------------%----------------			--------------------%------------------		
Spin-Aid	48	20 cd	24 c	3 de	43 e	53 d	23 d
Spin-Aid	72	33 b	20 c	5 de	55 d	65 c	28 d
Spin-Aid	96	33 b	20 c	15 bc	68 bc	68 c	43 c
Spin-Aid	144	49 a	40 b	28 a	78 ab	79 ab	60 ab
Spin-Aid / Spin-Aid	32/32	18 d	23 c	11 cd	58 cd	74 bc	50 bc
Spin-Aid / Spin-Aid	48/48	26 bcd	23 c	15 bc	80 a	81 ab	73 a
Spin-Aid / Spin-Aid	64/64	28 bc	48 a	23 ab	85 a	84 a	71 a
Non-Treated Control	-	0 e	5 d	0 e	0 f	8 e	5 e
LSD (0.10)		10	7	9	11	9	13

[a]Spin-Aid with methylated seed oil (MSO) at 1.5 pt/A for kochia control

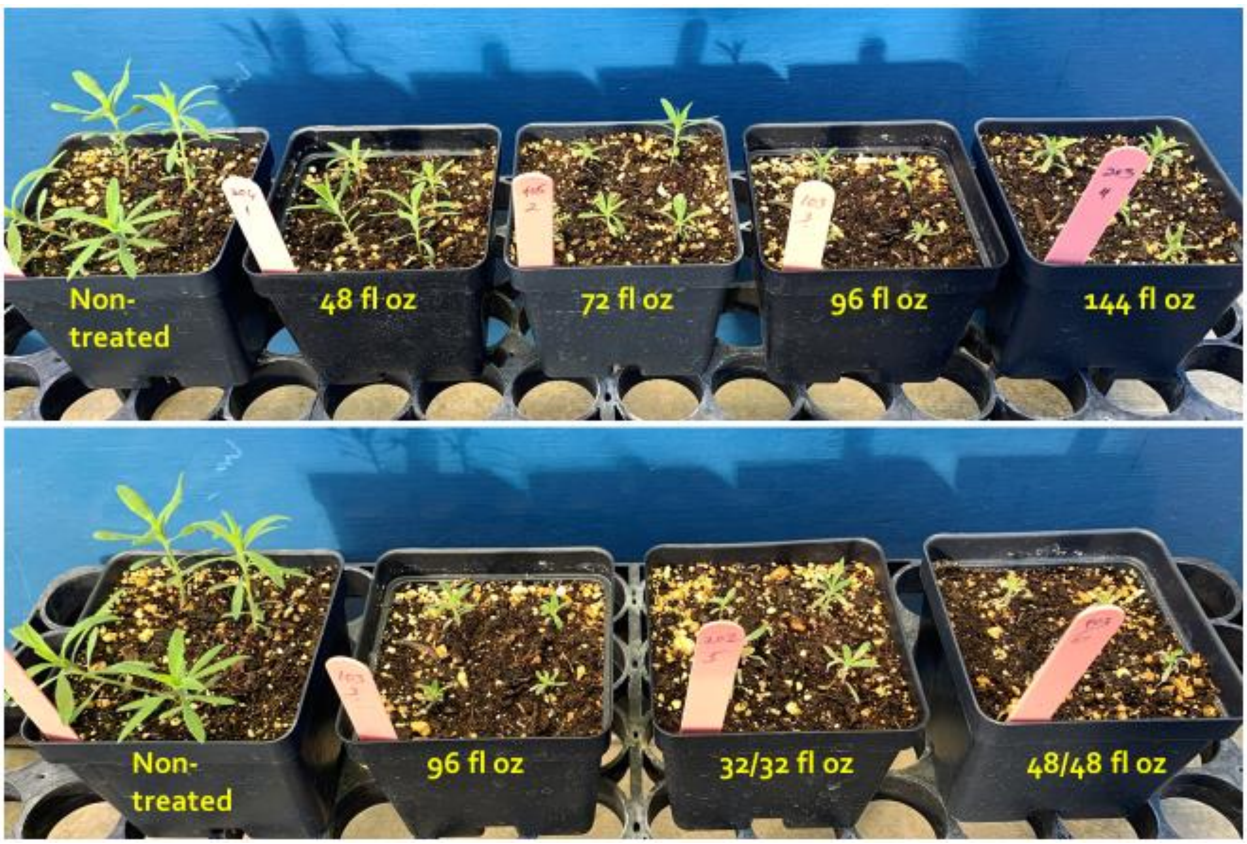

Figure 2. Kochia control in response to Spin-Aid singly or repeat Spin-Aid applications 6 days after Spin-Aid application, greenhouse, 2023.

did not increase sugarbeet injury as compared with Spin-Aid at 72 or 96 fl oz/A applied singly, 10 DAAA. However, repeat Spin-Aid 64 fb 64 fl oz/A applications caused more sugarbeet injury than a single 144 fl oz/A Spin-Aid application. Repeat 32 and 48 fl oz/A applications and a single application at 48, 72 and 96 fl oz/A caused less than 20% injury or negligible injury, 16 DAAA.

Kochia control was dependent on Spin-Aid rate and single or repeat Spin-Aid applications (Table 3, Figure 2). Kochia control was greatest from either Spin-Aid at 144 fl oz/A singly or from Spin-Aid at 48 or 64 fl oz/A followed by a repeat Spin-Aid application after six days. Spin-Aid at 48 fl oz/A fb Spin-Aid at 48 fl oz/A provided kochia control superior to a single 96 fl oz/A Spin-Aid application.

Spin-Aid plus ethofumeste for kochia control; Sugarbeet tolerance from Spin-Aid plus ethofumesate and Roundup PowerMAX3

Sugarbeet visible necrosis injury 4 days after application A (DAAA) was greatest with Spin-Aid at 80 and 96 fl oz/A mixed with ethofumesate and Roundup PowerMAX3 (Table 4 and Figure 3). Necrosis injury tended to correlate with Spin-Aid rate; injury was least with Spin-Aid at 24 fl oz/A and greatest with Spin-Aid at 96 fl oz/A. Necrosis injury was less with repeat Spin-Aid applications at 32 or 48 fl oz/A as compared with Spin-Aid singly at 64 or 96 fl oz/A, respectively.

Table 4. Sugarbeet injury and kochia control from single or repeat Spin-Aid applications with ethofumesate (and Roundup PowerMAX3), greenhouse, 2023.

		Sugarbeet injury		Kochia control	
Herbicide treatment[a]	Rate	4 DAAA	15 DAAA	4 DAAA	12 DAAA
	--fl oz/A--	----------%----------		-----------%-----------	
Spin-Aid + ethofumesate	64 +11	33 b	18 b	70 b	66 d
Spin-Aid + ethofumesate	80 +14	35 ab	14 b	73 b	74 c
Spin-Aid + ethofumesate	96 + 17	40 a	21 ab	86 a	91 a
Spin-Aid+etho / Spin-Aid+etho	24+4 / 24+4	13 e	18 b	33 e	74 c
Spin-Aid+etho / Spin-Aid+etho	32+6 / 32+6	18 de	21 ab	48 d	76 bc
Spin-Aid+etho / Spin-Aid+etho	40+7 / 40+7	20 cd	15 b	58 c	81 b
Spin-Aid+etho / Spin-Aid+etho	48+8 / 48+8	25 c	28 a	60 c	81 b
Non-Treated	-	0 f	4 c	0 f	0 e
LSD (0.10)		6	10	8	7

[a]Spin-Aid + ethofumesate (kochia) or Spin-Aid + ethofumesate + Roundup PowerMAX3 (sugarbeet); treatment contained methylated seed oil (MSO) at 1.5 pt/A for kochia control; treatment contained high surfactant methylated oil concentrate (HSMOC) at 1.5 pt/A for sugarbeet control.

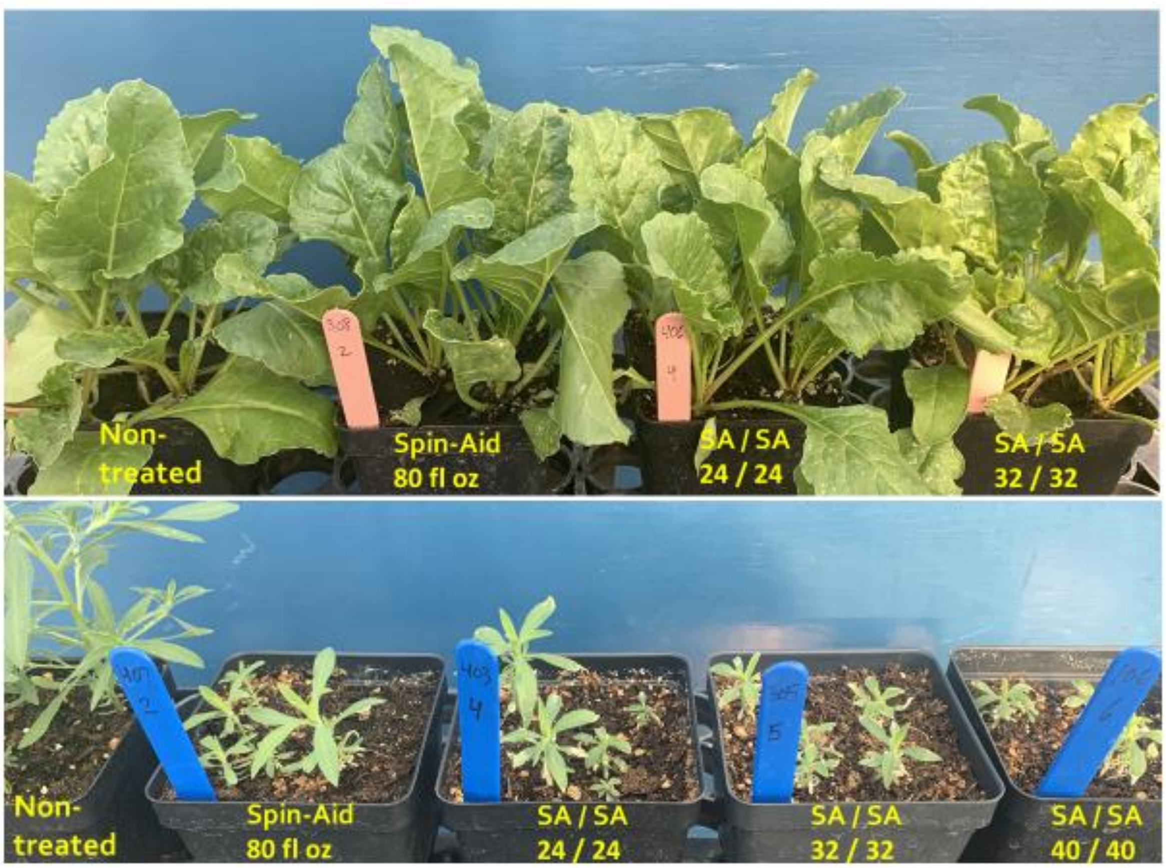

Figure 3. Sugarbeet tolerance or kochia control in response to Spin-Aid singly or repeat Spin-Aid applications after 7 days (sugarbeet) or after 6 days (kochia), greenhouse, 2023.

Sugarbeet visible growth reduction injury 15 DAAA was greatest with Spin-Aid singly at 96 fl oz/A, or repeat Spin-Aid applications at 32 or 48 fl oz/A with ethofumesate and Roundup PowerMAX3 (Table 4). Sugarbeet injury from other treatments was or tended to be the same.

Kochia control was greatest with Spin-Aid singly at 96 fl oz/A with ethofumesate 8 and 12 DAAA (Table 4, Figure 3). However, in general, repeat Spin-Aid applications with ethofumesate provided kochia control greater than Spin-Aid + ethofumesate singly. For example, Spin-Aid at 32 or 40 fl oz/A with ethofumesate followed by a repeat application, 6 days after the first application, provided kochia control greater than Spin-Aid singly at 64 or 80 fl oz/A with ethofumesate.

Conclusions

Target herbicide applications to kochia less than 1-inch tall (dime size) if sugarbeet growth stage will allow. Kochia is a difficult weed to control. These greenhouse experiment and observations from field experiments indicate kochia dime-sized in diameter is easier to control than kochia quarter-sized in diameter or kochia 2 or 3 inches tall. We observed a compromise with kochia control and sugarbeet tolerance from repeat Spin-Aid applications as compared with Spin-Aid singly. Further, mixing Spin-Aid with ethofumesate seemed to improved kochia control as compared to Spin-Aid alone, although Spin-Aid alone or Spin-Aid mixed with ethofumesate were not herbicide treatments in the same experiments. Finally, most producer applications will be a mixture of Spin-Aid with ethofumesate and RoundupPowerMAX3.

Spin-Aid rate will be triggered by sugarbeet growth stage (Table 5) although we prefer dime sized kochia as compared to larger kochia. We favor Spin-Aid at 24 to 32 fl oz/A and sugarbeet at the 2-lf stage and Spin-Aid at 32 or 40 fl oz/A for repeat application.

Field research will be conducted in 2023 to evaluate common lambsquarters and common ragweed control with Spin-Aid or Spin-Aid + ethofumesate.

Table 5. Dime-sized kochia control with Spin-Aid alone or in mixtures with ethofumesate or Spin-Aid following a soil residual herbicide, based on field and greenhouse research, 2022 and 2023.

	No Soil Residual Herbicides		Following soil residual herbicides
Sugarbeet stage (lf stage)	Spin-Aid	Spin-Aid + etho	Spin-Aid + etho
	--------------fl oz/A--------------		---fl oz/A---
Cotyledon	24	16 + 4	12 + 4
2	32	24 + 4	16 + 4
4	48	32 + 4	24 + 4
6	72	40 + 4	32 + 4

SUGARBEET TOLERANCE TO COMPLEX MIXTURES, REVISITED IN 2023

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Summary
1. Sugarbeet injury from formulation changes including Roundup PowerMAX3 and Stinger HL previously have not been evaluated in complex mixtures.
2. We observed more sugarbeet injury from PowerMAX3 and ethofumesate mixed with Outlook than in previous experiments.
3. Stinger HL mixed with PowerMAX3, ethofumesate, and Outlook increased sugarbeet injury with or without high surfactant methylated oil concentrate (HSMOC).
4. Mustang Maxx can be mixed with PowerMAX3, ethofumesate, and Outlook, but should not be mixed with PowerMAX3, ethofumesate, Outlook, and Stinger HL.
5. We continue to recommend reducing the HSMOC rate or eliminating HSMOC from the mixture when Stinger HL and/or Mustang Maxx is mixed with PowerMAX3, ethofumesate, and Outlook.

Introduction
Dr. Dexter wrote: "Sugarbeet herbicides may be tank mixed legally if all herbicides in the mixture are registered for use on sugarbeet, and if no prohibitions against tank mixes appear on a label."

Questions about tank-mixing herbicides are one of the most common telephone calls I receive from agriculturists and producers, and rightfully so. Combinations of postemergence herbicides can improve overall weed control and spectrum of control as compared with individual treatments. Mixtures also improve time efficiency as compared with making individual applications. However, the risk of sugarbeet injury also increases with combinations, especially under adverse environmental conditions. There are few herbicides truly safe to sugarbeet, meaning sugarbeet must detoxify sugarbeet sprays after application and before normal sugarbeet growth and development can resume. Detoxification is much more challenging with combinations or as "complex mixtures" as I like to call them, especially in cold and wet environments.

Key messages about complex mixtures are as follows. However, most of these messages were developed when Lorsban was available for control of insect pests and Stinger and Roundup PowerMAX formulations were used for weed control.

- Stinger can be mixed with Roundup PowerMAX, ethofumesate, and a chloroacetamide herbicide.
- Malformation injury resembling damage from Stinger when Betamix or Lorsban is mixed with Roundup PowerMAX, ethofumesate, a chloroacetamide herbicide, and Stinger is borderline not acceptable.
- HSMOC rate should be reduced when Lorsban is mixed with PowerMAX, ethofumesate and a chloroacetamide. HSMOC should be eliminated from the mixture when/if Stinger and Lorsban are mixed with PowerMAX3, ethofumesate and, a chloroacetamide herbicide.

The objective of this greenhouse research was a) to investigate sugarbeet injury from Stinger HL and Mustang Maxx mixed with Roundup PowerMAX3, ethofumesate and a chloroacetamide herbicide and b) to investigate if HSMOC contributes to injury when applied in complex mixtures.

Materials and Methods
Greenhouse experiments were conducted in 2023 to evaluate sugarbeet injury from complex mixtures POST with or without HSMOC. Greenhouse experiments were a randomized complete block design with a factorial treatment arrangement and four replications. Treatment factors were a) with or without HSMOC adjuvant and b) herbicide treatment. Herbicide treatment lists are found in Tables 1 and 2.

Soil was a 1:1 mixture of Wheatville silt loam from the Northwest Research and Outreach Center, Crookston and PROMIX general purpose greenhouse media (Premier Horticulture, Inc., Quakertown, PA). Herbicides were applied all sugarbeet were at a strong 2-lf stage. Plants were grown at approximately 73 to 81°C for a 16 h photoperiod under natural light supplemented with artificial lighting. Plants were watered and fertilized as necessary. Herbicide

Table 1. Herbicide treatment with or without HSMOC adjuvant, greenhouse Run 1, 2023.

Num	Factor A Adjuvant[a]	Factor B Postemergence Herbicide	Rate (fl oz / A)	Sugarbeet stage (lvs)
1	No	PowerMAX3 + ethofumesate	30 + 12	2-4 lvs
2	No	PowerMAX3 + etho + Outlook	30 + 12 + 21	2-4 lvs
3	No	PowerMAX3 + etho + Outlook + Stinger HL	30 + 12 + 21 + 3.6	2-4 lvs
4	No	PowerMAX3 + etho + Outlook + Stinger HL + Mustang Maxx	30 + 12 + 21 + 3.6 + 4.0	2-4 lvs
5	HSMOC	PowerMAX3 + ethofumesate	30 + 12	2-4 lvs
6	HSMOC	PowerMAX3 + etho + Outlook	30 + 12 + 21	2-4 lvs
7	HSMOC	PowerMAX3 + etho + Outlook + Stinger HL	30 + 12 + 21 + 3.6	2-4 lvs
8	HSMOC	PowerMAX3 + etho + Outlook + Stinger HL + Mustang Maxx	30 + 12 + 21 + 3.6 + 4.0	2-4 lvs
9		Non-treated Control	-	2-4 lvs

[a]HSMOC=Destiny HC at 1.5 pt/A.

Table 2. Herbicide treatment with or without HSMOC adjuvant, greenhouse Run 2, 2023.

Num	Factor A Adjuvant[a]	Factor B Postemergence Herbicide	Rate (fl oz / A)	Sugarbeet stage (lvs)
1	No	PowerMAX3 + ethofumesate	30 + 12	2-4 lvs
2	No	PowerMAX3 + etho + Outlook	30 + 12 + 21	2-4 lvs
3	No	PowerMAX3 + etho + Outlook + Mustang Maxx	30 + 12 + 21 + 4.0	2-4 lvs
4	No	PowerMAX3 + etho + Outlook + Mustang Maxx + Stinger HL +	30 + 12 + 21 + 4.0 + 3.6	2-4 lvs
5	HSMOC	PowerMAX3 + ethofumesate	30 + 12	2-4 lvs
6	HSMOC	PowerMAX3 + etho + Outlook	30 + 12 + 21	2-4 lvs
7	HSMOC	PowerMAX3 + etho + Outlook + Mustang Maxx	30 + 12 + 21 + 4.0	2-4 lvs
8	HSMOC	PowerMAX3 + etho + Outlook + Mustang Maxx + Stinger HL +	30 + 12 + 21 + 4.0 + 3.6	2-4 lvs
9		Non-treated Control	-	2-4 lvs

[a]HSMOC=Destiny HC at 1.5 pt/A.

treatments were applied using a spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet® 8002 Even banding nozzle (TeeJet Technologies, Glendale Heights, IL) calibrated to deliver 15 gpa spray solution at 25 psi and 3 mph. Visible sugarbeet injury (0% to 100%, 100% indicating complete loss of stand) was evaluated approximately 5, 10, 14, and 21 days after treatment (DAT). Data were analyzed with the ANOVA procedure of ARM, version 2022.5 software package. This report summarizes results from Run 1 and Run 2. In run 1 Stinger HL was incorporated into the mixture before Mustang Max. The order was flipped in Run 2 (see treatment list, Tables 1 and 2).

Results

Run 1

Herbicide treatment interacted with HSMOC, 10 and 14 DAT but not 5 (data not presented) and 21 DAT (Table 3). Likewise, images captured sugarbeet injury differences between herbicide treatments with or without HSMOC (Figure 1).

Table 3. Sugarbeet injury in response to herbicide treatment with and without HSMOC, Run 1, 2023.[a]

		Growth Reduction 10 DAT[b]		Growth Reduction 14 DAT		Growth Reduction 21 DAT	
Herbicide treatment	Rate	No HSMOC	HSMOC	No HSMOC	HSMOC	No HSMOC	HSMOC
	----fl oz/A----	----------------	----------------	------%	------	----------------	----------------
Base[c]		0 e	10 d	5 d	13 d	5	10
Base + Outlook	21	35 c	31 c	33 bc	30 c	20	13
Base + Outlook and Stinger HL	21 + 3.6	50 ab	48 b	48 b	43 bc	40	33
Base + Outlook, Stinger HL and Mustang Maxx	21 + 16 + 3.6 + 4	46 b	58 a	40 bc	68 a	33	50
LSD (0.10)		9		16		NS	

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]DAT=Days after POST treatment.
[c]Base= Roundup PowerMAX3 at 25 fl oz/A + Ethofumesate 4SC at 12 fl oz/A.

Run 1

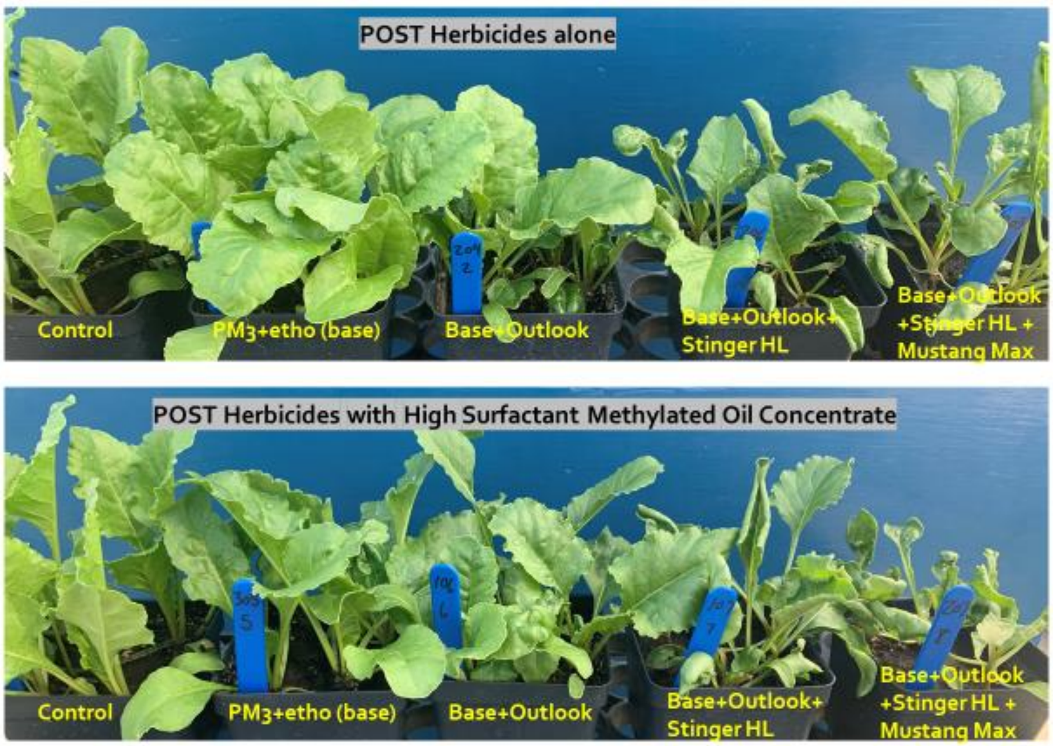

Figure 1. Sugarbeet injury from herbicide treatments with and without HSMOC 14 days after treatment (DAT), greenhouse, 2023.

Roundup PowerMAX3 mixed with ethofumesate caused negligible sugarbeet injury 10, 14 and 21 DAT. However, we observed increased injury from Outlook mixed with Roundup PowerMAX3 than in previous experiments with or without HSMOC. Sugarbeet injury from Stinger HL mixed with Roundup PowerMAX3, ethofumesate, and Outlook was greater or tended to be greater than sugarbeet injury from Roundup PowerMAX3, ethofumesate, and Outlook alone, across evaluation timings. The addition of HSMOC did not increase sugarbeet injury. Sugarbeet injury was or tended to be the greatest when Stinger HL and Mustang Maxx were mixed with Roundup PowerMAX3, ethofumesate, and Outlook. The addition of HSMOC increased or tended to increase injury as compared with no HSMOC.

We wondered if Mustang Maxx would similarly increase sugarbeet injury when mixed with Roundup PowerMAX3, ethofumesate, and Outlook as compared with Roundup PowerMAX3, ethofumesate, Outlook, and Stinger HL. Thus, in our second run, we switched the order; we mixed Mustang Maxx with Outlook, ethofumesate, and Roundup PowerMAX3 before evaluating the 5-way mixture.

Run 2
Herbicide treatment did not interact with oil adjuvant in Run 2 (P-Value > 0.10). Thus, herbicide treatments were averaged across HSMOC adjuvant. We observed less injury from Outlook mixed with Roundup PowerMAX3 and ethofumesate as compared with Run 1; however, we continued to observe more injury than in previous experiments (Table 4, Figure 2).

Table 4. Sugarbeet injury in response to herbicide treatment, averaged across HSMOC, Run 2, 2023.[a]

Herbicide treatment	Rate	10 DAT[b]	14 DAT	17 DAT
	----fl oz/A----	-------------------%-------------------		
Base[c]		10 c	4 c	3 c
Base + Outlook	21	27 b	12 b	9 c
Base + Outlook and Mustang Maxx	21 + 4	16 c	15 b	18 b
Base + Outlook, Mustang Maxx and Stinger HL	21 + 16 + 4 + 3.6	37 a	37 a	43 a
LSD (0.10)		10	9	10

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance
[b]DAT=Days after POST treatment.
[c]Base= Roundup PowerMAX3 at 25 fl oz/A + Ethofumesate 4SC at 12 fl oz/A.

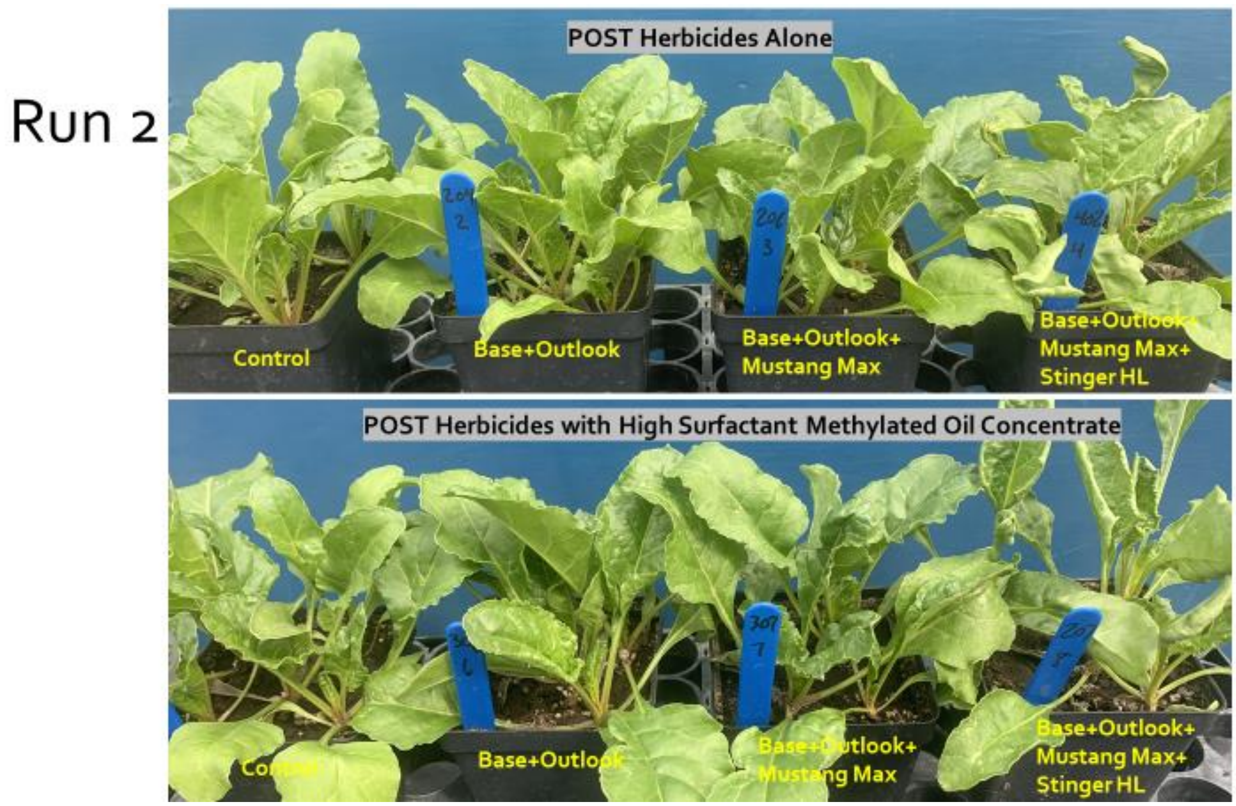

Figure 2. Sugarbeet injury from herbicide treatments with and without HSMOC 17 days after treatment (DAT), greenhouse, 2023.

Outlook in the field is usually split applied at 10 to 14 fl oz/A so perhaps the concern with increased sugarbeet injury with Roundup PowerMAX3 and ethofumesate mixtures with Outlook is unwarranted. Mustang Maxx mixed with Roundup PowerMAX3, ethofumesate, and Outlook was inconsistent; we observed less injury than PowerMAX3, ethofumesate and Outlook, 10 DAT but we observed more injury 17 DAT. Nonetheless, our results indicate it is safe to mix Mustang Maxx with Roundup PowerMAX3, ethofumesate, and a chloroacetamide herbicide.

Once again, sugarbeet injury was greatest with the 5-way mixture or Stinger HL mixed with Roundup PowerMax3, ethofumesate, Outlook, and Mustang Maxx. Observed injury consisted of a combination of growth reduction and malformation. Note, Stinger HL was applied at 3.6 fl oz/A in these experiments.

Conclusion

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

We are using different Roundup PowerMAX3 and clopyralid formulations with potentially different adjuvant systems than formulations previously evaluated. A confusing image from the field (Figure 3) and results from two greenhouse experiments suggest sugarbeet injury from Stinger HL mixed with Roundup PowerMAX3, ethofumesate, and a chloroacetamide herbicide might be different from previous experiments. Likewise, sugarbeet injury is more likely from complex mixtures or combinations of four or five pesticides with or without adjuvants as compared with past observations, both in the field and in the greenhouse, with previous formulations.

These experiments were conducted with individual treatments applied at full rates. I use full rates as an indicator for what might happen in the field under adverse environmental conditions. I will be the first to say that the possibility of Stinger HL injury at 3.6 fl oz/A is much greater than Stinger HL at 1.8 fl oz/A.

Figure 3. Ethofumesate + Dual Magnum (PRE) at 2 + 0.5 pt/A followed by Roundup PowerMAX3 + ethofumesate + *S*-metolachlor + Stinger HL (2-lf) at 25 + 6 + 16 +1.5 fl oz/A followed by Roundup PowerMAX3 + ethofumesate + *S*-metolachlor + Stinger HL (6-lf) at 25 + 6 + 16 + 1.5 fl oz/A, Rothsay, MN, 2022.

Literature Cited

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

COMPLEX MIXTURES WITH EXCALIA

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Summary

1. Quadris or Excalia can be mixed and applied with Mustang Maxx.
2. Sugarbeet injury from Excalia mixed with Roundup PowerMAX3, ethofumesate, Outlook, and Stinger HL was similar to injury with Roundup PowerMAX3, ethofumesate, and Outlook alone.
3. Quadris mixed with oil-based formulations or oil-based adjuvants causes necrosis injury.
4. Growers need to follow recommendations for complex mixtures or Roundup PowerMAX3 mixed with ethofumesate, the chloroacetamides, Stinger HL, and/or Mustang Maxx.

Introduction

Quadris is frequently used for control of Rhizoctonia in Minnesota and North Dakota. Questions about tank mixing Quadris with herbicides are common. Our research indicates Quadris can safely be tank mixed with glyphosate and Stinger HL, but mixing Quadris with oil-based herbicides like ethofumesate, the chloroacetamide herbicides for waterhemp control, or even oil-based adjuvants, such as methylated seed oil (MSO), causes unacceptable necrosis damage or leaf bronzing to sugarbeet. We recommend Quadris be applied three days prior to, or three days after, oil-based herbicides to avoid sugarbeet injury.

Drs. Chanda and Khan have been evaluating Excalia fungicide for Rhizoctonia control in sugarbeets. Valent has alluded that Excalia can be tank mixed with oil-based herbicides for both Rhizoctonia control and management of weeds. The objective of this greenhouse experiment was to compare sugarbeet tolerance with complex mixtures including Quadris or Excalia.

Materials and Methods

Betaseed 8927 sugarbeet was grown in 4 × 4 pots with a 1:1 mixture of Wheatville silt loam from the Northwest Research and Outreach Center, Crookston, MN and PROMIX greenhouse media to the 2-lf stage in the greenhouse. Sugarbeet were grown at 75°F to 81°F under natural light supplemented with a 16 h photoperiod of artificial light.

Herbicide treatments are in Table 1. All treatments were applied with Destiny HC high surfactant methylated oil concentrate (HSMOC) and ammonium sulfate (AMS) using a spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet® 8002 even banding nozzle (TeeJet Technologies, Glendale Heights, IL) calibrated to deliver 15 gpa spray solution at 25 psi and 3 mph when sugarbeet was at the 2- lf stage. Visible sugarbeet necrosis injury (0% to 100%, 100% indicating complete necrosis) and sugarbeet growth reduction injury (0% to 100%, 100% indicating complete loss of stand) were evaluated approximately 5, 7, and 14 (+/- 3 days) days after treatment (DAT). Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2022.5 software package.

Table 1. Herbicide treatment, rate, and sugarbeet stage at application, greenhouse, 2023.

Herbicide treatment[a]	Rate (fl oz/A)	Sugarbeet stage (Num of lvs)
Glyphosate + etho + Outlook	30 + 12 + 18	2-4
Excalia + glyphosate + etho + Outlook	2+ 30 + 12 + 18	2-4
Excalia + glyphosate + etho + Outlook + Mustang Maxx	2+ 30 + 12 + 18 + 4	2-4
Excalia + glyphosate + etho + Outlook + Stinger HL	2+ 30 + 12 + 18 + 2.4	2-4
Excalia + Mustang Maxx	2 + 4	2-4
Quadris + glyphosate + etho + Outlook	14.3 + 30 + 12 + 18	2-4
Quadris + glyphosate + etho + Outlook + Mustang Maxx	14.3 + 30 + 12 + 18 + 4	2-4
Quadris + glyphosate + etho + Outlook + Stinger HL	14.3 + 30 + 12 + 18 + 2.4	2-4
Quadris + Mustang Maxx	14.3 + 4	2-4
Non-treated control	-	2-4

[a]Treatment with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5% v/v.

Results and Discussion

Tank mixing Quadris with Roundup PowerMAX3, ethofumesate, and Outlook, or tank mixing Quadris with Mustang Maxx or Stinger HL and Roundup PowerMAX3, ethofumesate, and Outlook caused necrosis injury (Table 2, Figure 1). Sugarbeet injury was similar for all treatments and necrosis injury tended to be along the edges of sugarbeet leaves. There was no injury, or injury was negligible, with Excalia mixed with Roundup PowerMax3, ethofumesate, Outlook, Mustang Maxx, or Stinger HL.

Figure 1. Sugarbeet injury in response to Excalia or Quadris mixed with various sugarbeet pesticides greenhouse, 2023. Images collected on May 1, 2023, 11 DAT. *Base is Roundup PowerMAX3 + ethofumesate + Outlook.

Table 2. Sugarbeet injury in response to herbicide treatment, greenhouse, 2023.

		Necrosis	Growth Reduction		
Herbicide treatment[a]	Rate	4 DAT	4 DAT	8 DAT	14 DAT
	--fl oz/A--	----------------------------%---------------------------			
Base + Outlook	16	8 c	16 cd	5 d	13 bcd
+ Excalia + Outlook	2 + 16	0 d	16 cd	18 c	20 b
+ Excalia + Outlook + Mustang Maxx	2 + 16 + 4	0 d	8 de	10 cd	14 bc
+ Excalia + Outlook + Mustang Maxx + Stinger	2 + 16 + 4 + 2.4	0 d	19 c	28 b	21 b
Excalia and Mustang Maxx	2 + 4	0 d	10 cde	3 d	0 e
+ Quadris + Outlook	14.3 + 16	30 a	50 b	48 a	33a
+ Quadris + Outlook + Mustang Maxx	14.3 + 16 + 4	20 b	65 a	53 a	43 a
+ Quadris + Outlook + Mustang Maxx + Stinger	14.3 + 16 + 4 + 2.4	30 a	60 ab	55 a	43 a
Quadris and Mustang Maxx	14.3 + 4	0 d	11 cde	5 d	5 cde
Non-treated Control	-	0 d	3 e	3 d	3 de
LSD (0.10)		5	11	10	11

[a]Base = Roundup PowerMAX3 plus ethofumesate at 25 + 6 fl oz/A plus HSMOC at 1.5 pt/a and Amsol AMS at 2.5 % v/v.

Quadris mixed with Roundup PowerMAX3, ethofumesate, and Outlook, or mixing Quadris with Mustang Maxx or Stinger HL and Roundup PowerMAX3, ethofumesate, and Outlook caused growth reduction injury ranging from 65% to 33%, 4, 8 or 14 DAT (Table 2). Necrosis, or growth reduction injury, from Quadris with Roundup PowerMAX3, ethofumesate, and Outlook alone, or Quadris, Roundup PowerMAX3, ethofumesate, and Outlook mixed with Stinger HL or Mustang Maxx was the same or tended to be the same.

Roundup PowerMAX3 mixed with ethofumesate and Outlook tended to be negligible but growth reduction injury was statistically greater than the non-treated control. Tank mixing Mustang Maxx or Stinger HL with Excalia and Roundup PowerMAX3, ethofumesate, and Outlook did not increase sugarbeet injury.

Mustang Maxx mixed with either Quadris or Excalia did not cause necrosis damage or growth reduction damage (Figure 2).

Figure 2. Sugarbeet injury from Excalia or Quadris mixed with Mustang Maxx, greenhouse, 2023. Images collected on May 1, 2023, 11 DAT.

Conclusions

Questions about tank mixing herbicides are one of the most common telephone calls I receive from agriculturists and producers, and rightfully so. Combinations of postemergence herbicides can improve weed control and spectrum of control as compared with individual treatments. Mixtures also improve time efficiency as compared with making individual applications. However, the risk of sugarbeet injury also increases with combinations, especially under adverse environmental conditions. There are few herbicides truly safe to sugarbeet, meaning sugarbeet must detoxify herbicide sprays after application and before normal sugarbeet growth and development can resume. Detoxification is much more challenging with combinations, or as “complex mixtures” as I like to call them, especially in cold and wet environments.

Sometimes herbicides interact with components of other herbicides and/or adjuvants. Quadris should not be tank mixed with oil-based herbicide formulations or oil containing (petroleum or crop) adjuvants since sugarbeet injury may occur under certain weather conditions, particularly high temperature conditions.

This experiment concludes that Excalia mixed with oil-based adjuvants or herbicide formulations does not increase sugarbeet injury as compared with these same herbicides or adjuvants alone.

SOIL MANAGEMENT PRACTICES

NOTES

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

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[2]/Southern Minnesota Beet Sugar Cooperative, Renville, MN

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. The majority 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 in the midst of 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 encourages 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 Fall 2020 and two in Fall of 2021 (Table 1). Each year, one of the field trials will be located in the northern growing region at the Northwest Research and Outreach Center at Crookston following wheat, and the second will be located on an on-farm trial location in the southern growing region following corn near Hector. 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^{o}F and incorporated as soon as possible after application. Spring application are 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 main effect significance is given in Table 3a and 3b 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 at the two trial locations 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 and 5b for 2021 and 2022, respectively. Since this report represents the first year of a multiple year study no conclusions will be drawn at the end of this report.

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. The fall treatments were all applied as planned for the rate trial at Crookston and both trials at Hector in 2021. 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.

Sugar beet emergence was significantly impacted by N rate at both locations and the rate by time interaction was significant at both sites (Table 3a and Figure 1a) in 2021. In both cases, sugar beet emergence was less as the rate of N applied as spring urea increased. Fall urea had a slight impact on sugarbeet emergence at Crookston while there generally was no impact of fall urea on sugrbeet emergence at Hector. 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.

Urea source impacted emergence at both locations (Table 6a) 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). More data will be required to achieve a better understanding of how the urea sources impact emergence over time.

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 varied by urea source only at Hector (Table 6a) in 2022. 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)

The decrease in plant population did not impact sugar beet root yield. The loss of population was compensated by the sugar beet plants which increased the mass of roots per plant (not shown). While higher rates of N as spring urea could reduce yield the effect on root yield should be minimal if the variety planted can compensate by growing larger roots. 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).

Urea source had a relatively minor impact on recoverable sucrose (Table 6a). 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 and 4b. 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 (Table 5a and 5b). 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.

Source effects on petiole and leaf blade nitrate-N concentration are summarized in Tables 6a and 6b. The timing main effects on leaf blade nitrate-N concentration differed for all three locations (Tables 5a and 5b), however, petiole nitrate-N only varied for the two 2021 locations (Table 5a). The relative rankings among the sources varied by site and individual site effects will not be discussed but are given in Tables 6a and 6b. 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 three field locations. It should be noted that only the spring application from Crookston in 2021 was utilized while both fall and spring data from Hector 2021 and Crookston 2022 were used. There was no significant impact of time or source on sugarbeet emergence and root-yield (Figures 7 and 8, respectively). The lack of effect on emergence isn't surprising with the low rate of N applied. The lack of a significant impact on root yield is surprising but not unexpected as a response to N at Crookston in 2021 and 2022 may not have been likely due to the high amounts of residual nitrate-N.

Recoverable sucrose per ton was decreased following nitrogen application with the greatest decrease coming following application of Super-U (Figure 9). Most other urea sources and AMS decreased recoverable sucrose similarly except for straight urea which was not different from most sources nor significantly different from the non-fertilized control.

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 similar to what is seen with other tests such as the corn basal stalk N test. While we could say that 850 ppm would be a sufficient petiole nitrate concentration for sugar beet what to do if you concentration is below that level is more difficult to determine. As we continue the nitrogen work, we will add more data to the dataset. One item of note is that root yield at Lake Lillian did not respond to nitrogen and yield levels were 40+ tons similar to Wood Lake, yet many of the petiole nitrate concentration were less than 850 ppm. Past research has also not been able to calibrate the petiole nitrate test. The petiole nitrate test may work to help manage nitrogen at specific locations, but it may not be possible to determine which locations it may work until yield data is available at a given location.

Acknowledgments

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

Year	Location	Date of Urea Application		Date of Planting	Date of Tissue Sampling	Date of Harvest	Soil Series	Soil Texture†	Soil 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

† CL, clay loam; FSL, fine sandy 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	0-6" Soil Test Ammonium Acetate K	0-6" Soil Test pH	0-6" Soil Test SOM	Soil Test Nitrate-N 0-2'	Soil Test Nitrate-N 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
				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

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 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 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		na
Spring	68.5a	na	599	na	3322	na	23.3a	na	312a	na		na

†Numbers followed by the same letter are not significantly different at the *P*≤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

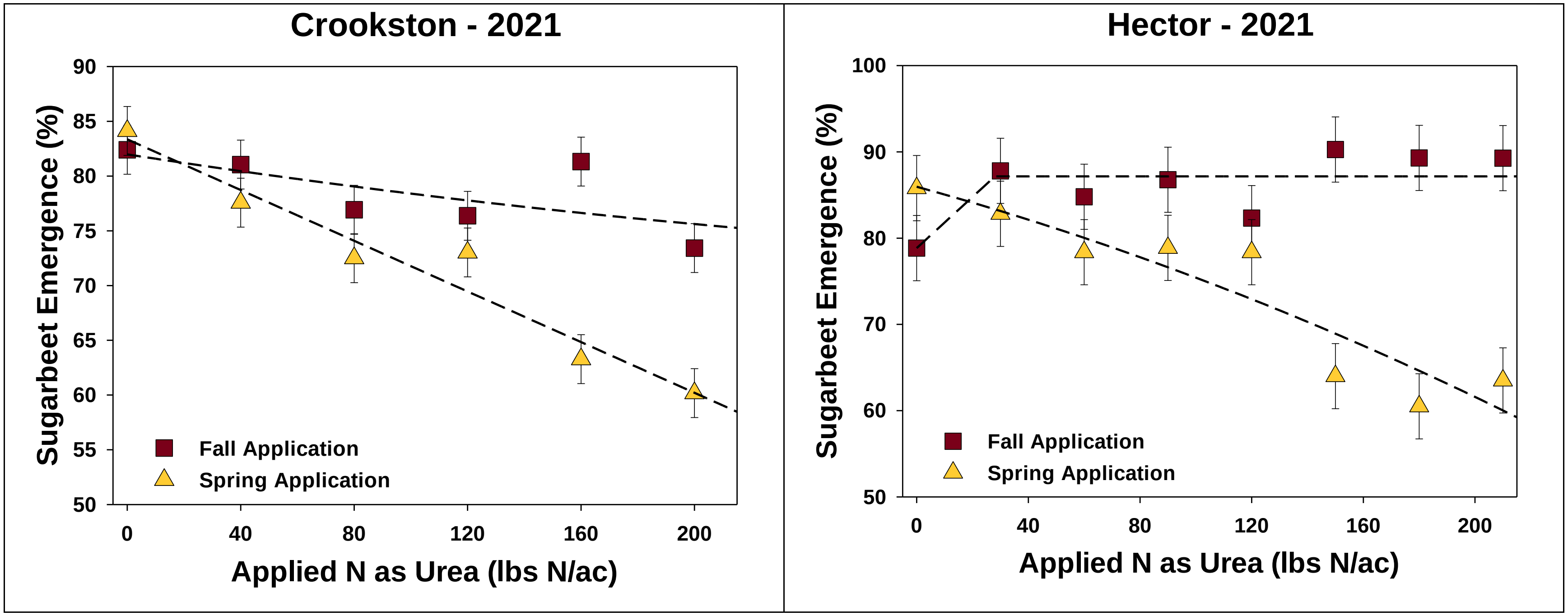

Figure 1a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet emergence at two Minnesota locations during the 2021 growing season.

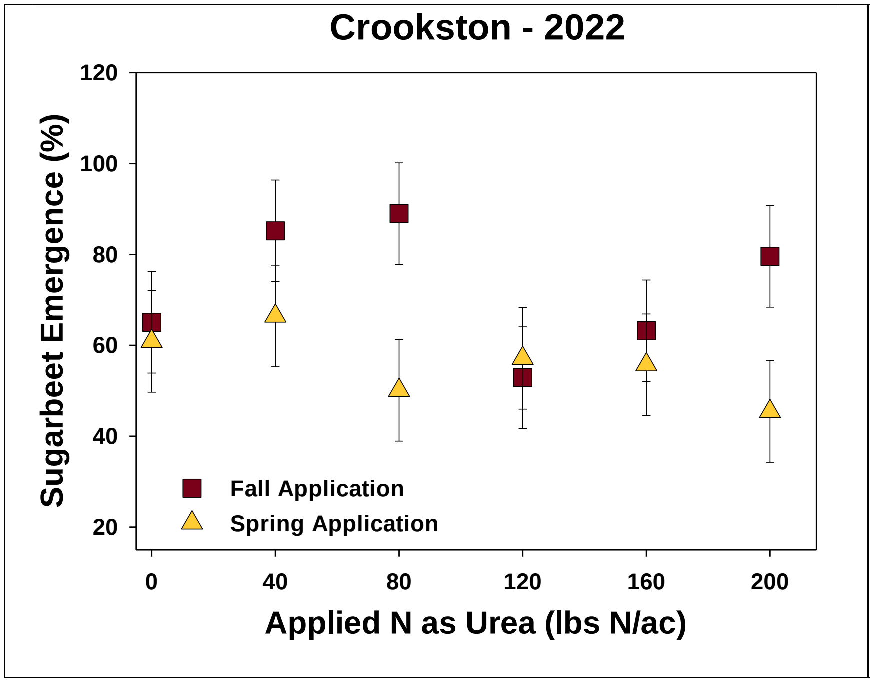

Figure 1b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet emergence at two Minnesota locations during the 2022 growing season.

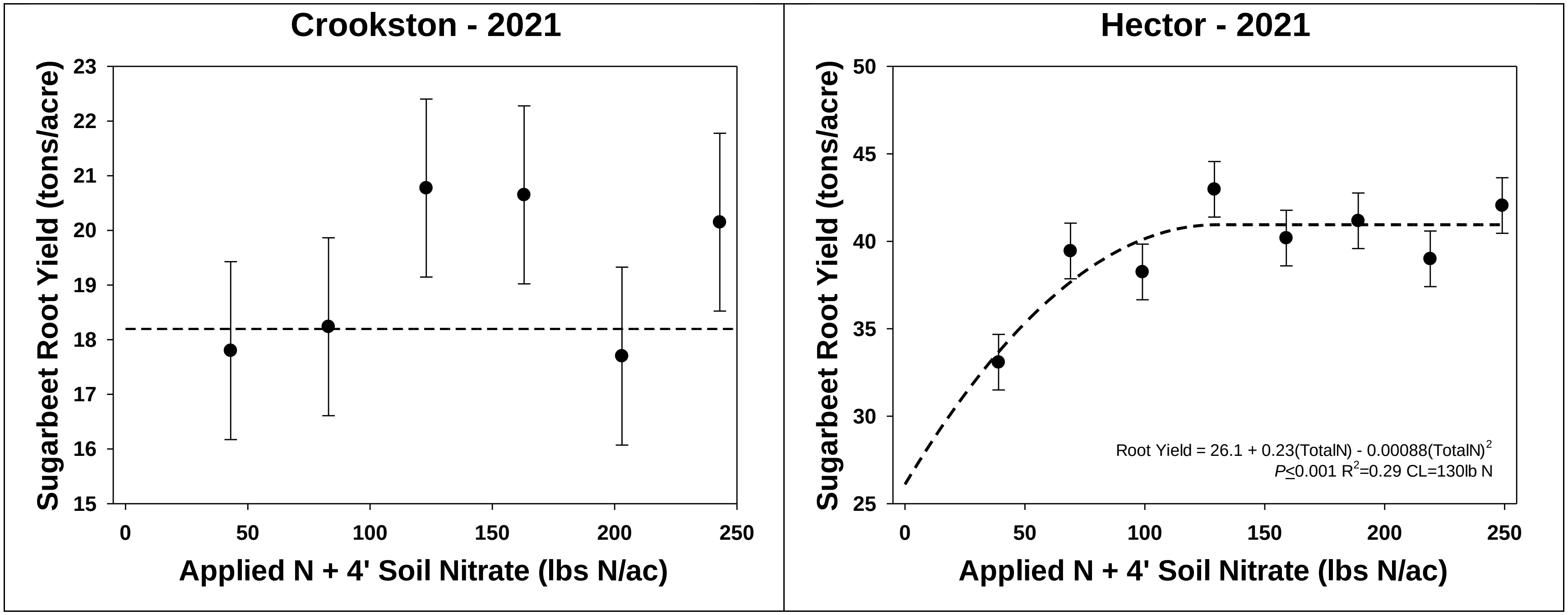

Figure 2a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet root yield at two Minnesota locations during the 2021 growing season.

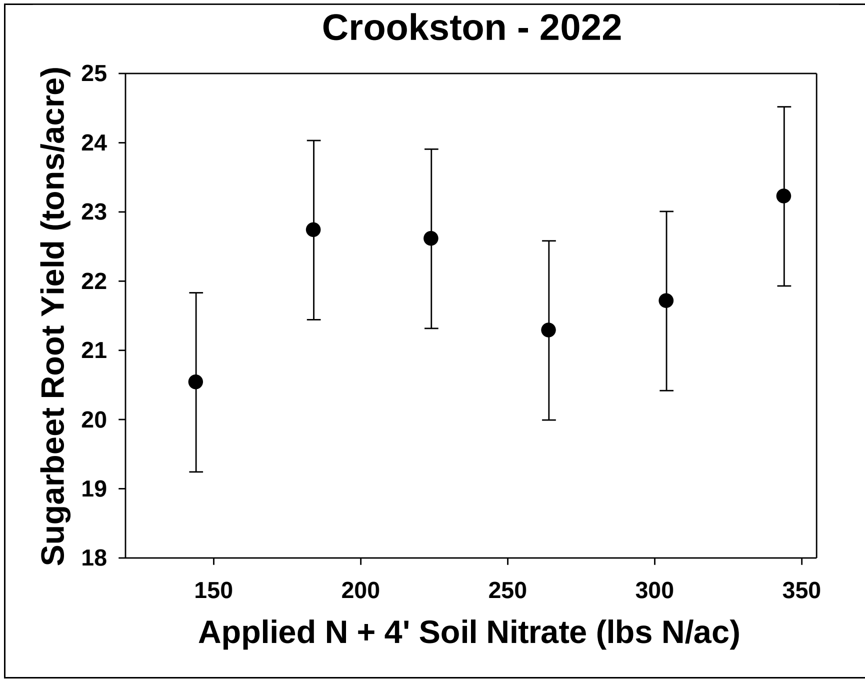

Figure 2b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet root yield at two Minnesota locations during the 2022 growing season.

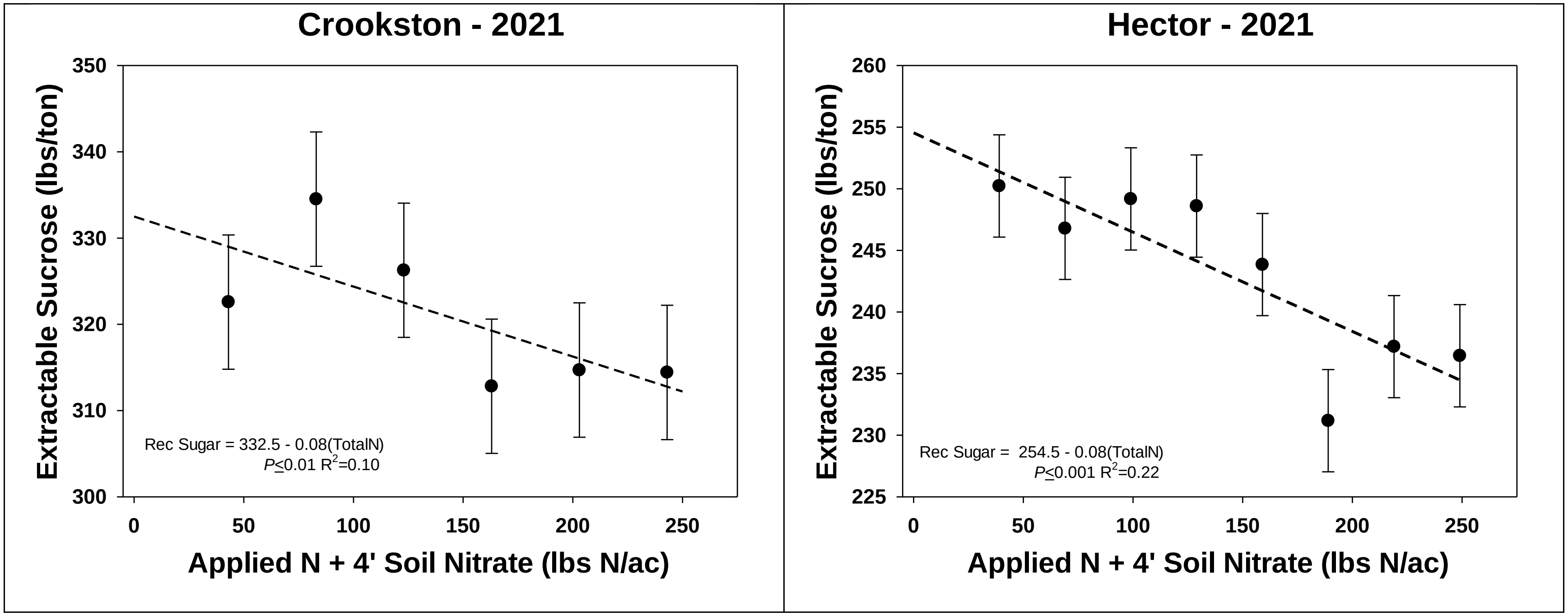

Figure 3a. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet extractable sucrose per ton at two Minnesota locations during the 2021 growing season.

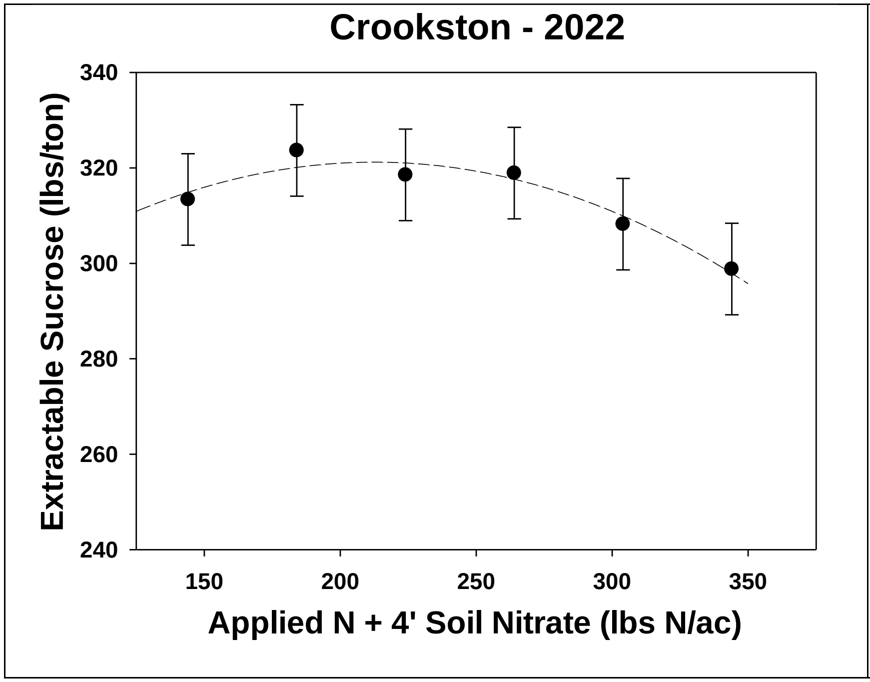

Figure 3b. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet extractable sucrose per ton at two Minnesota locations during the 2022 growing season.

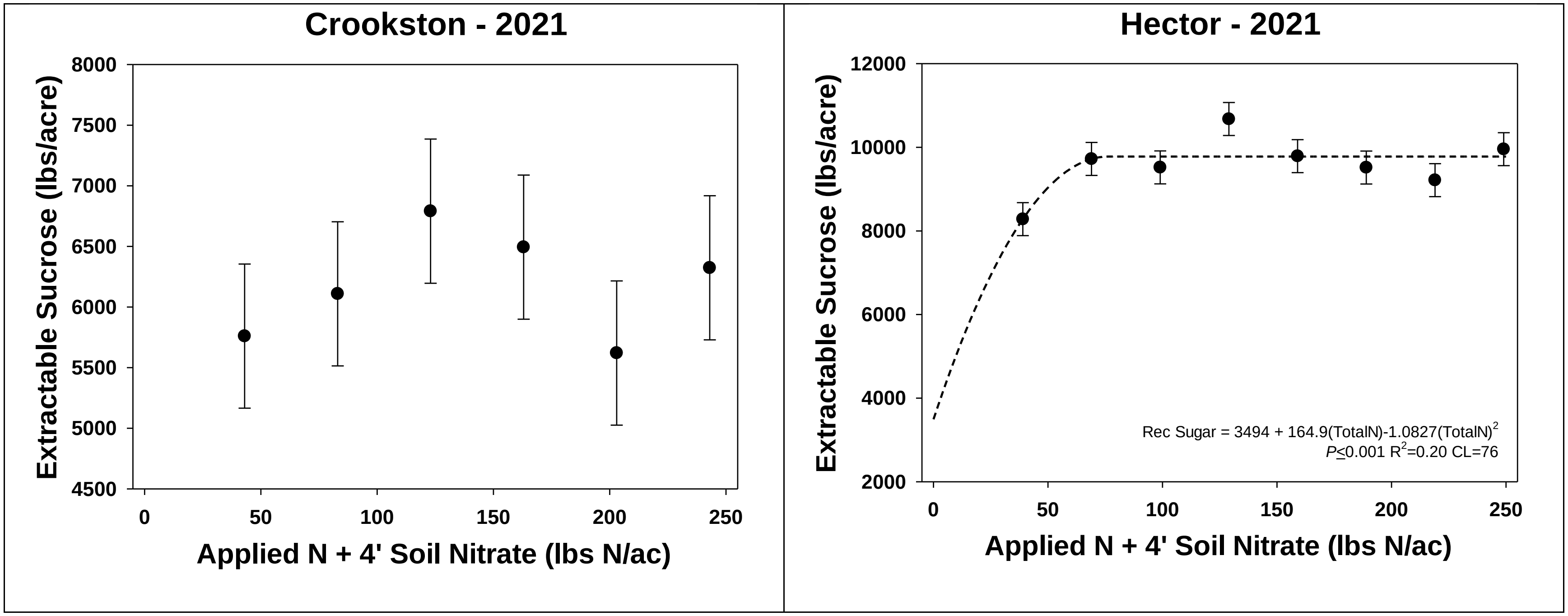

Figure 4a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet total extractable sucrose per acre at two Minnesota locations during the 2021 growing season.

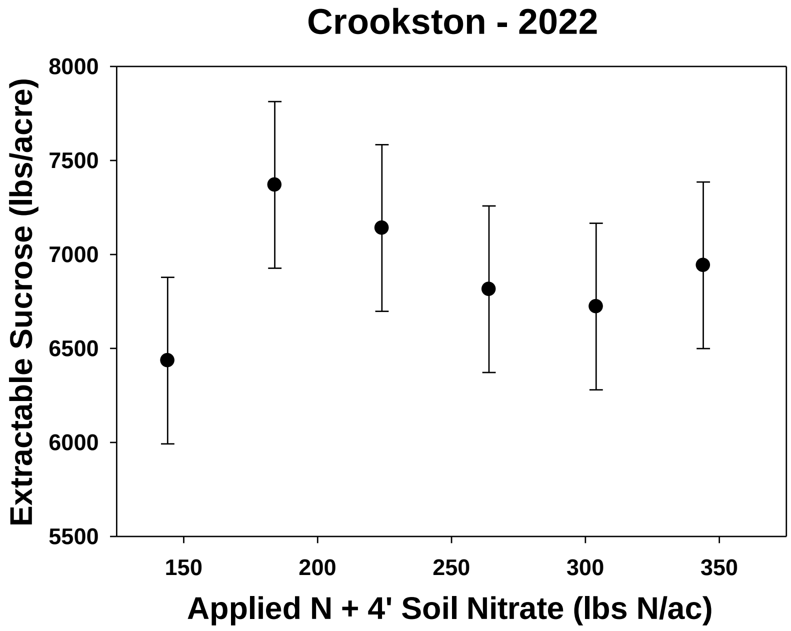

Figure 4b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet total extractable sucrose per acre at two Minnesota locations during the 2022 growing season.

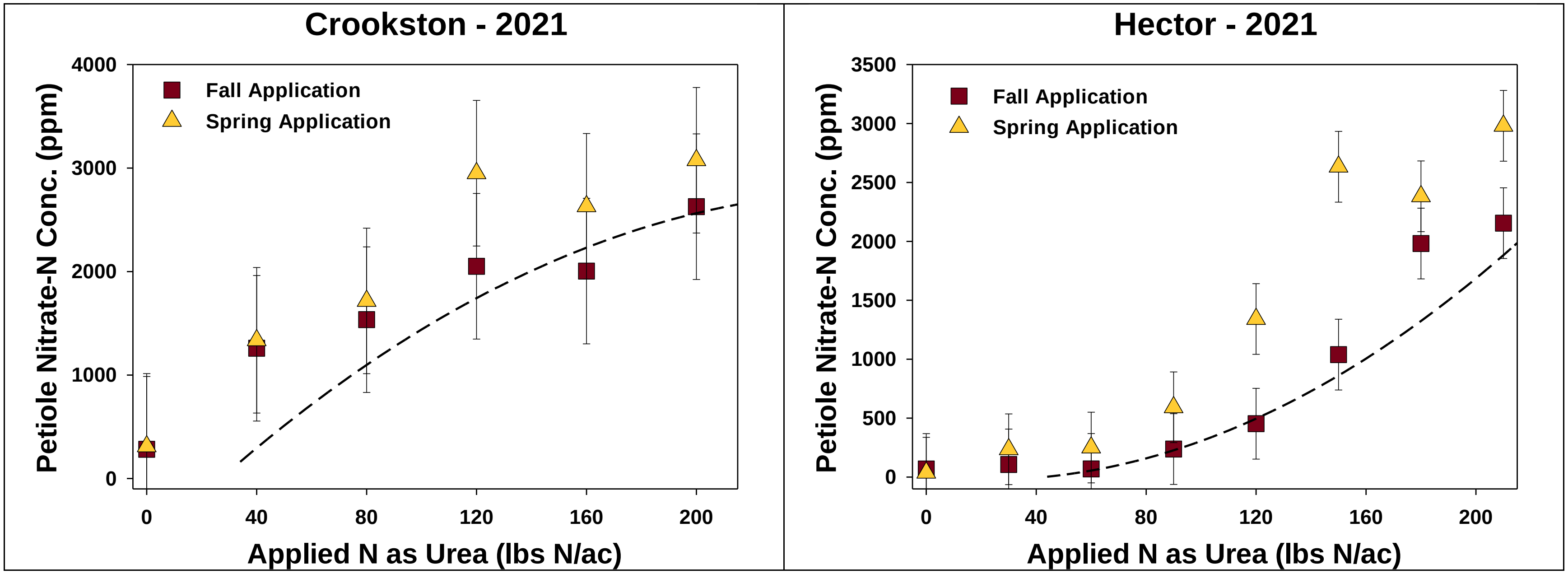

Figure 5a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July petiole nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2021 growing season. Samples were collected but had not been analyzed at the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

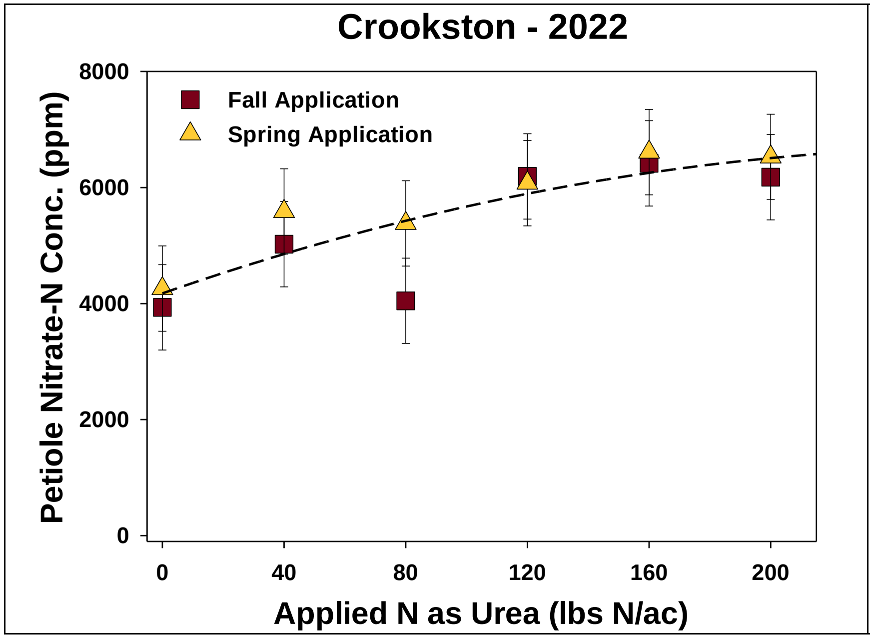

Figure 5b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July petiole nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2022 growing season. Samples were collected but had not been analyzed at the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

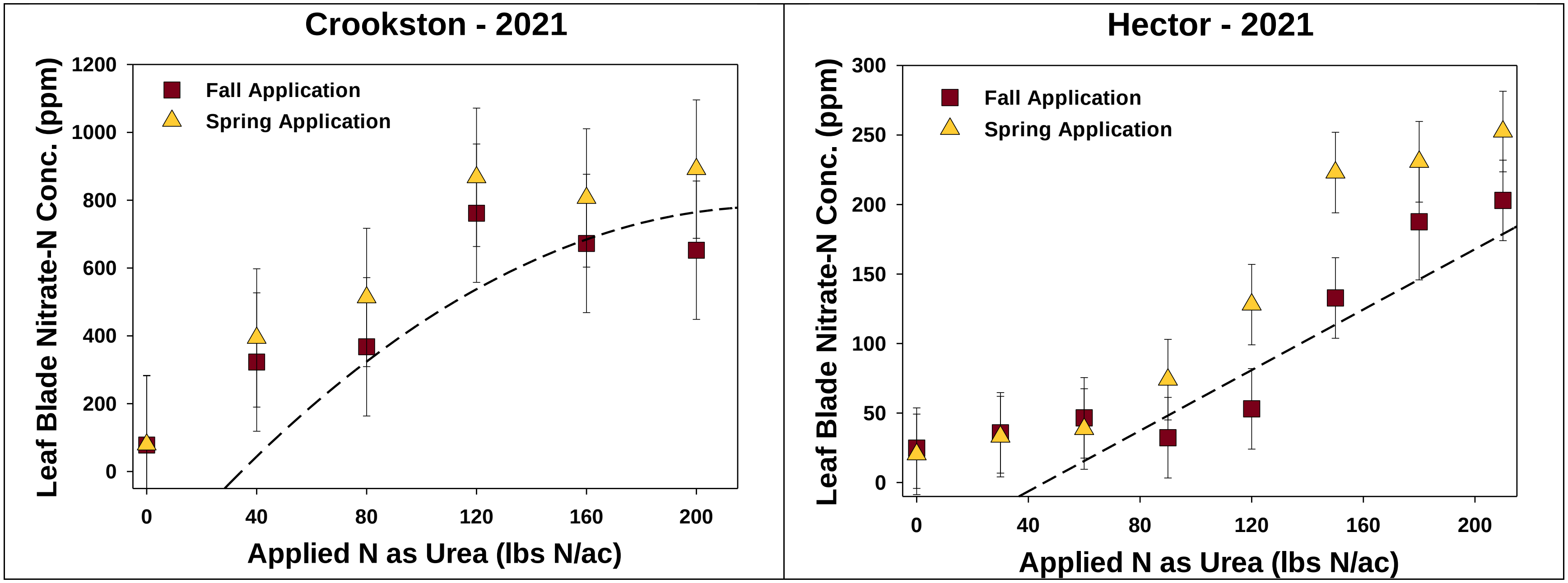

Figure 6a. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July leaf blade nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2021 growing season. Samples were collected but had not been analyzed at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

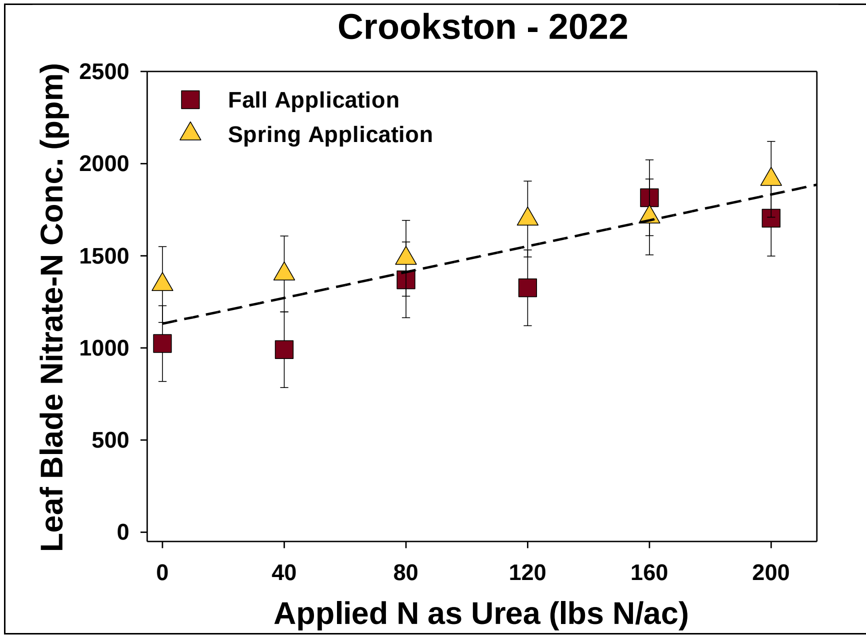

Figure 6b. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet early to mid-July leaf blade nitrate measured from the newest fully developed leaf at two Minnesota locations during the 2022 growing season. Samples were collected but had not been analyzed at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

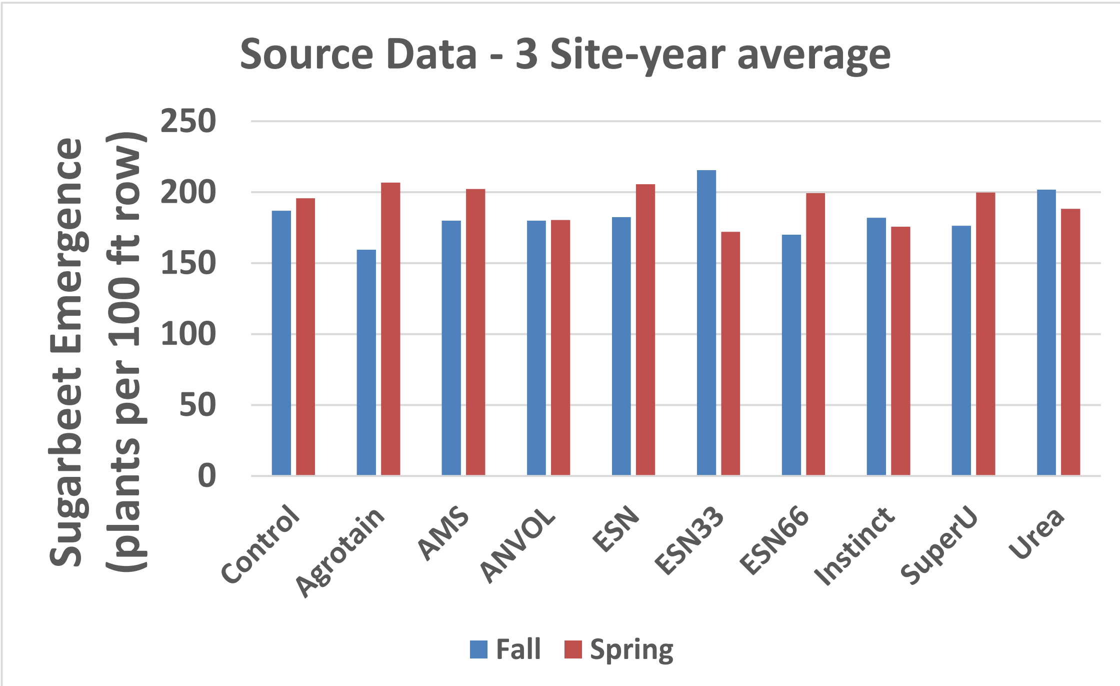

Figure 7. Summary of the impact of urea timing and source impacts on sugarbeet emergence following application of multiple urea sources and ammonium sulfate applied at 45 lbs. of N per acre summarized across 3 site-years for northern and southern Minnesota locations.

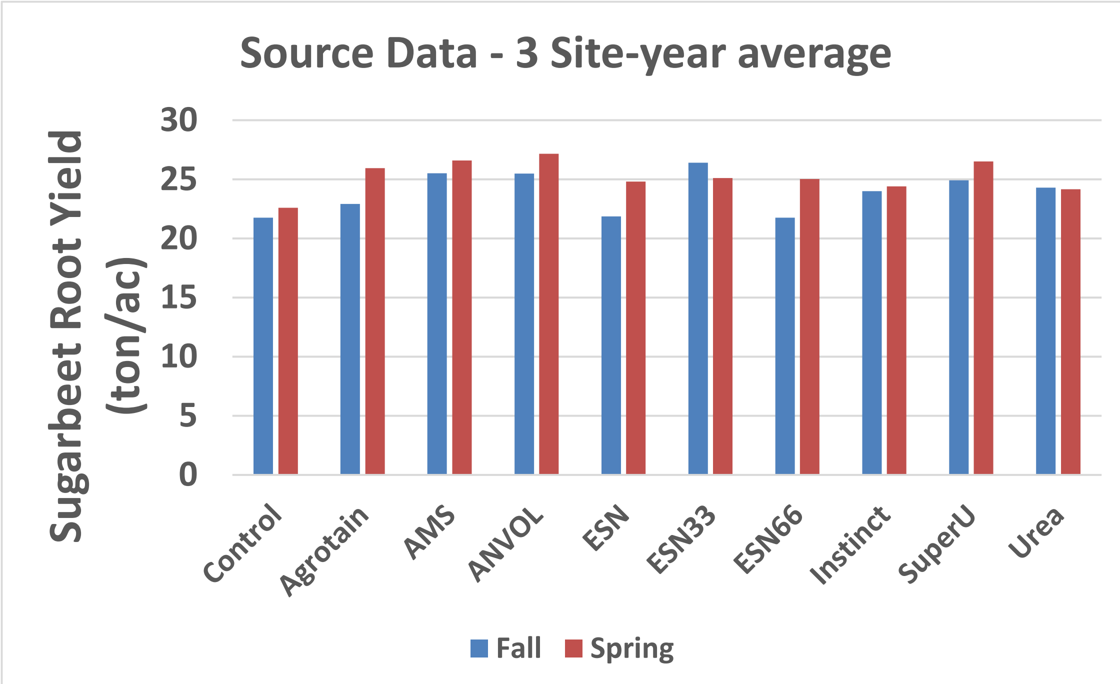

Figure 8. Summary of the impact of urea timing and source impacts on sugarbeet root yield following application of multiple urea sources and ammonium sulfate applied at 45 lbs. of N per acre summarized across 3 site-years for northern and southern Minnesota locations.

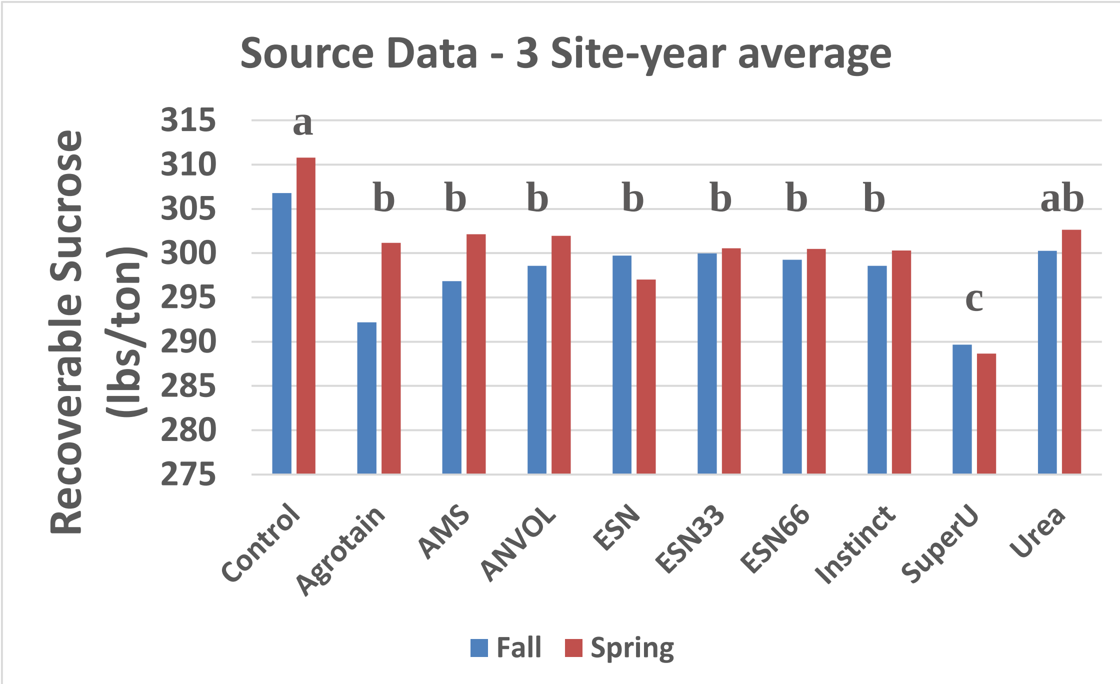

Figure 9. Summary of the impact of urea timing and source impacts on sugarbeet extractable sucrose per ton following application of multiple urea sources and ammonium sulfate applied at 45 lbs. of N per acre summarized across 3 site-years for northern and southern Minnesota locations.

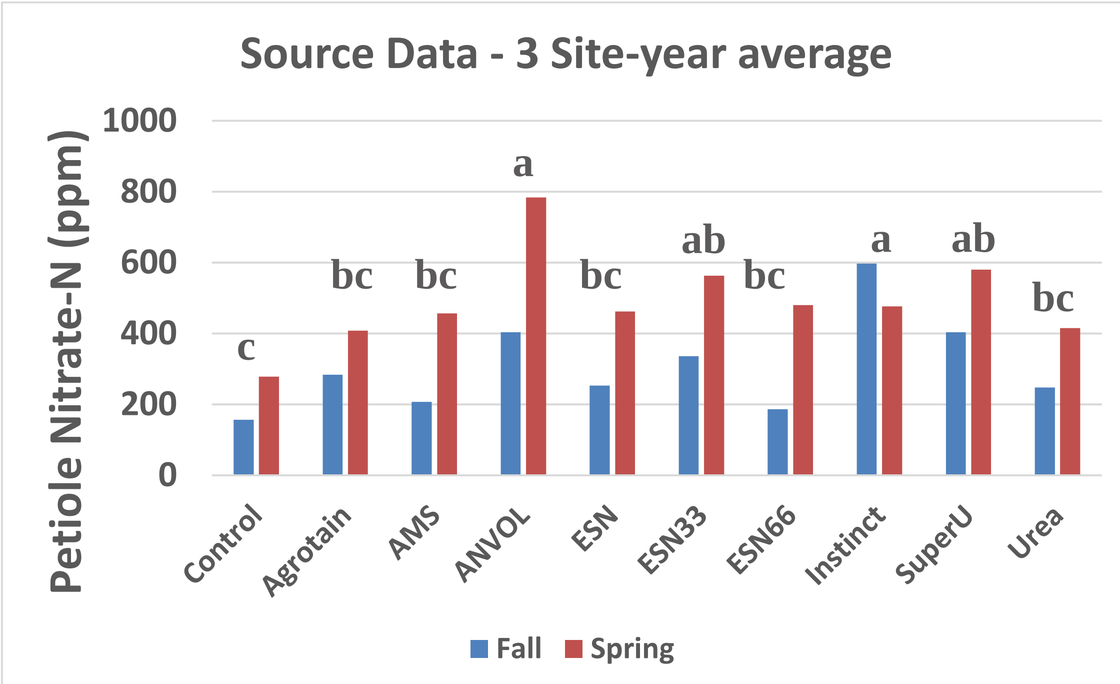

Figure 10. Summary of the impact of urea timing and source impacts on sugarbeet petiole nitrate-N concentration from the uppermost fully developed leaf 40-50 days after planting following application of multiple urea sources and ammonium sulfate applied at 45 lbs. of N per acre summarized across 3 site-years for northern and southern Minnesota locations.

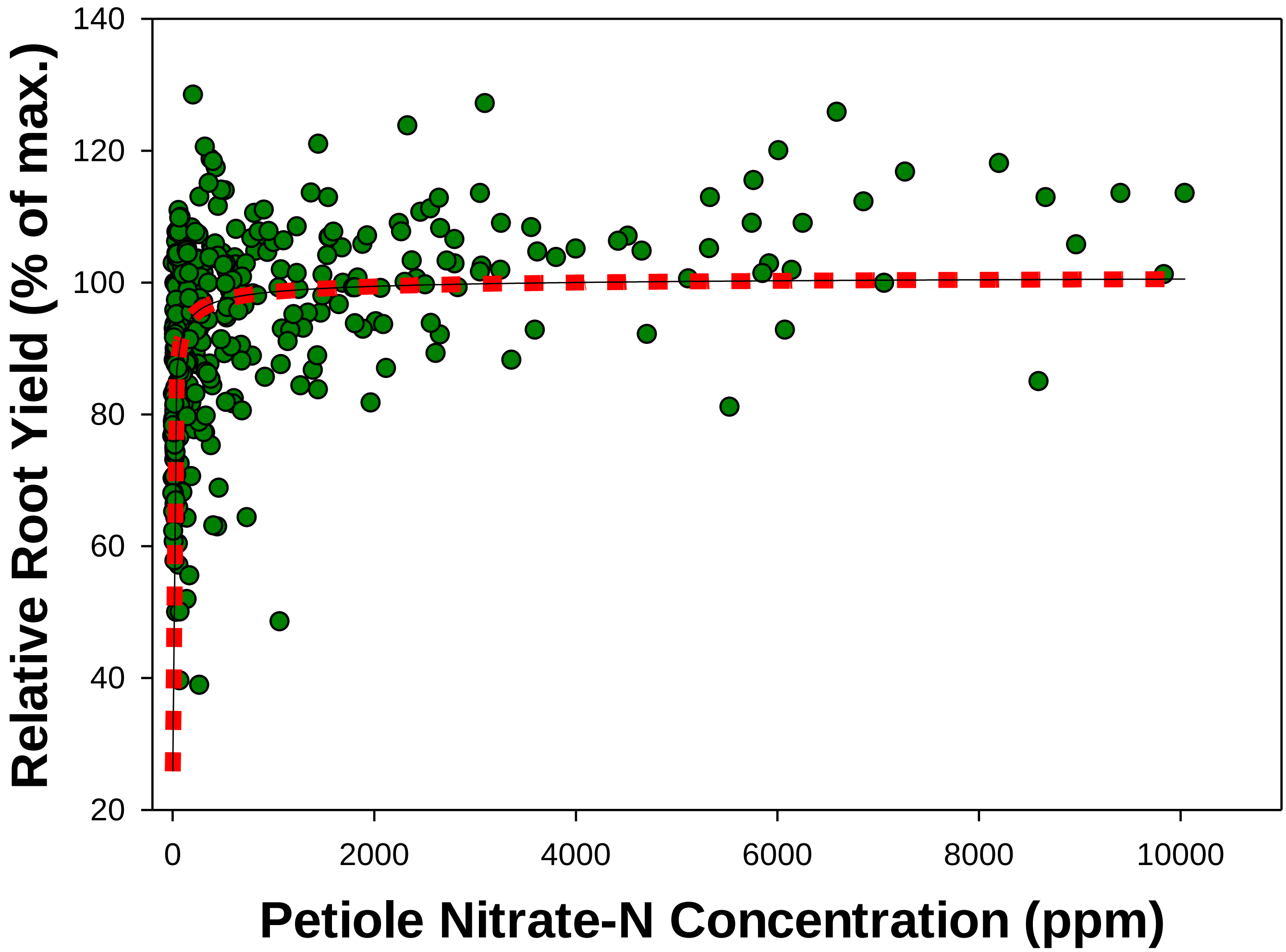

Figure 11. Relationship between relative sugar beet root yield (% of site maximum yield) and nitrate concentration in the uppermost fully developed petiole sampled in early- to mid-July roughly 40 to 50 days after planting.

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:

<u>Year 1 following manure application</u> - 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 ($p > 0.05$).

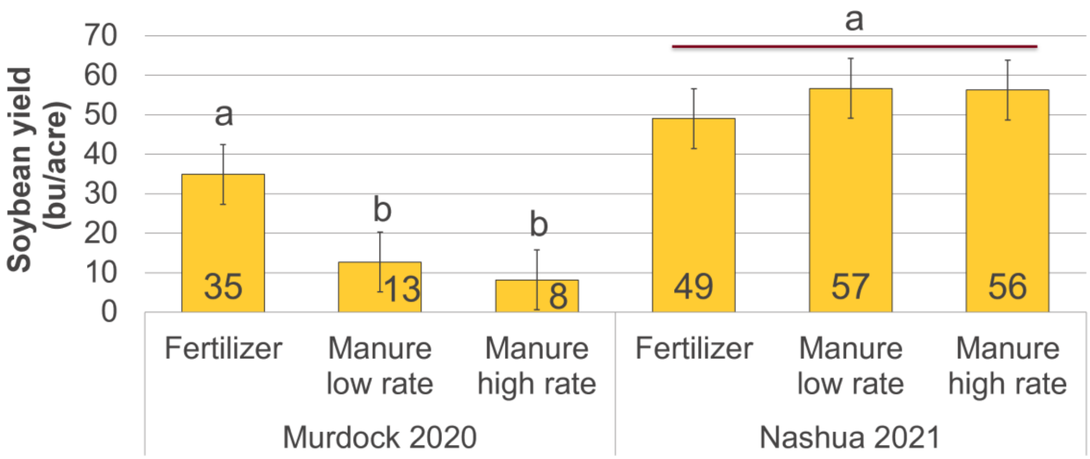

Figure 1. Soybean yield (adjusted to 13% moisture) at Murdock site in 2020 and Nashua site in 2021. There was a significant site by nutrient source interaction. Different letters above a bar indicates a significant difference (p <0 .05).

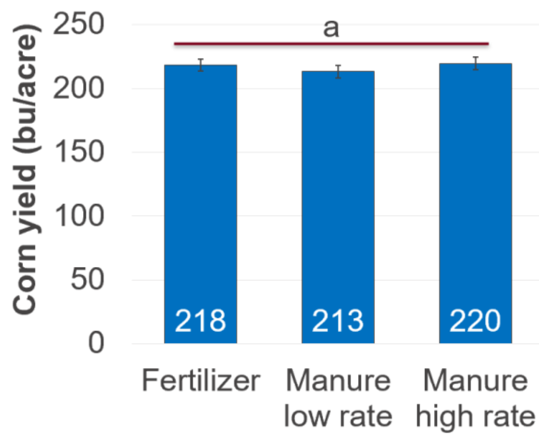

Figure 2. Corn yield (adjusted to 15.5% moisture) averaged over sites (Murdock in 2020 and Nashua in 2021). Different letters above a bar indicates a significant difference ($p < 0.05$).

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 – 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 ($p > 0.05$).

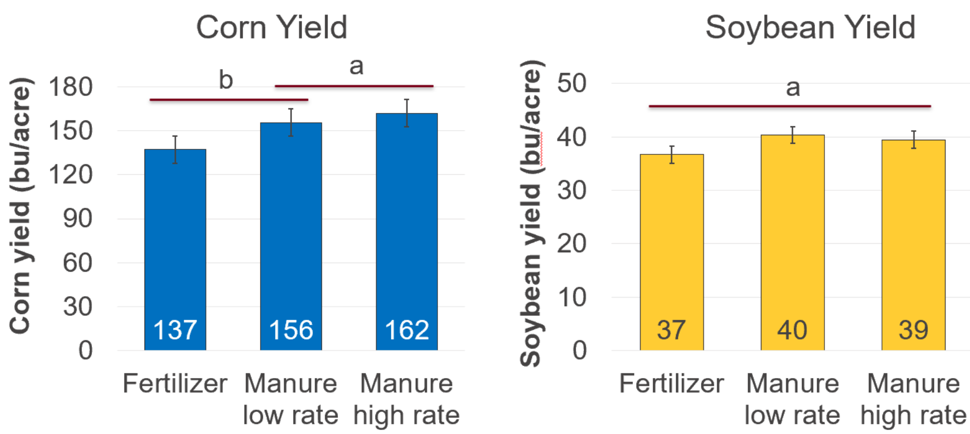

Figure 3. Corn (adjusted to 15.5% moisture) and soybean (adjusted to 13% moisture) yield averaged over sites (Murdock site in 2021 and Nashua site in 2022). In this second year, only fertilizer was applied but a nitrogen credit was taken for the manure. Soil tests for each treatment were used to adjust 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. 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 2021		
Initial soil test results	**Nitrate 0-24” (lb/ac)**	**Olsen P (ppm)**	**K (ppm)**
Previous crop sugarbeet (going into soybean)			
Fertilizer-only	14	7	172
Low-rate manure	12	8	186
High-rate manure	16	11	213
Previous crop soybean (going into corn)			
Fertilizer-only	76	8	209
Low-rate manure	85	10	241
High-rate manure	75	10	254
Previous crop corn (going into sugarbeet)			
Fertilizer-only	97	6	174
Low-rate manure	78	9	186
High-rate manure	86	12	222

Year 3 following manure application – 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. 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 samples 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. There were no differences across nutrient source treatments for sugarbeet root yield or quality measures (Table 8). 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).

Table 8. Yield, extractable sucrose (per ton and per acre), and sucrose percent purity at Murdock in 2022 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	32.1a†	268a	8,616a	88.7a
Low dairy manure rate	31.1a	263a	8,173a	88.2a
High dairy manure rate	35.3a	268a	9,451a	88.9a

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

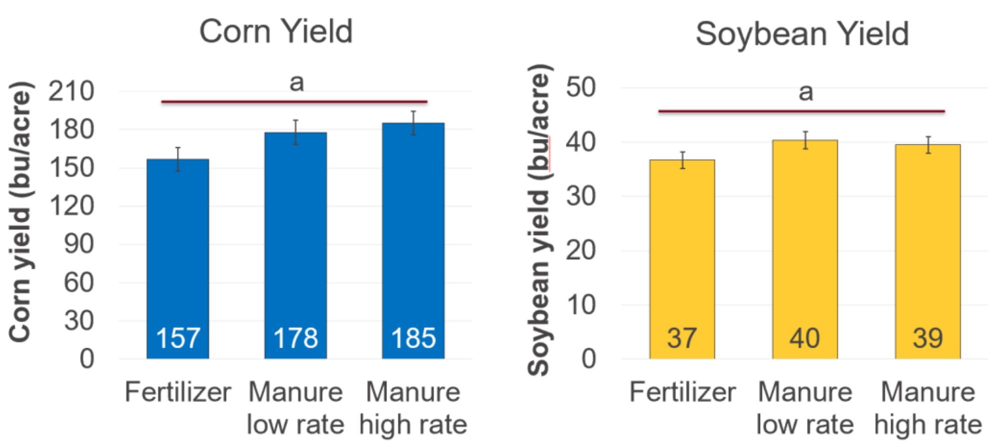

Figure 4. Corn (adjusted to 15.5% moisture) and soybean (adjusted to 13% moisture) yield at the Murdock site in 2022. In this third year, only fertilizer was applied based on N-needs of each crop. Soil tests for each treatment were used to adjust phosphorus and potassium application rates, as well. Different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

Overall, the liquid-separated dairy manure does not seem to have negatively affected sugarbeet yield, regardless of when it was applied in the rotation. We still have one more year of research, though. The trials at the Nashua research site will continue into 2023 to complete the third year of the rotation at that site. As before, soil tests will be used to adjust fertilizer rates as needed.

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SUGARBEET PHYSIOLOGY/STORAGE/PRODUCTION PRACTICES/ECONOMICS

NOTES

PRELIMINARY REPORT ON THE INCIDENCE OF POSTHARVEST PATHOGENS IN SUGARBEET

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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 stations, 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 rot 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 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 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 yards and non-ventilated piles. Samples were collected from top, middle, and bottom of both non-ventilated piles and randomly from different points of the factory yard. A total of 150 sugarbeet roots comprising of 50 each from top, middle and bottom of the non-ventilated piles of Southern Minnesota Sugar Cooperative (SMBC) on Dec. 8, 2021 and on 14, 2021 from Raymond, MN. Nearly 40 infected roots were collected on June 02, 2022 from the factory yard of SMBC, Renville MN. A total of 150 roots were collected on March 29, 2022 from the factory yard of East Grand Forks factory of American Crystal Sugar Company. 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) amended with antibiotics using the protocol of Woodhall et al. (2020). Microbial isolates were further grown on the PDA or water agar until a pure culture of single isolates were received. The pure cultures of individual microbes were transferred into 15% 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 and bacteria, respectively, using sanger sequencing platform (Azenta Life Sciences, South Plainfield, NJ; Molecular Cloning Lab, South San Francisco, CA). 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.

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. A total of 35 fungal and 18 bacterial isolates were identified in root samples received from storage piles and factory yards. Fungal species; *Penicillium* spp., *Mucor* spp., *Hypocrea*/*Trichoderma* spp., *Fusarium* spp., and bacterial species; *Gluconobacter* spp., *Pseudomonas* spp., and *Rahnella* spp. were found primarily associated to infected tissues in postharvest sugarbeet roots (Figs. 1 and 2). 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 2023.

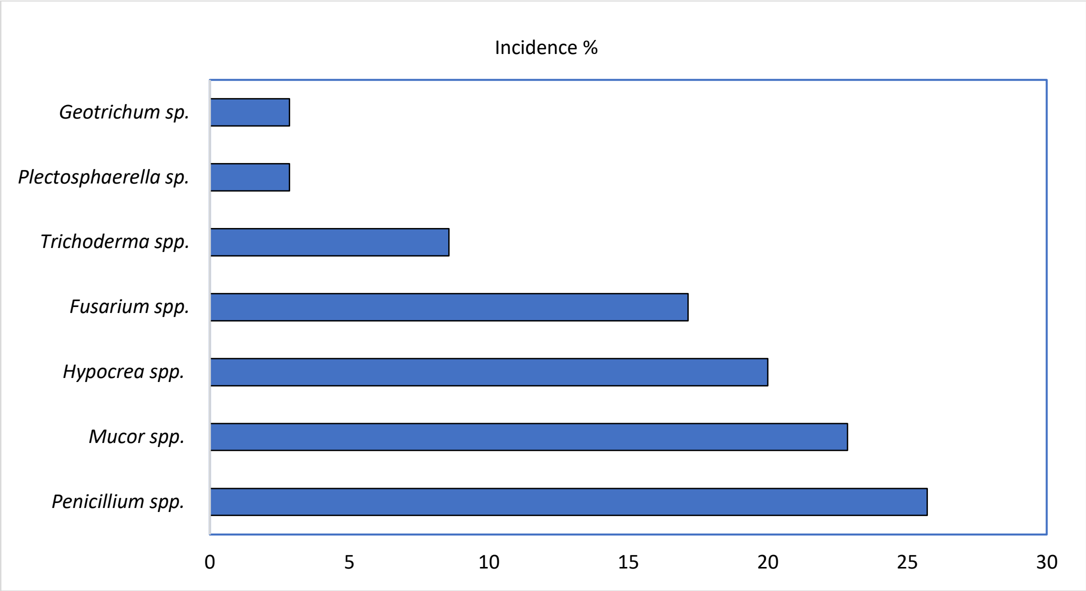

Fig. 1. Incidence of fungal isolates associated with the decaying tissues of sugarbeet roots from storage piles and factory yards.

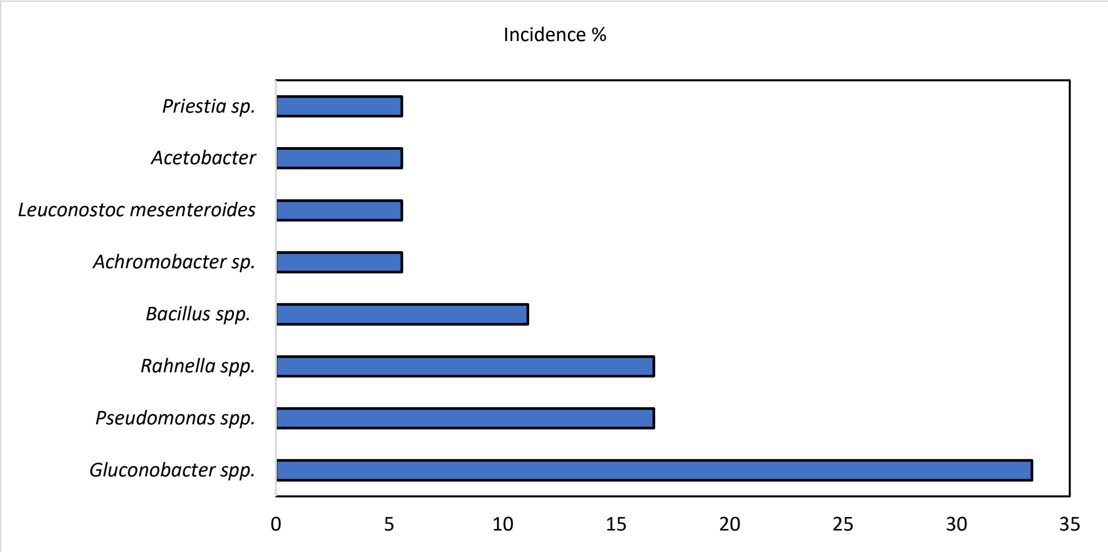

Fig. 2. Incidence of bacterial isolates associated with the decaying tissues of sugarbeet roots from storage piles and factory yards.

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 Peter Hakk, Dept. of Plant Pathology, North Dakota State University and personnel 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 2022

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Attendees of the 2023 Winter Sugarbeet Grower Seminars held at Fargo, Grafton, Grand Forks, and Wahpeton, ND were asked about their 2022 insect pest issues and associated management practices in a live polling session by using a Turning Point® interactive personal response system. Missing data from the Wahpeton seminar resulted from question exclusion by site hosts, thus precluding presentation of that data in this report.

Initial questioning included identifying the county in which grower respondents produced the majority of their sugarbeet crop in 2022. Those results are presented in Tables 1-4). The majority (73%) of Fargo seminar attendees indicated that the majority of their sugarbeet crop was grown in Clay, Norman, or Mahnomen counties of Minnesota, with the remaining 27% of respondents having produced most of their crop in either Cass or Traill County, ND (Table 1).

Table 1. 2023 Fargo Grower Seminar – county in which sugarbeet was grown in 2022

County	Number of responses	Percent of responses
Cass	3	10
Clay	11	38
Norman/Mahnomen	10	35
Traill	5	17
Totals	29	100

The majority (66%) 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 and Marshall counties of Minnesota accounted for an additional 12% each of the attendees of the Grafton seminar, and Grand Forks County, ND was represented by an additional 8% of Grafton respondents.

Table 2. 2023 Grafton Grower Seminar – county in which sugarbeet was grown in 2022

County	Number of responses	Percent of responses
Grand Forks	4	8
Kittson	6	12
Marshall	6	12
Pembina	14	28
Walsh	19	38
Other	1	2
Totals	50	100

At the Grand Forks winter sugarbeet grower seminar, the largest proportion (47%) of attendees indicated that the majority of their sugarbeet production occurred in Polk County, MN (Table 3). An additional 25% 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 and Nelson counties of Minnesota, and Traill and Walsh counties of North Dakota.

Table 3. 2023 Grand Forks Grower Seminar – county in which sugarbeet was grown in 2022

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 48% of the attending producers grew the majority of their sugarbeet crop in Wilkin County, MN, with another 26% of the respondents reporting that most of their crop was produced in Richland County, ND (Table 4). An additional 10% of grower attendees at the Wahpeton seminar indicated that most of their sugarbeet production occurred in Grant County, MN, with Clay and Traverse counties of Minnesota each being where 7% of the Wahpeton attendees grew most of their sugarbeet in 2022.

Table 4. 2023 Wahpeton Grower Seminar – county in which sugarbeet was grown in 2022

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 production activities on an estimated 126,300 acres of sugarbeet grown in 2022 by 172 grower respondents that attended the 2023 Fargo, Grafton, Grand Forks, and Wahpeton Winter Sugarbeet Grower seminars (Table 5). The majority (34%) of respondents reported growing sugarbeet on between 300 and 599 acres during the 2022 production season. An additional 28% of producers grew sugarbeet on between 600 and 999 acres, whereas 10% produced sugarbeet on less than 200 acres. Similar to previous years, 9% of respondents reported growing sugarbeet on 1,500 acres or more in 2022.

Table 5. Ranges of sugarbeet acreage operated by respondents in 2022

		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	23	0	0	4	22	26	17	4	13	4	9
Grafton	46	2	11	7	15	17	11	9	15	9	4
Grand Forks	63	3	10	6	8	29	16	16	13	0	0
Wahpeton	40	3	8	5	10	13	20	13	15	13	3
Totals	172	2	8	6	12	22	16	12	14	6	3

From a combined total of 178 respondents at the Fargo, Grafton, Grand Forks, and Wahpeton seminars, 36% identified the sugarbeet root maggot (SBRM) as their worst insect pest problem in 2022, and 32% viewed grasshoppers as their worst insect pest problem (Table 6). Springtails were rated as the worst pest by 9% of all seminar respondents. Other insect groups identified as causing problems in 2022 included white grubs, wireworms, and cutworms (3, 3, and 1%, of all seminar respondents, respectively) as averaged across the four seminar locations.

The majority of respondents at Grafton (52%) and Grand Forks (49%) identified the SBRM as their worst insect pest problem, whereas, grasshoppers were reported as the worst insect problem for 52, 28, 15, and 50% of producer respondents at Fargo, Grafton, Grand Forks, and Wahpeton, respectively. Springtails were identified as the worst insect pest problem by 8, 15, and 10% of respondents at Fargo, Grand Forks, and Wahpeton, respectively.

Table 6. Worst insect pest problem in sugarbeet in 2022

Location	Number of responses	Springtails	Cutworms	Lygus bugs	Wireworms	Root maggot	White grubs	Grass-hoppers	None
		--			% of responses			--	
Fargo	25	8	0	0	4	24	0	52	12
Grafton	46	0	2	0	2	52	0	28	15
Grand Forks	65	15	0	0	2	49	2	15	17
Wahpeton	42	10	2	0	7	5	10	50	17
Totals	178	9	1	0	3	36	3	32	16

A combined total of 89% of all grower respondents at across all winter grower seminars indicated that they used some form of insecticide to manage insect pests in 2022, with the majority (37%) reporting that they planted seed treated with Poncho Beta insecticidal seed treatment (Table 7). An additional 23% reported using Counter 20G for at-plant protection from insect pests. The remaining producers indicated that they used either Mustang (i.e., Mustang or Mustang Maxx; 10%), Midac (6%), Cruiser (3%), or NipsIt Inside (3%). The majority of planting-time insecticide use in 2022 was carried out by growers that attended the Fargo, Grafton, and Grand Forks seminars, at which 93, 92, and 94% of respondents, respectively, reported using insecticidal protection at planting. Conversely, only 41% of Wahpeton seminar respondents responded as having used an insecticide at planting.

At the Fargo seminar, 37% of producers reported using insecticide-treated seed, with the majority (34%) of those individuals using Poncho Beta-treated seed and the remaining 3% planting their fields with Cruiser-treated seed. An additional 28% 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 2022, with the majority of those applications being either Midac (14%) or Mustang (10% Mustang Maxx; 3% Mustang).

The majority (51%) of Grafton attendees reported planting Poncho Beta insecticide-treated seed. Cruiser- and NipsIt Inside-treated seed were each used by an additional 4% of Grafton attendees. A surprisingly low proportion (19%) of Grafton seminar attendees reported using Counter 20G for planting-time insect pest management. An additional 15% of growers at Grafton indicated that they used a sprayable liquid insecticide, which involved applications of Midac, Mustang, and Mustang Maxx (9, 4, and 2% of respondents, respectively).

Poncho Beta-treated seed was used by 42% of the attendees of the Grand Forks seminar location, and an additional 6 and 5% of respondents at that location reported using NipsIt Inside- and Cruiser-treated seed, respectively. Counter 20G was reported as being used at planting by 29% of grower respondents at Grand Forks, whereas, 8% of attendees at that location reported using Mustang Maxx and an additional 5% responded as using Midac as their planting-time insecticide.

At the Wahpeton seminar location, 17% of respondents indicated that they applied Mustang Maxx for planting-time protection from insect pests in 2022. Similarly, 15% of Wahpeton attendees reported using Counter 20G, and an additional 10% indicated that they used Poncho Beta-treated seed for insect pest management. No other insecticides were reported as being used during the 2022 growing season by Wahpeton seminar attendees.

Table 7. *Planting-time* insecticide use for sugarbeet insect pest management in 2022

Location	Number of responses	Counter	Midac	Mustang Maxx	Mustang	Poncho Beta	Cruiser	NipsIt Inside	Other	None
		--				% of responses		--		
Fargo	29	28	14	10	3	34	3	0	0	7
Grafton	53	19	9	2	4	51	4	4	0	8
Grand Forks	66	29	5	8	0	42	5	6	0	6
Wahpeton	41	15	0	17	0	10	0	0	0	59
Totals	189	23	6	8	2	37	3	3	0	18

Averaged across the Fargo, Grafton, and Grand Forks seminar locations, the moderate and high (7.5 and 8.9 lb product/ac) rates of Counter 20G were the most commonly used (16 and 15%, respectively) granular insecticide treatments for insect management in 2022 (Table 8). The majority of Fargo (55%), Grafton (60%), and Grand Forks (67%) respondents reported no use of a granular insecticide in 2022. However, 70% of the Fargo respondents that did use a granular insecticide applied Counter 20G at the 7.5-lb rate and 10% used the 5.25-lb rate, but no one at the Fargo seminar location reported applying it at the high (8.9 lb product/ac) label rate.

At the Grafton seminar location, 40% of producers reported applying a granular insecticide in 2022. Fifty percent of those respondents applied Counter at the high (8.9 lb) rate, and 33% used it at the moderate rate of 7.5 lb product per acre. Similarly, 33% of Grand Forks respondents reported using a granular insecticide in 2022. Fifty percent of the Grand Forks attendees that used a granular insecticide in 2022 indicated that they applied Counter 20G at the high labeled rate, and an additional 35% applied it at 7.5 lb product per acre.

Averaged across the Fargo, Grafton, and Grand Forks seminar locations, Thimet 20G was used by 2% of grower respondents, and all reported use of Thimet was at its lower rate of 4.5 lb product per acre. The survey question relating to granular insecticide use in 2022 was errantly excluded at the Wahpeton seminar in 2023.

Table 8. Application rates of *granular* insecticides used for sugarbeet insect pest management in 2022

	Number of	Counter 20G			Thimet 20G			
Location	responses	8.9 lb	7.5 lb	5.25 lb	7 lb	4.5 lb	Other	None
		--------------------------------------% of responses--------------------------------------						
Fargo	22	0	32	5	0	0	9	55
Grafton	45	20	13	2	0	2	2	60
Grand Forks	60	17	12	2	0	2	2	67
Totals	127	15	16	2	0	2	3	62

Averaged across the Fargo, Grafton, and Grand Forks survey locations, 46% of respondents reported using a postemergence insecticide to manage the sugarbeet root maggot (SBRM) (Table 9). At the Fargo seminar site, 33% of respondents applied Mustang Maxx for postemergence root maggot control in 2022, which was 70% of all insecticide use reported for that purpose by Fargo grower respondents. Additionally, 14% of all producer respondents at Fargo reported using Thimet 20G to manage the root maggot, which accounted for 30% of all reported postemergence insecticide use for root maggot control by Fargo attendees.

At the Grafton seminar location, 66% of grower respondents indicated that they used some form of postemergence insecticide for SBRM control in 2022. The majority (41%) of Grafton attendees applied Mustang Maxx for postemergence root maggot management, which was 62% of all respondents who used a postemergence insecticide for root maggot control in 2022.

A total of 30% of Grand Forks seminar attendees reported using a postemergence insecticide for root maggot management in 2022. Two-thirds of the producer respondents that did apply an insecticide for SBRM control indicated that they used Mustang Maxx, whereas, only 11% of them used Asana XL, and 22% relied on Thimet 20G for protection against the pest.

Table 9. *Postemergence* insecticide use for *sugarbeet root maggot* management in 2022

Location	Number of responses	Asana XL	Lannate	Movento	Mustang Maxx	Mustang	Thimet	Other	None
		---% of responses--							
Fargo	21	0	0	0	33	0	14	0	53
Grafton	44	7	0	0	41	9	9	0	34
Grand Forks	60	3	2	0	20	0	5	0	70
Totals	125	4	1	0	3	3	8	0	54

Averaged across the Fargo, Grafton, and Grand Forks seminar locations, 63% of grower respondents rated their satisfaction with the insecticide applications they made for root maggot control in 2022 as good to excellent (Table 10). Conversely, an average of 22% of growers that attended the three seminars rated the SBRM control performance of their insecticide program as being fair, and an additional 4% rated it as poor.

Individually, grower satisfaction with insecticide performance for root maggot control in 2022 was rated as good to excellent by 75, 55, 67% of Fargo, Grafton, and Grand Forks respondents, respectively. Satisfaction with insecticide performance for SBRM control was rated as fair by 8, 30, and 19% of respective respondents at the Fargo, Grafton, and Grand Forks seminar locations, which was similar to results those locations in previous years.

At the Fargo seminar location, 17% of respondents that used an insecticide for sugarbeet root maggot control viewed the control provided by the insecticide as poor. However, it should be noted that only 12 grower attendees provided a response to this question, so the poor performance rating involved an even smaller number of respondents.

At the Grafton seminar location, just 3% of grower respondents who used an insecticide for root maggot control rated the insecticide performance as poor; no respondents at the Grand Forks seminar gave a poor rating of performance for their root maggot control treatments. Although the percentages of respondents that rated their root maggot control tool performance as poor may be viewed as low, the incidence of these views was higher during this series of grower seminar surveys than in recent years.

Table 10. *Satisfaction* with insecticide treatments for sugarbeet root maggot management in 2022

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		-------------------------------------	% of responses	---	---	-------------------------------------
Fargo	12	33	42	8	17	0
Grafton	33	3	52	30	3	12
Grand Forks	36	25	42	19	0	14
Totals	81	17	46	22	4	11

As presented in Table 11, a combined average of 72% of grower respondents at the Fargo, Grafton, and Grand Forks grower seminar locations used an insecticide for planting-time protection against springtails. That is a substantial increase when compared to the usage reported from the past few years, in which the use of insecticides for springtails hovered around 50% of growers surveyed. The majority (37%) of respondents that did use an insecticide for this purpose in 2022 relied on Poncho Beta seed treatment insecticide. An additional 19% applied Counter 20G for springtail control. Other notable uses reported included overall averages of 8 and 5% of respondents that used Midac and Mustang Maxx for springtail control. About 28% of all growers surveyed at the three seminar locations reported not using any insecticide for springtail control, which was significantly lower than had been recorded in recent years.

At the Fargo seminar, Counter 20G and Poncho Beta were each used by 21% of respondents, and 17% reported applying Midac for springtail control in 2022. Mustang Maxx was reported as being used by just 4% of Fargo respondents.

The majority (44% of respondents) of insecticide use for springtail management by Grafton seminar attendees involved planting seed treated with Poncho Beta. Cruiser seed treatment insecticide and Counter 20G were each used for springtail control by 7% of the Grafton seminar respondents. The remaining use of insecticides for springtail control, as reported by attendees of the Grafton seminar, included Mustang Maxx (5% of respondents) and Midac (2% of respondents). Thirty-five percent of Grafton attendees indicated that they did not use an insecticide for protection from springtail injury.

Similar to the results from Fargo and Grafton, the majority (38%) of grower respondents at the Grand Forks seminar location indicated that Poncho Beta insecticidal seed treatment was their choice for springtail management during the 2022 growing season. A relatively large number (27%) of Grand Forks respondents also reported that they used Counter 20G at planting for springtail control. Other insecticide use reported by Grand Forks attendees included Midac (8% of respondents), Mustang Maxx (5% of respondents), and NipsIt Inside seed treatment (3% of respondents). This question was excluded at the Wahpeton grower seminar by the site hosts, so no data were collected on springtail management for that growing area.

Table 11. Insecticide use for *springtail* management in 2022

Location	Number of responses	Cruiser	NipsIt Inside	Poncho Beta	Mustang Maxx	Counter 20G	Midac	Other	None
		-------------------------------------			% of responses				-------------------------------------
Fargo	24	0	0	21	4	21	17	0	38
Grafton	43	7	0	44	5	7	2	0	35
Grand Forks	60	0	3	38	5	27	8	0	18
Totals	127	2	2	37	5	19	8	0	28

As presented in Table 12, an overall average of 83% of grower respondents surveyed at the Fargo, Grafton, and Grand Forks seminar locations rated their insecticide performance for springtail management as good to excellent, and only 2% of respondents across all locations viewed their insecticide performance as poor. It should be noted, however, that the combined total of 10% of respondents rating the performance of their springtail control program as being either fair or poor differed markedly from the previous survey (2021 crop year), in which no respondents gave fair or poor ratings for their springtail control.

Satisfaction among Fargo attendees, with regard to insecticide performance for springtail control, was fairly strong, with 71% rating their insecticide performance as either good or excellent. However, the Fargo seminar attendees also had the highest incidence (7%) of respondents that rated their springtail control as poor.

Among grower respondents at the Grafton location, most (63%) viewed their springtail control as being either good or excellent. Only 7% rated the performance of their springtail control program as being fair, and no respondents rated it as poor. Interestingly, 30% of respondents at the Grafton seminar were unsure of the performance of springtail control in their fields.

Grower respondents at the Grand Forks seminar had the highest incidence (79% of respondents) of good to excellent ratings of their springtail control programs. However, 10% of Grafton respondents rated their springtail control as being fair to poor.

Table 12. *Satisfaction* with insecticide treatments for springtail management in 2022

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		----------	----------	% of responses	----------	----------
Fargo	14	50	21	0	7	21
Grafton	30	53	10	7	0	30
Grand Forks	48	44	35	8	2	10
Totals	92	48	35	8	2	10

Lygus bugs were not a major production problem for Red River Valley producers in 2022. This was demonstrated by the combined average of 88% of survey respondents at the Fargo, Grafton, and Grand Forks winter grower seminars reporting that they did not use an insecticide in 2022 for *Lygus* bug control (Table 13).

Fargo seminar attendees reported the highest incidence of insecticide use (26% of respondents) for *Lygus* bug management during the 2022 growing season. A total of 16% of Fargo respondents indicated that they applied Mustang (i.e., Mustang or Mustang Maxx) for *Lygus* bug control, which was the majority of reported insecticide use for this purpose by Fargo seminar respondents in 2022.

Only 8% of Grafton respondents reported using an insecticide for *Lygus* bug management in 2022, with 3% of respondents indicating that they used Asana XL. An additional 5% of total respondents reported that they used an insecticide that was not included as a choice in the survey.

Attendees of the Grand Forks grower seminar also reported low levels of insecticide use for *Lygus* bug control. A total of 10% of Grand Forks respondents indicated that they sprayed for *Lygus* bugs in 2022, with the majority (5% of attendees) reporting that they chose Mustang Maxx for this use. Asana XL and Lannate were each reported as being applied for *Lygus* bug control by 2% of Grand Forks respondents, and an additional 2% indicated that they used an insecticide that was not included as a choice in the survey.

Table 13. Insecticide use for *Lygus bug* management in 2022

Location	Number of responses	Asana XL	Lannate	Movento	Mustang Maxx	Mustang	Other	None
		----------	----------	----------	% of responses	----------	----------	----------
Fargo	19	0	0	0	11	5	11	74
Grafton	38	3	0	0	0	0	5	92
Grand Forks	58	2	2	0	5	0	2	90
Totals	115	2	1	0	4	1	4	88

Survey results on satisfaction with insecticide performance for *Lygus* bug control are presented in Table 14. Those results should be interpreted with discretion because the relative infrequency of insecticide use for that purpose resulted in a very small sample size. Overall, the results suggest that 48% of respondents that used an insecticide for *Lygus* bug management in 2022 viewed its performance as good to excellent, and a similar proportion (47%) of respondents were unsure.

Table 14. *Satisfaction* with insecticide treatments for *Lygus bug* management in 2022

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		--------------------------------------	----------% of responses----------	--------------------------------------		
Fargo	6	33	17	0	0	50
Grafton	5	40	0	0	0	60
Grand Forks	6	0	50	17	0	33
Totals	17	24	24	6	0	47

Grasshoppers were problematic for many North Dakota and Minnesota producers in 2022; however, outbreaks were not as widespread as they had been during the 2021 growing season. About 39% of all grower respondents that attended the Fargo, Grafton, and Grand Forks grower seminars indicated that they used a foliar postemergence insecticide for grasshopper control in 2022 (Table 15). Mustang (i.e., Mustang or Mustang Maxx) was chosen for grasshopper control in 2022 by 21% of all respondents at the three aforementioned 2023 winter grower seminars, which was 56% of all growers who actually used an insecticide for this purpose. An additional 6% of all survey respondents across all grower seminar locations indicated that they had used Asana XL for grasshopper control, which was 16% of all who used an insecticide to manage grasshoppers in 2022.

Grower attendees of the Fargo seminar reported the highest use (72% of all respondents) of foliar rescue insecticides for grasshopper control in 2022. The majority (46% overall; 63% of growers that sprayed for grasshoppers) indicated that they chose Mustang (i.e., Mustang or Mustang Maxx) for this use, whereas 18% of all Fargo respondents (25% of those who used an insecticide for grasshopper control) applied Asana XL.

At the Grafton winter grower seminar, 43% of respondents indicated that they had used a foliar insecticide for grasshopper management in 2022. Of those producers that used an insecticide for this purpose, 55% applied either Mustang or Mustang Maxx, and 15% reported that they used Asana XL for grasshopper control in 2022.

The Grand Forks seminar survey indicated that 23% of respondents used an insecticide to control grasshoppers in 2022; 50% of those attendees who used an insecticide applied either Mustang or Mustang Maxx, and an additional 7% used Asana XL to manage grasshopper infestations in their sugarbeet fields in 2022. This question was excluded from the survey by site hosts at the Wahpeton seminar location.

Table 15. Insecticide use for *grasshopper* management in 2022

Location	Number of responses	Asana XL	Lannate	Movento	Mustang Maxx	Mustang	Other	None
		------------------------	------------------------	---------% of responses---------	------------------------	------------------------		
Fargo	22	18	0	0	32	14	9	27
Grafton	46	7	0	2	20	4	11	57
Grand Forks	60	2	0	2	8	3	8	77
Totals	128	6	0	2	16	5	9	61

Good to excellent grasshopper control was reported by 65% of all respondents that attended the three winter grower seminar locations where this question was asked (Table 16); however, 27% of all grower seminar respondents viewed their grasshopper control tool performance as being fair to poor.

At the Fargo winter grower seminar, 63% of respondents rated their insecticide as having provided good to excellent grasshopper control in 2022. Thirty-one percent of Fargo seminar respondents that used an insecticide for grasshopper control in 2022 rated its performance as only fair, but no Fargo respondents rated it as poor.

Grafton seminar respondents that applied an insecticide for grasshopper control in 2022 mostly (67% of those that used an insecticide for that purpose) viewed its performance as either good or excellent. Survey respondents at the Grafton seminar location also had the lowest (19%) incidence of growers that rated their insecticide performance for grasshopper management as fair.

Survey results from the Grand Forks grower seminar were similar to those at the other two locations. Sixty-four percent of Grand Forks respondents rated their insecticide performance in managing grasshopper infestations as being good to excellent, whereas 27% rated their grasshopper control as fair to poor.

Table 16. *Satisfaction* with insecticide treatments for *grasshopper* management in 2022

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		--------------------------------------% of responses--------------------------------------				
Fargo	16	13	50	31	0	6
Grafton	21	24	43	19	5	10
Grand Forks	11	9	55	27	0	9
Totals	48	17	48	25	2	8

Survey responses to the question about postemergence insecticide spray output volume used in 2022 are presented in Table 17. When averaged across all three grower seminar locations where attendees were asked about the finished spray output volume they used for postemergence insecticide applications, 68% of grower respondents reported that they applied their insecticide in the range of six to 10 gallons per acre (GPA). An additional 26% of all seminar respondents reported making postemergence insecticide applications in an output volume of between 11 and 15 GPA, and the remaining 6% used a finished spray volume of 16 to 20 GPA.

At the Fargo seminar location, the majority (88%) of respondents that used a postemergence insecticide in 2022 indicated that they applied it in a total spray output volume of between six and 10 GPA. The remaining 12% of respondents reported applying their postemergence insecticide in an output volume of between 11 and 15 GPA.

Most (68%) of the Grafton grower seminar attendees reported that they applied postemergence liquid insecticides in an output volume that ranged between six and 10 gallons per acre (GPA) in 2022. Another 29% of respondents at Grafton indicated that they delivered their postemergence sprays in output volumes ranging between 11 and 15 GPA, and 3% reported using an output volume of between 16 and 20 gallons per acre.

The majority (57%) of Grand Forks seminar attendees that applied a postemergence sprayable insecticide in 2022 indicated that they delivered it in an output volume that ranged between six and 10 GPA. Twenty-nine percent of Grand Forks attendees reported applying their postemergence insecticide sprays by using an output volume of between 11 and 15 GPA, and an additional 14% of Grand Forks respondents indicated that they applied the material in a spray volume that ranged between 16 and 20 GPA.

Table 17. Spray volume output used for ground-applied postemergence insecticide applications in 2022

Location	Number of responses	1–5 GPA	6–10 GPA	11–15 GPA	16–20 GPA	> 20 GPA
		-----------------------------------% of responses------------------------------------				
Fargo	16	0	88	12	0	0
Grafton	34	0	68	29	3	0
Grand Forks	28	0	57	29	14	0
Totals	78	0	68	26	6	0

Attendees of all four 2023 winter sugarbeet grower seminars were asked about how their insecticide use for insect pest management compared to previous years. Overall, 60% of all respondents (Fargo, Grafton, Grand Forks, and Wahpeton locations combined) reported that their insecticide use in 2022 did not differ from the previous five years (Table 18). The most significant insecticide use change observed with this question was that 50% of Fargo seminar attendees reported an increase in insecticide use in 2022 when compared to previous years. Similarly, 30% and 27% of respondents at the Grafton and Wahpeton seminars, respectively, also reported that their insecticide usage in 2022 was greater than it had been during the previous five years. Increases in insecticide use by grower attendees of the Fargo and Grafton seminars could have been a product of increasing intensity and geographic spread of sugarbeet root maggot populations, combined with several outbreaks of grasshoppers in 2022. The increased insecticide usage reported by Wahpeton seminar attendees were more likely a result of several outbreaks of sugarbeet webworm, beet armyworm, and grasshoppers during the 2022 growing season.

Table 18. Insecticide use in sugarbeet during 2022 compared to the previous 5 years

Location	Number of responses	Increased	Decreased	No Change	No Insecticide Use
		------------------------------------% of responses----------------------------------			
Fargo	24	50	4	46	0
Grafton	40	30	8	58	5
Grand Forks	57	14	12	70	4
Wahpeton	37	27	5	57	11
Totals	158	27	8	60	5

Grower seminar attendees were also asked about their use of various information sources for making sugarbeet insect pest management decisions. Averaged across all four grower seminar locations, 49% of respondents indicated that they used a publicly available decision-making tool or information source for sugarbeet insect management decision making during the 2022 growing season (Table 19). About 50% of attendees indicated that they used alternative sources for making insect management decisions, and just 1% 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 2022, as averaged across locations, included the NDSU Crop & Pest Report (23% of respondents), sugar cooperative-generated cellular text alerts (15% of respondents), and the Sugarbeet Production Guide (11% of respondents). Pest management information source usage was mostly consistent among surveyed locations, with the exception that no attendees of the Fargo seminar reported using the Sugarbeet Production Guide in 2022.

Table 19. Use of information sources for sugarbeet insect pest management decision making in 2022

Location	Number of Responses	Cellular text alerts	NDSU Crop & Pest Report	Sugarbeet Production Guide	Other	None
		---% of responses--				
Fargo	26	19	31	0	50	0
Grafton	58	16	24	12	48	0
Grand Forks	81	14	21	14	51	1
Totals	165	15	23	11	50	1

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 2022

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Sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), fly activity was monitored at 123 grower field sites throughout the Red River Valley (RRV) during the 2022 growing season. This effort was carried out as a collaborative effort between the NDSU Department of Entomology and American Crystal Sugar Company.

The 2022 growing season was the fifth consecutive year of increasing root maggot fly activity as measured across the Red River Valley as a whole (Figure 1). Additionally, the SBRM fly levels observed in 2022 were the highest recorded by this project over the past 16 years (i.e., since the expanded fly monitoring program began in 2007). The most intense SBRM fly activity in 2022 was observed in the central and northern Red River Valley, which is somewhat typical of what is observed annually on this pest. This suggests that control efforts between 2017 and 2021 had been unsuccessful in reducing overall population levels for many producers in those areas.

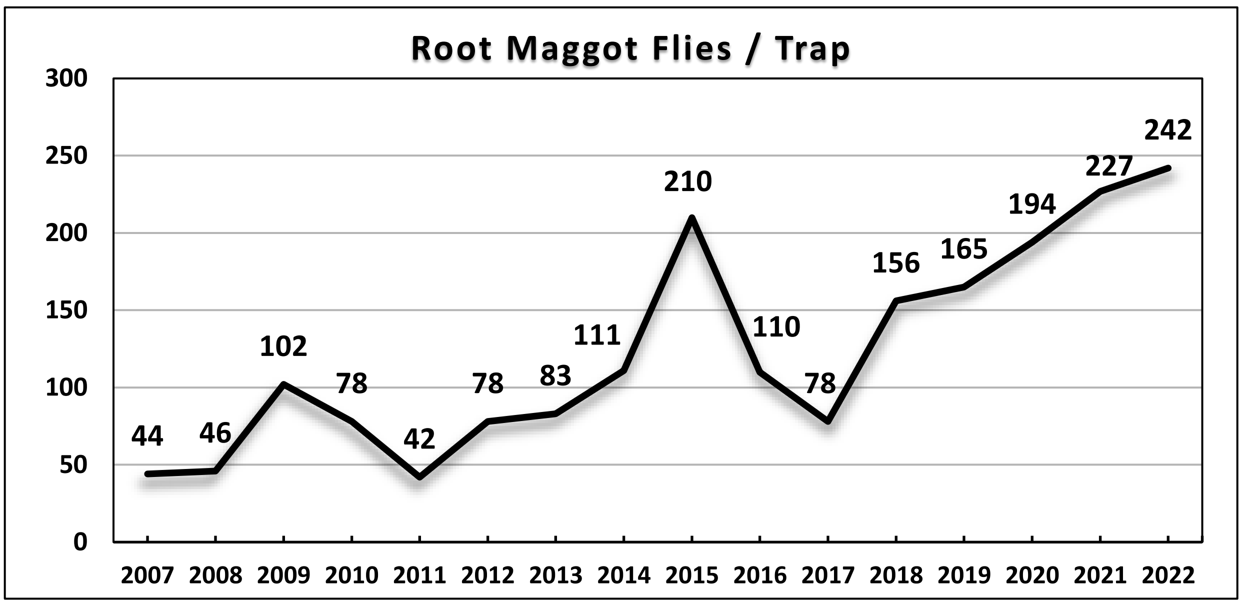

Figure 1. Yearly averages of sugarbeet root maggot flies captured on sticky-stake traps (Blickenstaff and Peckenpaugh, 1976) in the Red River Valley from 2007 to 2022.

High to severe levels of SBRM fly activity (i.e., cumulative capture of at least 200 flies per sticky stake) were observed in 2022 in fields near the following communities (cumulative flies per stake in parentheses): Auburn (1031), Bathgate (300), Bowesmont (440), Buxton (274), Cashel (388), Cavalier (324), Crystal (673), Drayton (658), Glasston (792), Grand Forks (260), Hensel (678), Hoople (261), Oakwood (532), Reynolds (743), St. Thomas (744), Thompson (301), and Voss (220), ND, as well as Angus (350), Argyle (232), Climax (484), Crookston (333), Donaldson (354), East Grand Forks (671), Eldred (385), Halma (587), Sabin (1098), and Warren (266), MN.

Moderately high levels of activity were also recorded near Ardoch (100), Hamilton (144), Merrifield (52), and Nash (127), ND, and near Ada (167), Borup (60), Climax (89), Euclid (60), Kennedy (76), Nielsville (150), Sherack (46), and Tabor (57), MN. Fly activity was either economically insignificant or undetectable in most other locations.

Figure 2 presents sugarbeet root maggot fly monitoring results from three representative sites (i.e., Sabin, MN; Reynolds and Auburn, ND) during the 2022 growing season. Adult fly emergence began in early June at all three of those sites. That was slightly later historical averages that have shown the onset of emergence typically begins within the last seven to 10 days in May. Although SBRM fly emergence began about one week later than the historical average for the Red

River Valley growing area as a whole, the Valley-wide average peak in activity during 2022 occurred precisely on the 15-year average date of June 13.

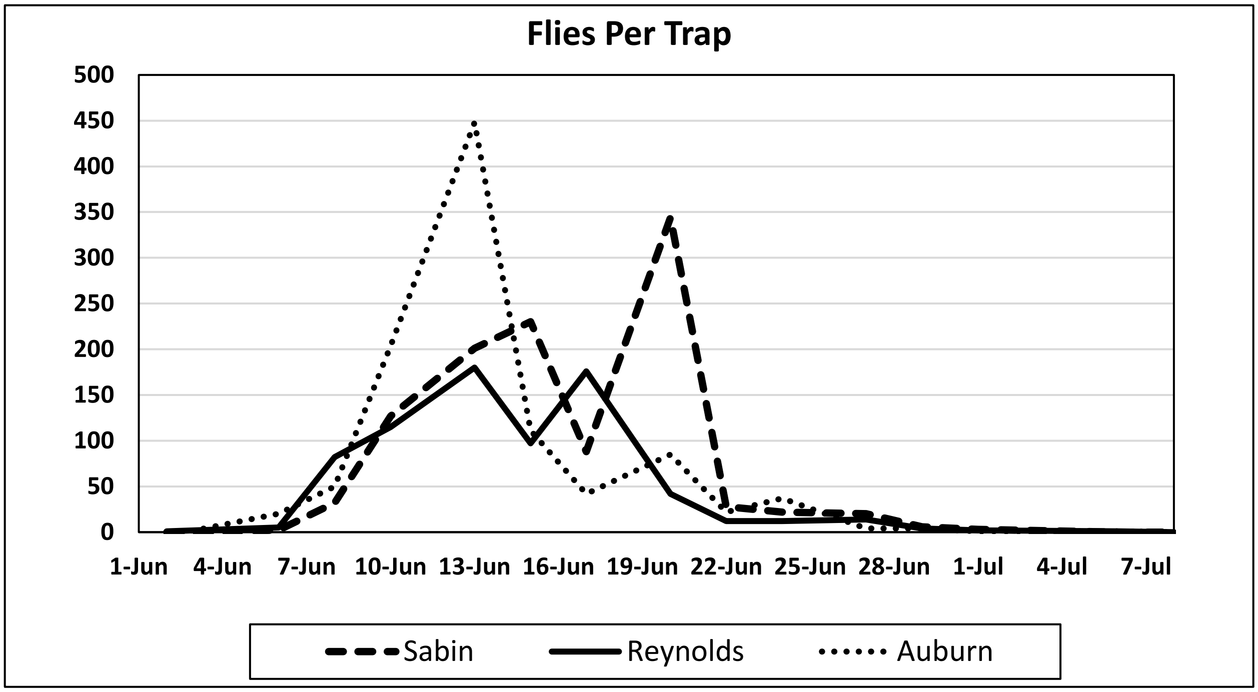

Fig. 2. Sugarbeet root maggot flies captured on sticky-stake traps at selected Red River Valley sites, 2022.

An even more unusual observation in 2022 was that SBRM fly activity in the Auburn area (northernmost of the three sites) began at about the same time as activity in the Sabin area (southern RRV), and Auburn appeared to peak earlier. Windy conditions in the Sabin area during what would likely have been the timing for peak fly activity probably kept SBRM adults down on and near the ground, thus delaying peak flight in area sugarbeet fields.

Another unusual phenomenon in 2022 involved the occurrence of what appeared to be bimodal (i.e., double peaks) SBRM fly activity patterns at many monitoring sites throughout the Valley. As shown in Figure 2 above, the bimodal pattern was very evident in fly counts from Reynolds and Sabin and, to a lesser extent, Auburn, as well as several other sites within the monitoring network. Those observations also were likely a product of unfavorable weather that included high winds, which was not conducive to SBRM flight activity. The occurrence of two SBRM fly activity peaks within the growing season is somewhat rare, but it occurs about every three to five years.

In late-August of 2022, after most SBRM larval feeding had ceased, 50 of the fly monitoring sites were rated for root maggot feeding injury in accordance with the 0-9 scale of Campbell et al. (2000) to assess whether fly outbreaks and larval infestations were managed effectively. The resulting data 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 0.96 on the 0 to 9 rating scale. That amounted to a 42% decrease in SBRM feeding injury when compared to that recorded in 2021. 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 224 flies/trap near Argyle, MN to 1,098 flies/trap near Sabin, MN. All of those fields had severely high SBRM fly infestations in comparison to most of the previous 15 years; however, the average root maggot larval feeding injury recorded for all of them was low to moderate, which suggests that the producers managing those fields were moderately to highly successful in controlling the SBRM infestations that developed in them. Other fly monitoring network fields that had a combination of high fly activity and at least moderate SBRM feeding injury 2022 included sites near Reynolds, ND (351 cumulative flies/trap; average root rating = 2.38) and Argyle, MN (232 cumulative flies/trap; average root rating = 2.18). Other areas within the monitoring network likely also sustained moderate to even high SBRM feeding injury; however, it was logistically impossible to rate all monitored fields for damage.

Table 1. Sugarbeet root maggot fly activity and larval feeding injury in Red River Valley commercial sugarbeet fields where injury exceeded 2.5, 2022

Nearest City	Township	State	Flies/stake	Average Root Injury Rating[a]
Sabin	Elmwood	MN	1,098	3.83
Cavalier	S. Cavalier	ND	224	2.98
St. Thomas	S. St. Thomas	ND	699	2.60

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

Although the collective results from root injury ratings of grower fields conducted late-summer of 2022 suggest that RRV sugarbeet growers were fairly 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 2023. Vigilant monitoring and effective SBRM management on an individual-field basis by sugarbeet producers could also help prevent significant population increases from one year to another, because even moderate levels of root maggot survival in one year can be sufficient to result in economically damaging infestations in the subsequent growing season. That assertion is substantiated by the significant increase in SBRM fly activity that occurred in the Sabin area between 2021 and 2022.

Acknowledgments:

The authors extend sincere appreciation to the numerous sugarbeet producers that allowed us to monitor SBRM fly activity in their fields. We also are grateful to the following American Crystal Sugar Company agriculturists for collaborating with us on this project by monitoring dozens of commercial sugarbeet fields (in alphabetical order): Clay Altepeter, Andrew Clark, Thomas Cymbaluk, Todd Cymbaluk, Mike Doeden, Tyler Driscoll, Curtis Funk, Tyler Hegg, Austin Holy, Bob Joerger, Tim Kenyon, Holly Kowalski, Kody Kyllo, Kyle Lindberg, Chris Motteberg, Alysia Osowski, Travis Pederson, Nolan Rockstad, Nick Shores, Aaron Sawatzky, Nick Shores, and Dan Vagle.

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SUGARBEET ROOT MAGGOT FORECAST FOR THE 2023 GROWING SEASON

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The 2023 risk map for 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 five years and, in 2022, it was greater than that recorded in any of the past 16 growing seasons. The exceptionally high infestations in 2022 suggest that many areas within the valley are at high risk for damaging SBRM infestations in 2023.

Areas at highest risk of SBRM problems in 2023 include rural Auburn, Cashel, Cavalier, Crystal, Drayton, Glasston, Grand Forks, Hensel, Hoople, Oakwood, Reynolds, St. Thomas, Thompson, and Voss, ND, as well as Argyle, Climax, Crookston, Donaldson, East Grand Forks, Sabin, and Warren, MN. Moderate risk is expected in areas bordering high-risk zones, as well as fields near Ardoch, Bathgate, Bowesmont, Buxton, Hamilton, and Nash, ND, and Ada, Angus, Borup, Eldred, Euclid, Halma, Kennedy, Nielsville, Sherack, and Tabor, MN. The rest of the area is at lower risk.

Proximity to previous-year beet fields where populations were high and/or control was unsatisfactory can increase risk. Areas where high fly activity occurred in 2022 should be monitored closely in 2023. Growers in high-risk areas should use an aggressive form of at-plant insecticide treatment (granular insecticide) and expect the need for a postemergence rescue insecticide application.

Those in moderate-risk areas using insecticidal seed treatments for at-plant protection should monitor fly activity levels closely in their area and be ready to apply additive protection if justified. Pay close attention to fly activity levels in late May through June to determine the need for a postemergence insecticide application.

NDSU Entomology will continue to inform growers regarding SBRM activity levels and hot spots each year through radio reports, the NDSU "Crop and Pest Report" and notification of sugar cooperative agricultural staff when appropriate. Root maggot fly counts for the current growing season and those from previous years can be viewed at https://tinyurl.com/SBRM-FlyCounts.

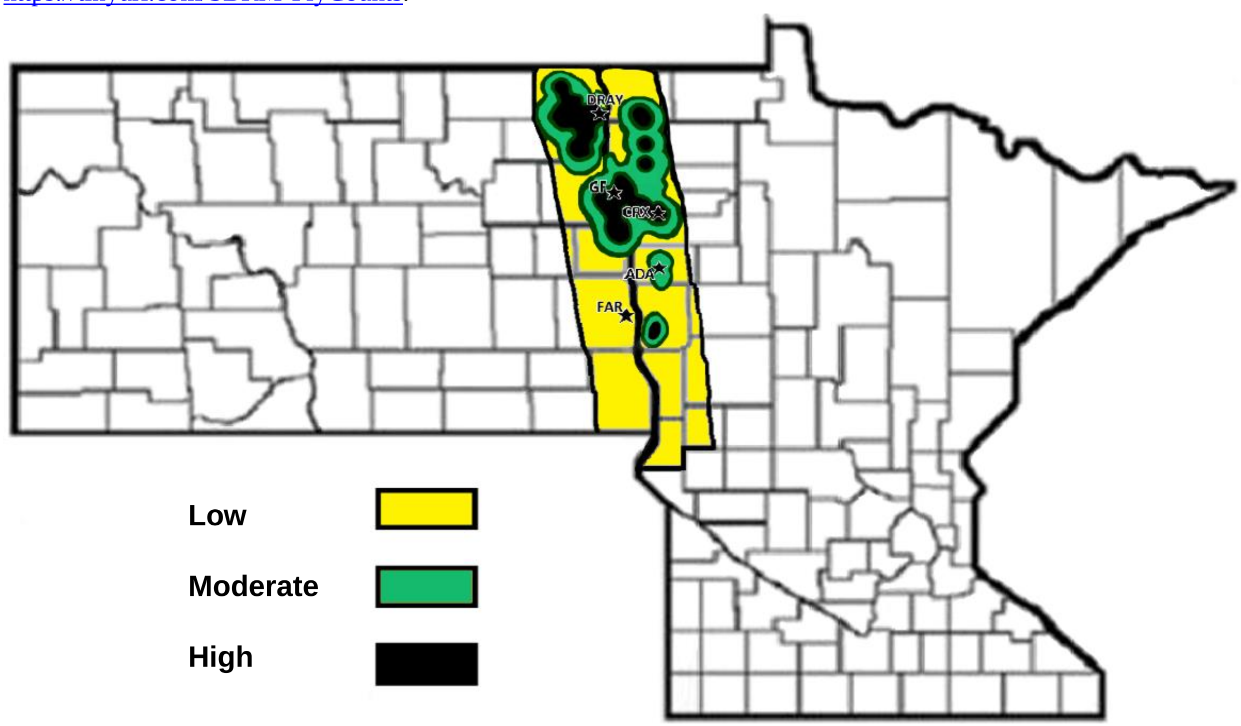

Fig. 1. Anticipated risk of SBRM fly activity and damaging larval infestations in the Red River Valley.

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We greatly appreciate the efforts of the following sugar cooperative agriculturists in monitoring several grower fields for sugarbeet root maggot fly activity, which we believe has added precision to this forecast (presented in alphabetical order): Clay Altepeter, Andrew Clark, Thomas Cymbaluk, Todd Cymbaluk, Mike Doeden, Tyler Driscoll, Curtis Funk, Tyler Hegg, Austin Holy, Bob Joerger, Tim Kenyon, Holly Kowalski, Kody Kyllo, Kyle Lindberg, Chris Motteberg, Alysia Osowski, Travis Pederson, Nolan Rockstad, Nick Shores, Aaron Sawatzky, Nick Shores, and Dan Vagle. Thanks are also due to the following NDSU summer aides for providing assistance with fly monitoring activities: Nick Antonoplos, Emma Harmsen, Grace Harmsen, and Margaret Huettl. Finally, are grateful 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.

SUGARBEET ROOT MAGGOT CONTROL BY USING MULTIPLE-COMPONENT MANAGEMENT REGIMES

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is a severe insect pest threat to sugarbeet production in central and northern portions of the Red River Valley (RRV) of North Dakota and Minnesota. Previous research has shown that the SBRM is capable of causing more than 45% yield losses in the absence of effective control measures (Boetel et al. 2010). The high root maggot infestation levels that commonly occur in the RRV often require aggressive management programs to ensure adequate protection of the sugarbeet crop. As such, SBRM management programs in areas at high risk of economic loss from this pest usually consist of planting-time protection, in the form of a granular, liquid, and/or seed treatment insecticide, followed by an additive postemergence insecticide application (i.e., either a granular or sprayable liquid product) when the SBRM infestation level warrants it. Broadcast applications of sprayable liquid insecticides, applied on an as-needed, rescue basis, are the most commonly used postemergence tools for SBRM control in the region. An advantage of postemergence sprays is that they allow growers to use a "wait and see" approach to make informed decisions on whether rescue insecticide treatments are needed based on current fly activity levels in their fields.

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

The objectives of Study II were to: 1) measure the impacts of NipsIt Inside seed treatment and Counter 20G (at differing application rates) on root maggot control in dual-insecticide programs comprised of postemergence broadcast spray applications of Asana XL insecticide; 2) evaluate the SBRM control provided by rotated applications of Asana XL and Mustang Maxx; 3) assess the impact of tank mixing Exponent insecticide synergist with Asana XL on SBRM management; and 4) compare the SBRM control efficacy of at-plant and postemergence applications of Asana XL.

Materials and Methods:

Both of these experiments were conducted on a commercial sugarbeet field site near St. Thomas (Pembina County), ND during the 2022 growing season. Betaseed 8961 glyphosate-resistant seed was used for all entries in both experiments, and a professional seed preparation company (Germains Seed Technology, Fargo, ND). Study I was planted on May 25, and Study II was planted on May 26, 2022. All plots were planted using a 6-row Monosem NG Plus 4 7x7 planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. No insecticide was applied to the outer "guard" rows (i.e., rows one and six) of each plot, as those rows served as untreated buffers. Each plot was 35 feet long, and 35-foot alleys between replicates were maintained weed-free throughout the growing season by using tillage operations. Both experiments were arranged in a randomized complete block design with four replications of the treatments.

<u>Planting-time insecticide applications</u>: Counter 20G was applied in both trials by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy^{TM} row banders. Granular application rates were regulated by using a planter-mounted SmartBox^{TM} computer-controlled insecticide delivery system that was calibrated on the planter immediately before all applications. In Study II, planting-time liquid insecticide treatments, which included Asana XL and a combination of Asana XL with Exponent, spray solutions were applied by using dribble in-furrow (DIF) placement. This involved directing the spray solution into the open seed furrow through microtubes (1/4" outside diam.). Inline Teejet^{TM} No. 18 orifice plates were used to stabilize the spray volume output rate, and the system was calibrated to deliver a finished spray output volume of 5 gallons per acre (GPA).

Postemergence insecticide applications: Postemergence insecticides in Study I consisted of two granular materials (i.e., Counter 20G and Thimet 20G) that were both band-applied (Post B) on June 13 (i.e., 2 days before peak SBRM fly activity). Delivery of postemergence banded granules was achieved by using Kinze™ row banders that were attached to a tractor-mounted tool bar and adjusted to a height to deliver the insecticides in 4-inch bands. Similar to at-plant insecticide applications, postemergence granular output rates were also regulated by using a SmartBox™ system mounted on a tractor-drawn four-row toolbar. Granules were incorporated by using two pairs of rotary tines that straddled each row on the tool bar. A paired set of tines was positioned ahead of each bander, and a second pair was mounted behind the granular drop zone of each row unit. This system effectively stirred soil around the bases of sugarbeet seedlings and incorporated granules as the unit passed through each plot.

The postemergence spray applications of Mustang Maxx (Studies I and II) and Asana XL (Study II) were broadcast-applied on June 17 (i.e., 2 days after peak SBRM fly activity). Sprays were applied from a tractor-mounted CO_2-propelled spray system equipped with an 11-ft boom that was calibrated to deliver a finished spray output volume of 10 GPA through TeeJet™ 11001VS nozzles.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed for these experiments on August 1 (Study I) and August 2 (Study II). Rating procedures consisted of randomly collecting ten sugarbeet roots (i.e., five from each of the outer two treated rows) per plot, hand-washing them in a bucket of water, and scoring each in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. Both studies were harvested on October 5. Foliage was removed from plots immediately before harvest by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were extracted from soil using a mechanical harvester, and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

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

Results and Discussion:

Study I. Results from sugarbeet root maggot feeding injury ratings for Study I are presented in Table 1. The level of root injury sustained by roots in the untreated check plots (mean = 6.43 on the 0 to 9 scale of Campbell et al. [2000]) suggested that a moderately high infestation of SBRM larvae was present for the experiment. Although the SBRM larval feeding pressure was not severe, differences among treatments with regard to root damage provided valuable insights associated with treatment program performance in managing this pest.

Significantly lower levels of SBRM feeding injury were recorded in all insecticide-protected treatments in Study I when compared to the untreated check. This showed that all insecticide treatments, including the stand-alone Poncho Beta seed treatment, a single at-plant application of Counter 20G insecticide, and the multiple-component insecticide combinations, provided significant levels of protection from SBRM feeding injury.

The greatest root protection (i.e., lowest overall SBRM larval injury) in Study I occurred in plots planted with Poncho Beta insecticide-treated seed and treated at planting with Counter 20G at its moderate (7.5 lb product/ac) rate, then subsequently treated with a postemergence application of Thimet 20G at its high rate (7 lb product per acre). Although that treatment sustained the lowest average SBRM feeding injury, it was not statistically superior to the following entries that also provided excellent root protection:

1) Poncho Beta + Counter 20G (8.9 lb/ac, at-plant band) + Thimet (7 lb/ac banded, 2d before peak fly); and

2) Counter 20G (8.9 lb/ac, at-plant band) + Thimet (7 lb/ac, 2d pre-peak) + Mustang Maxx 2d post-peak.

All triple-component control regimes in this trial resulted in significantly greater root protection from root maggot feeding injury when compared to the single-component treatments. Similarly, trends suggested that dual- component programs also tended to perform better with respect to root protection from SBRM feeding injury than single-component programs, although differences were not universally significant. The results from SBRM root injury ratings also showed that single-component control programs are not sufficient to protect the crop from moderately high root maggot infestations such as that which developed for this trial.

Table 1. ***Larval feeding injury*** **in an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence insecticides, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study I)**				
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Poncho Beta + Counter 20G + Thimet 20G	Seed B 2 d Pre-peak Post B	 7.5 lb 7 lb	68 g a.i./ unit seed 1.5 1.4	1.70 e
Poncho Beta + Counter 20G + Thimet 20G	Seed B 2 d Pre-peak Post B	 8.9 lb 7 lb	68 g a.i./ unit seed 1.8 1.4	1.80 e
Counter 20G + Thimet 20G + Mustang Maxx	B 2 d Pre-peak Post B 2 d Post-peak Broadcast	8.9 lb 7 lb 4 fl oz	1.8 1.4 0.025	2.40 de
Counter 20G + Thimet 20G +	B 2 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	2.87 cd
Poncho Beta + Counter 20G +	Seed B	 8.9 lb	68 g a.i./ unit seed 1.8	2.90 cd
Poncho Beta + Counter 20G +	Seed 2 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	3.03 cd
Counter 20G	B	8.9 lb	1.8	3.33 c
Poncho Beta	Seed		68 g a.i./ unit seed	4.43 b
Check	---	----	---	6.43 a
LSD (0.05)				0.758

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band; Post B = 4-inch postemergence band; Seed = insecticidal seed treatment

Yield data from Study I are presented in Table 2. All insecticide treatments in this experiment, including the single-component treatments involving Counter 20G or Poncho Beta, resulted in statistically significant increases in recoverable sucrose yield when compared to the untreated check. As observed in root injury rating results, the top-performing entry with regard to recoverable sucrose yield and gross economic return involved planting Poncho Beta insecticide-treated while applying Counter 20G at its moderate (7.5 lb product/ac) rate, combined with a postemergence application of Thimet 20G at its high rate (7 lb product per acre). That entry generated a gross revenue of $1,978/ac, which was $1,161/ac greater revenue than the untreated check plots. It also grossed $339 more revenue than plots protected solely by the planting-time application of Counter at 8.9 lb/ac and $556 more revenue than the single-component Poncho Beta treatment.

The following entries in Study I also provided excellent yields and gross economic returns, and were not statistically outperformed in relation to sucrose yield or root tonnage by the aforementioned top-performing treatment (i.e., Counter 20G at planting [7.5 lb/ac] + Thimet 20G [2d before peak fly, 7 lb/ac]):

1) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb/ac, 2d before peak fly) + Mustang Maxx (4 fl oz/ac, 2d after peak fly);
2) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb/ac, 2d before peak fly);
3) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting);
4) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb/ac, 2d before peak fly);
5) Counter 20G (8.9 lb/ac, banded at planting); and
6) Poncho Beta + Counter 20G (8.9 lb/ac, banded at planting).

Although these control programs resulted in numerically lower gross economic return than the aforementioned top-yielding treatment, they still generated between $822 and $1080/ac more gross revenue than that recorded for the untreated check plots. Additionally, these revenue increases would have easily paid for the product and application costs associated with their use, and also would have provided excellent net returns in revenue per acre for a producer.

Table 2. *Yield parameters* from an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence insecticides, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study I)

Treatment/ form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Poncho Beta + Counter 20G + Thimet 20G	Seed B 2 d Pre-peak Post B	 7.5 lb 7 lb	68 g a.i./ unit seed 1.5 1.4	10,311 a	31.8 a	17.13 a	1,978
Counter 20G + Thimet 20G + Mustang Maxx	B 2 d Pre-peak Post B 2 d Post-peak Broadcast	8.9 lb 7 lb 4 fl oz	1.8 1.4 0.025	9,869 a	30.3 a	17.21 a	1,897
Poncho Beta + Counter 20G + Thimet 20G	Seed B 2 d Pre-peak Post B	 8.9 lb 7 lb	68 g a.i./ unit seed 1.8 1.4	9,459 a	30.0 a	16.67 ab	1,768
Poncho Beta + Counter 20G	Seed B	 8.9 lb	68 g a.i./ unit seed 1.8	9,358 a	29.6 a	16.81 ab	1,754
Counter 20G + Thimet 20G +	B 2 d Pre-peak Post B	8.9 lb 7 lb	1.8 1.4	9,082 ab	29.4 a	16.48 bc	1,665
Counter 20G	B	8.9 lb	1.8	8,898 ab	27.6 ab	16.99 ab	1,698
Poncho Beta + Counter 20G +	Seed 2 d Pre-peak Post B	 8.9 lb	68 g a.i./ unit seed 1.8	8,834 ab	28.3 ab	16.66 ab	1,639
Poncho Beta	Seed		68 g a.i./ unit seed	7,578 b	23.9 b	16.74 ab	1,422
Check	---	----	---	4,594 c	15.3 c	15.99 c	817
LSD (0.05)				1,555.7	4.56	0.647	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band; Post B = 4-inch postemergence band; Seed = insecticidal seed treatment

There were no significant differences in sucrose yield or root tonnage between dual- and triple-component control programs in Study I; however, all three triple-component insecticide programs generated numerically more sucrose yield, root tonnage, and gross revenue than dual- and single-component programs. Also, the addition of Mustang Maxx to plots initially established with an at-plant application of Counter 20G at its moderate (i.e., 7.5 lb product/ac) rate, combined with a postemergence application of Thimet 20G (7 lb product/ac) resulted in a numerical increase of 1,229 lb in recoverable sucrose yield (a 13.5% improvement) and $232 in additional revenue per acre when compared to the similar entry that lacked the Mustang.

Table 3 provides the results from a series of three counts of surviving plant stands conducted in Study II. All stand counts were conducted after the majority of SBRM fly activity had been completed. Therefore, it can be presumed that SBRM larval feeding injury had begun impacting plant survival before the first stand count was conducted at 28 days after planting (DAP). The highest stand counts at 28 DAP were observed in treatments that included a planting-time application of Counter 20G and/or a postemergence spray application of Mustang Maxx.

At the second stand count (42 DAP), nearly all insecticide programs provided significant levels of plant protection when compared to the stand loss incurred in the untreated check plots. The only exceptions to this were the two treatments comprised of single postemergence-only applications of Asana XL, which were applied either alone or tank mixed with Exponent insecticide synergist. NOTE: the postemergence-only applications of Asana XL (i.e., alone and mixed with Exponent) were only included in this experiment for comparative purposes. Sole reliance on a single postemergence insecticide treatment such as those evaluated in this trial are not recommended in areas where moderate to high SBRM infestations are expected.

Plant stand results from the final stand count (56 DAP) were similar to those from the 42 DAP counts, with excellent stand protection being observed in most treatments that involved dual- or triple-component insecticide programs. All insecticide regimes, except the single-component programs involving postemergence Asana, provided significant levels of plant stand protection when compared with the untreated check. The best overall final stands were recorded in plots that received a planting-time application of Counter 20G at its moderate (i.e., 7.5 lb product/ac) rate, which was combined with a postemergence application of Mustang Maxx at two days before peak SBRM fly activity; however, the following entries resulted in similar levels of stand protection that were not statistically different from that treatment:

1) Counter 20G (7.5 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d after peak fly) + Mustang Maxx (4 fl oz/ac, 8d post-peak);
2) NipsIt Inside treated seed + tank mixed Asana XL (9.6 fl oz) & Exponent (8 fl oz) 2d post-peak;
3) Counter 20G (7.5 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d post-peak) + Asana XL (9.6 fl oz, 5d post-peak) + Mustang Maxx (4 fl oz/ac, 8d post-peak);
4) NipsIt Inside + Asana XL (9.6 fl oz, 2d post-peak);
5) Counter 20G (7.5 lb/ac, banded at planting); and
6) NipsIt Inside + Asana XL (9.6 fl oz; applied dribble in-furrow [DIF] at planting).

Table 3. *Surviving Plant stand counts* from an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence liquid insecticide sprays, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study II)

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[b] (plants / 100 ft)		
				28 DAP[c]	42 DAP[c]	56 DAP[c]
Counter 20G + Mustang Maxx	B 2 d Post-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	232.1 a	215.5 a	199.3 a
Counter 20G + Mustang Maxx + Mustang Maxx	B 2 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.025	233.8 a	210.0 a	194.1 ab
NipsIt Inside Asana XL + Exponent	Seed 2 d Post-peak Broadcast	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	233.6 a	196.7 ab	190.2 abc
Counter 20G + Mustang Maxx + Asana XL + Mustang Maxx	B 2 d Post-peak Broadcast 5 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 9.6 fl oz 4 fl oz	1.5 0.025 0.025	237.4 a	217.1 a	189.1 abc
NipsIt Inside Asana XL	Seed 2 d Post-peak Broadcast	 9.6 fl oz	60 g a.i./ unit seed	228.3 ab	183.8 ab	179.5 abc
Counter 20G	B	7.5 lb	1.5	231.7 a	187.9 ab	175.0 abc
NipsIt Inside Asana XL	Seed DIF	 9.6 fl oz	60 g a.i./ unit seed	230.7 ab	189.1 ab	174.5 abc
NipsIt Inside Asana XL + Exponent	Seed DIF	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	204.5 c	175.0 b	163.6 bc
NipsIt Inside	Seed		60 g a.i./ unit seed	229.5 ab	175.5 b	160.2 c
Asana XL	2 d Post-peak Broadcast	9.6 fl oz		203.1 c	117.6 c	110.7 d
Asana XL + Exponent	2 d Post-peak Broadcast	9.6 fl oz 8 fl oz	60 g a.i./ unit seed	206.7 c	120.5 c	104.5 d
Check	---	---	---	212.4 bc	106.0 c	99.3 d
LSD (0.05)				18.48	33.80	32.30

Means within a column sharing a letter are not significantly (P = 0.05) 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

[b]Surviving plant stands were counted on June 23, July 7, and July 21 (i.e., 28, 42, and 56 days after planting [DAP], respectively).

Results from evaluations of sugarbeet root maggot larval feeding injury in Study II indicated that a high SBRM infestation developed for this trial. This is supported by the high level of root maggot feeding injury (i.e., 7.87 rating on the 0 to 9 scale) recorded for the untreated check plots (Table 4).

Most insecticide-treated entries provided significant reductions in SBRM feeding injury when compared to the untreated check, with the exceptions being the two postemergence-only Asana XL (i.e., with or without Exponent) treatments. The treatment combinations involving Counter 20G at planting, combined with postemergence applications of Mustang Maxx (single or repeated) and Asana XL (alternated with Maxx) provided the best protection from SBRM feeding injury in this trial. Counter 20G was an effective component that resulted in significant reductions in root maggot damage in this trial. The results also demonstrated the positive performance of Mustang Maxx in reducing SBRM feeding injury to plots that had initially been treated with Counter 20G.

In plots established with NipsIt Inside insecticidal seed treatment and an at-plant DIF application of Asana XL, the inclusion of Exponent, an insecticide synergist, resulted in a numerical reduction in SBRM feeding injury, but the difference was not statistically significant. Similarly, plots treated with a postemergence foliar application of Asana XL that was tank mixed with Exponent also resulted in a numerical reduction in SBRM feeding injury when compared with a similar postemergence application of Asana without the synergist; however, the difference was not significant.

Table 4. *Larval feeding injury* from an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence liquid insecticide sprays, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study II)

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Mustang Maxx	B 2 d Post-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	2.80 e
Counter 20G + Mustang Maxx + Asana XL + Mustang Maxx	B 2 d Post-peak Broadcast 5 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 9.6 fl oz 4 fl oz	1.5 0.025 0.025	3.23 e
Counter 20G + Mustang Maxx + Mustang Maxx	B 2 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.025	3.37 de
NipsIt Inside Asana XL + Exponent	Seed DIF	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	4.77 cd
NipsIt Inside Asana XL	Seed DIF	 9.6 fl oz	60 g a.i./ unit seed	4.93 c
Counter 20G	B	7.5 lb	1.5	4.97 c
NipsIt Inside Asana XL	Seed 2 d Post-peak Broadcast	 9.6 fl oz	60 g a.i./ unit seed	5.23 c
NipsIt Inside Asana XL + Exponent	Seed 2 d Post-peak Broadcast	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	5.37 bc
NipsIt Inside	Seed		60 g a.i./ unit seed	5.60 bc
Asana XL + Exponent	2 d Post-peak Broadcast	9.6 fl oz 8 fl oz	60 g a.i./ unit seed	6.77 ab
Asana XL	2 d Post-peak Broadcast	9.6 fl oz		7.13 a
Check	---	----	---	7.87 a
LSD (0.05)				1.433

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

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

Yield results for Study II are presented in Table 5. Similar to the results from the final stand counts and the SBRM feeding injury rating data, the yield analyses showed that nearly all insecticide programs provided significant increases in both recoverable sucrose yield and root tonnage in this trial.

The highest overall recoverable sucrose yield in Study II was observed in plots initially treated at planting with Counter 20G at its moderate rate of 7.5 lb product per acre, which was followed by successive postemergence foliar applications of Mustang Maxx (4 fl oz/ac), Asana XL (9.6 fl oz/ac), and Mustang Maxx (4 fl oz) made at 2, 5, and 8 days after peak SBRM fly activity, respectively. That combination generated an average of $1,716 in gross revenue per acre, which was $869/ac more revenue than the untreated check, and at least $293/ac more than any single-component insecticide treatment in the experiment. This was an encouraging finding, because those application timings are not recommended or considered optimal for SBRM control. The late timing of those applications was due to a combination of factors. First, the plot area remained excessively wet well into mid-/late May, thus forcing exceptionally late planting. Secondly, despite the unfortunate delay for planting this trial, warm spring temperatures accelerated the accumulation of SBRM degree-day units to nearly normal levels by mid-June. The combination of those two factors resulted in abnormally young plants during mid-June when the postemergence sprays were applied, thus making plants more vulnerable to attack by newly hatched SBRM larvae. As such, the performance of the aforementioned treatment and other similar entries in the study was a positive result. Other treatments that performed at levels that were similar to, and did not differ significantly in recoverable sucrose yield from, the aforementioned top-yielding treatment included the following:

1) Counter 20G (7.5 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d after peak fly) + Mustang Maxx (4 fl oz/ac, 8d post-peak);
2) Counter 20G (7.5 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d post-peak);
3) NipsIt Inside + tank mixed Asana XL (9.6 fl oz) & Exponent (8 fl oz); applied dribble in-furrow (DIF) at planting;

4) NipsIt Inside treated seed + tank mixed Asana XL (9.6 fl oz) & Exponent (8 fl oz) 2d post-peak;

5) Counter 20G (7.5 lb/ac, banded at planting); and

6) NipsIt Inside.

As observed with both stand count and root injury rating data, the only treatments that failed to provide a statistically significant increase in recoverable sucrose or root yield when compared with the untreated check were the two treatments that involved a postemergence-only (i.e., no at-plant insecticide) application of Asana XL (i.e., when applied alone or tank mixed with Exponent).

Table 5. *Yield parameters* from an evaluation of planting-time insecticide granules or seed treatments, combined with postemergence liquid insecticide sprays, for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study II)

Treatment/ form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G + Mustang Maxx + Asana XL + Mustang Maxx	B 2 d Post-peak Broadcast 5 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 9.6 fl oz 4 fl oz	1.5 0.025 0.025	8,786 a	26.5 ab	17.43 a	1,716
Counter 20G + Mustang Maxx + Mustang Maxx	B 2 d Post-peak Broadcast 8 d Post-peak Broadcast	7.5 lb 4 fl oz 4 fl oz	1.5 0.025 0.025	8,632 a	27.4 a	16.73 a	1,611
Counter 20G + Mustang Maxx	B 2 d Post-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	8,510 ab	26.3 ab	17.13 a	1,631
NipsIt Inside Asana XL + Exponent	Seed DIF	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	8,499 ab	26.5 ab	16.96 a	1,616
NipsIt Inside Asana XL + Exponent	Seed 2 d Post-peak Broadcast	 9.6 fl oz 8 fl oz	60 g a.i./ unit seed	7,488 abc	23.8 abc	16.67 a	1,398
Counter 20G	B	7.5 lb	1.5	7,456 abc	23.1 bc	16.99 a	1,423
NipsIt Inside	Seed		60 g a.i./ unit seed	7,415 abc	23.3 bc	16.74 a	1,397
NipsIt Inside Asana XL	Seed 2 d Post-peak Broadcast	 9.6 fl oz	60 g a.i./ unit seed	7,199 bc	23.0 bc	16.50 a	1,339
NipsIt Inside Asana XL	Seed DIF	 9.6 fl oz	60 g a.i./ unit seed	7,055 c	22.1 c	16.84 a	1,337
Asana XL + Exponent	2 d Post-peak Broadcast	9.6 fl oz 8 fl oz	60 g a.i./ unit seed	5,126 d	16.7 d	16.27 a	934
Asana XL	2 d Post-peak Broadcast	9.6 fl oz		4,919 d	15.7 d	16.53 a	914
Check	---	----	---	4,736 d	15.7 d	15.97 a	847
LSD (0.05)				1418.5	3.94	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band; Seed = insecticidal seed treatment

Collectively, the results of both Studies I and II demonstrate the economic significance of the sugarbeet root maggot as a major economic pest of sugarbeet in the Red River Valley. As such, the development implementation of effective control tools will continue to be critical to sustaining the profitability of sugarbeet production and maximizing economic returns in areas affected by this pest. The overall results of these trials also show that effective SBRM management can be achieved by combining at-plant insecticide protection that involves applying a granular insecticide such as Counter 20G, an insecticidal seed treatment (e.g., Poncho Beta or NipsIt Inside), or a sprayable at-plant liquid insecticide (e.g., Asana XL), and combining it with a postemergence rescue insecticide (e.g., Thimet 20G, Mustang Maxx, or Asana XL) application.

Additionally, although differences were mostly numerical and only rarely significant, it appears that tank mixing pyrethroid insecticides with the insecticide synergist, Exponent, can result in improved SBRM control performance. Despite the relative lack of significant yield improvements with Exponent, the observed revenue increases it appeared to generate in this research suggest that it could prove to be a valuable aid in SBRM management programs. As such, further research should be conducted on Exponent to determine its future role in controlling this pest.

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INSECTICIDE, FUNGICIDE, AND STARTER FERTILIZER COMBINATIONS IN SUGARBEET: AN EVALUATION OF ROOT MAGGOT CONTROL EFFICACY AND PLANT SAFETY

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Introduction:

The integration of pesticide and fertilizer applications into a single implement pass through the field, either during planting operations or after emergence of the crop, can be a valuable, input cost saving strategy for producers. However, the impacts of such combinations on plant health or pest control efficacy should be thoroughly investigated before they are recommended for implementation on the farm.

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. 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 of these tools. In situations where high SBRM fly activity and associated larval feeding pressure are expected, most producers also supplement the initial at-plant insecticide(s) with a postemergence granular or sprayable liquid insecticide application.

Fungicides are also often applied to manage 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. Starter fertilizer, applied at planting time, is also commonly used by RRV sugarbeet producers. However, little is known about the crop safety of combining these applications or if they either complement or impair 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.

This experiment was carried out 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 during the 2022 growing season in a commercial sugarbeet field site near St. Thomas in rural Pembina County, ND. Plots were planted on May 27, 2022. Betaseed 8961 glyphosate-tolerant 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 the most commonly used azoxystrobin-based fungicides used by RRV producers for at-plant and postemergence root diseases, respectively, in the Red River Valley growing area.

<u>Planting-time insecticide applications</u>. Planting-time applications of Counter 20G were applied by using band (B) placement

(Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular application rates were regulated by using planter-mounted SmartBox™ 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 three gallons 10-34-0 starter fertilizer to two gallons water spray solution, and the applications were made by orienting a microtube (1/4" outside diam.) directly into the open seed furrow. 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 13, which was about two days before peak SBRM fly activity (i.e., "pre-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 made on June 17, which was about two days after peak SBRM fly activity (i.e., 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 8, 15, 24 June, and on 1 July, 2022 (i.e., 20, 27, 34, and 46 days after planting [DAP], respectively). Plant stand assessments involved counting all living plants within each 35-ft-long row. Raw stand counts were then converted to plants per 100 linear row feet for the analysis.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this experiment on August 3, 2022. 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 5, 2022. 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 a series of 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 20 days after planting (20 DAP), most treatments, including the untreated check, had favorable plant stands that hovered around 200 plants per 100 linear row feet. However, significantly lower stands were recorded in entries comprised of concurrent applications of Counter 20G insecticide with the tank mixture of 10-34-0 starter fertilizer and AZteroid fungicide when compared to similar plots that did not receive the fertilizer/fungicide combination, irrespective of whether the Counter was applied at 7.5 or 8.9 lb product per acre.

Table 1. *Plant stand counts* from an evaluation of concurrently applied and tank-mixed combinations of azoxystrobin fungicide with sugarbeet root maggot-targeted insecticides, St. Thomas, ND, 2022							
Treatment/form.[a]	**Placement[b]**	**Rate (product/ ac)**	**Rate (lb a.i./ac)**	**Stand count[c] (plants / 100 ft)**			
				20 DAP[c]	**27 DAP[c]**	**34 DAP[c]**	**46 DAP[c]**
Counter 20G	B	8.9 lb	1.8	215.7 a	226.0 a	226.7 a	213.6 a
Counter 20G + Mustang Maxx	B 10" Post B, 2 d Post-peak	8.9 lb 4 fl oz	1.8 0.025	206.9 ab	225.0 a	222.8 abc	211.9 a
Counter 20G	B	7.5 lb	1.5	214.3 a	226.0 a	225.5 ab	204.1 ab
Counter 20G + Thimet 20G	B 4" Post B, 2 d Pre-peak	8.9 lb 7 lb	1.8 1.4	195.5 bc	211.4 bcd	214.3 abc	203.8 ab
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	194.5 bc	210.7 bcd	209.5 bc	202.6 ab
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	203.1 ab	211.7 bc	208.3 c	201.9 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	186.4 cd	202.9 cde	210.0 abc	200.2 ab
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	204.3 ab	217.9 ab	213.6 abc	194.1 ab
Counter 20G + AZteroid FC+ 10-34-0	B DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.0625	176.9 d	193.1 ef	190.2 d	182.4 b
Counter 20G + AZteroid FC+ 10-34-0	B DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.0625	182.1 cd	191.0 f	191.4 d	178.6 b
Check	-----	----	-----	203.8 ab	210.0 bcd	186.7 d	131.9 c
Fertilizer check	DIF	5 GPA		191.4 bcd	200.0 def	181.2 d	124.3 c
LSD (0.05)				15.92	11.64	16.72	27.57

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 8, 15, 24 June, and on 1 July, 2022 (i.e., 20, 27, 34, and 46 days after planting [DAP], respectively).

In stand counts conducted at 27 DAP, plots treated at planting with Counter 20G at its high rate (8.9 lb product/ac) had significantly lower plant stands when a concurrent planting-time application of 10-34-0 starter fertilizer was included. A similar pattern was observed when the moderate (7.5 lb) rate of Counter was applied at planting with a concurrent application of 10-34-0, but the difference in plant stands between plots that received starter fertilizer and those that were not fertilized was not statistically significant.

As observed during the initial stand counts, there was a significant stand reduction at 27 DAP 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 disparity in surviving plant stands was the case irrespective of whether Counter was applied at 7.5 or 8.9 lb product per acre. Additionally, in plots treated with the high (8.9 lb) rate of Counter 20G at planting, the addition of a concurrent application of 10-34-0 starter fertilizer resulted in a significant stand reduction when compared to similar that in plots that received the high rate of Counter without fertilizer.

At 34 DAP, which was slightly more than one week after peak SBRM fly activity and, presumably approaching peak SBRM larval feeding activity, the highest average plant stand counts were recorded in plots treated solely with a planting time application of Counter 20G at 8.9 lb product per acre. However, other entries in the study that also had high stand counts, which were not significantly different from that treatment, included the following (listed in descending order of mean surviving plant stand at 34 DAP):

1) Counter 20G (7.5 lb/ac, banded at planting);
2) Counter 20G (8.9 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d after peak fly);
3) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb product/ac, banded, 2d pre-peak);
4) Counter 20G (7.5 lb/ac, banded at planting) + 10-34-0 (at-plant, DIF); and
5) 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).

Combining a planting-time application of Counter 20G at its moderate (7.5 lb product/ac) rate with DIF-applied 10-34-0 starter fertilizer did not appear to impact plant survival at 34 DAP. However, in plots treated with Counter 20G at planting time using its high (8.9 lb product/ac) rate, the inclusion of the starter fertilizer resulted in a significant reduction in surviving plant stands. Plant stands were also significantly reduced in treatment combinations that included Counter 20G and a tank mixture of starter fertilizer and AZteroid fungicide, irrespective of whether the Counter was applied at 7.5 or 8.9 lb product per acre. Similarly, in comparing Counter 20G/fertilizer combinations versus Counter20G/fertilizer/Azteroid combinations, the latter programs had significantly lower surviving stands than when the fungicide was excluded, and the rate of Counter 20G used was not a factor in plant survival with those comparisons.

In stand counts conducted on July 1 (46 DAP), the highest overall stand counts were recorded in plots that treated solely with a planting-time application of Counter 20G at its high (8.9 lb product/ac) rate. However excellent stands were also recorded for most other insecticide-treated plots. The following treatments in this trial had surviving plant stands that were not statistically different from the single, high rate of Counter 20G (listed in descending order of mean surviving plant stand):

1) Counter 20G (8.9 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d after peak fly);
2) Counter 20G (7.5 lb/ac, banded at planting);
3) Counter 20G (8.9 lb/ac, banded at planting) + Thimet 20G (7 lb product/ac, banded, 2d post-peak);
4) Counter 20G (8.9 lb/ac, banded at planting) + Mustang Maxx (4 fl oz/ac, 2d post-peak fly) + Quadris (banded, 10 fl oz/ac, 2 d post-peak);
5) Counter 20G (8.9 lb/ac, banded at planting) + 10-34-0 (at-plant, DIF);
6) 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); and
7) Counter 20G (7.5 lb/ac, banded at planting) + 10-34-0 (at-plant, DIF).

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 46 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 component was applied at the 7.5- or 8.9-lb rate, and the combinations that included the AZteroid/10-34-0 tank mixture appeared to exert a more pronounced negative effect on plant survival than when the fertilizer was excluded from the application. However, it bears noting that, at the 46 DAP stand count, all insecticide/fungicide and insecticide/fertilizer combinations resulted in significantly greater plant stands than the untreated check and the 10-34-0 fertilizer control.

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 (5.83 and 6.70, respectively, on the 0 to 9 scale of Campbell et al. [2000]) indicated the presence of a moderately high 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, which was accompanied by a concurrent banded application of Quadris fungicide; however, that entry was not statistically superior in preventing SBRM feeding injury in comparison to any of the dual (i.e., planting-time plus postemergence) insecticide treatments in the experiment.

Protection of roots from SBRM feeding injury was not significantly impaired by including concurrent dribble-in-furrow applications of 10-34-0 starter fertilizer concurrently 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 concurrently applied and tank-mixed combinations of azoxystrobin fungicide with sugarbeet root maggot-targeted insecticides, St. Thomas, ND, 2022

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
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	1.10 d
Counter 20G + Thimet 20G	B 4" Post B, 2 d Pre-peak	8.9 lb 7 lb	1.8 1.4	1.53 cd
Counter 20G + Mustang Maxx	B 10" Post B, 2 d Post-peak	8.9 lb 4 fl oz	1.8 0.025	2.50 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	2.50 bcd
Counter 20G	B	8.9 lb	1.8	2.60 bc
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	2.73 bc
Counter 20G	B	7.5 lb	1.5	3.10 b
Counter 20G + AZteroid FC+ 10-34-0	B DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.0625	3.23 b
Counter 20G + AZteroid FC+ 10-34-0	B DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.0625	3.70 b
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	3.90 b
Check	-----	----	-----	5.83 a
Fertilizer check	DIF	5 GPA		6.70 a
LSD (0.05)				1.409

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. All treatments in the experiment that included an insecticide provided significant increases in both recoverable sucrose yield and root yield when compared to the untreated check and the fertilizer check. Generally, the performance patterns observed in relation to recoverable sucrose yield and root tonnage indicated that postemergence applications of Thimet 20G performed slightly better than those involving a post-applied liquid spray application of Mustang Maxx. However, it is important to point out that, although all postemergence insecticide applications were made later than optimal, the timing of Mustang Maxx applications was likely more detrimental to its performance than were the Thimet applications. A timely 1.15-inch rainfall that occurred one day after the Thimet applications probably activated the insecticide from Thimet granules, which would have resulted in favorable conditions for control of SBRM larvae in the soil near the bases of sugarbeet plants. Conversely, Mustang Maxx applications, which are directed at killing adult SBRM flies, occurred two days after peak SBRM fly activity. As such, a substantial amount of egg laying likely occurred before the Mustang treatments could be applied.

Interestingly, although plant stand data suggested negative effects from concurrent applications of 10-34-0 starter fertilizer and Counter 20G, there were no statistically significant yield reductions, either negative or positive, from combining concurrent at-plant insecticide/fertilizer applications in this experiment. Similarly, despite the observations of significant plant stand reductions when tank-mixed combinations of AZteroid fungicide and 10-34-0 were applied at the same time as planting-time Counter 20G applications in this study, the differences did not translate to significantly negative yield impacts.

Although significant differences among treatments that included an insecticide were somewhat lacking, some patterns in the yield results of this experiment provide cause for concern. For example, applying a postemergence application of Quadris fungicide during the application of Thimet 20G resulted in numerical reductions in recoverable sucrose yield and root tonnage, which translated to a $50/ac reduction in gross revenue when compared with a similar treatment combination that excluded the Quadris application.

Table 3. *Sugarbeet yield parameters and gross economic return* from an evaluation of concurrently applied and tank-mixed combinations of azoxystrobin fungicide with sugarbeet root maggot-targeted insecticides, St. Thomas, ND, 2022							
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 + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	10,583 a	30.5 ab	18.14 a	2,150
Counter 20G + Thimet 20G	B 4" Post B, 2 d Pre-peak	8.9 lb 7 lb	1.8 1.4	10,517 a	31.1 a	17.81 a	2,092
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	10,263 ab	30.3 ab	17.76 a	2,042
Counter 20G + AZteroid FC+ 10-34-0	B DIF	7.5 lb 5.7 fl oz 5 GPA	1.5 0.0625	10,144 ab	30.4 ab	17.64 a	1,996
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	9,943 ab	29.5 ab	17.69 a	1,972
Counter 20G + Mustang Maxx	B 10" Post B, 2 d Post-peak	8.9 lb 4 fl oz	1.8 0.025	9,886 ab	29.4 ab	17.65 a	1,957
Counter 20G	B	7.5 lb	1.5	9,832 ab	30.1 ab	17.32 a	1,899
Counter 20G + AZteroid FC+ 10-34-0	B DIF	8.9 lb 5.7 fl oz 5 GPA	1.8 0.0625	9,671 ab	28.3 b	17.94 a	1,939
Counter 20G	B	8.9 lb	1.8	9,659 ab	28.8 ab	17.66 a	1,909
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	9,382 b	28.0 b	17.56 a	1,849
Fertilizer check	DIF	5 GPA		6,219 c	20.0 c	16.69 a	1,146
Check	-----	----	-----	6,089 c	19.2 c	16.77 a	1,143
LSD (0.05)				975.5	2.47	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 is a feasible approach to fertility and pest management that is unlikely to result in negative impacts on sugarbeet root maggot control or sugarbeet yield parameters, even when the insecticide is applied at its high labeled rate of 8.9 lb product per acre.

However, numerical (i.e., not statistically significant) trends observed in this research suggest that there could be some level of plant health or stand establishment risk associated with applying azoxystrobin fungicide/10-34-0 starter fertilizer tank mixtures concurrently with planting-time tank applications of Counter 20G in sugarbeet. Similarly, non-significant, but concerning numerical trends 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. For example, although not statistically significant, plots treated with a tank mixture comprised of Mustang Maxx and Quadris produced numerically lower recoverable sucrose yield and root tonnage (i.e., reduced by 504 lb and 1.4 tons per acre, respectively), and generated $108/ac less gross revenue than plots that received a Mustang Maxx application without the Quadris component. Therefore, research on concurrent and tank-mixed applications of these treatment combinations should be further explored.

Finally, it bears noting that this trial was conducted in an environment that involved the presence of a moderately high sugarbeet root maggot 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.

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EVALUATION OF MIDAC FC® AND PONCHO BETA® FOR SUGARBEET ROOT MAGGOT CONTROL

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is the most common and widespread insect pest of sugarbeet in the Red River Valley (RRV) growing area. Sugarbeet producers in the RRV that commonly face damaging SBRM infestations typically manage this pest by using a two-pronged approach that involves planting-time protection with a granular, liquid, or seed-applied insecticide, and following it with at least one postemergence insecticide application to avoid major yield and revenue loss.

Sugarbeet producers have had to mostly rely on insecticides belonging to the same mode of action, acetylcholinesterase (ACHE) inhibition for managing the SBRM for well over four decades, because only a small number of insecticide products have been commercially available for use in the crop. This long-term, repeated use of ACHE inhibitor insecticides has exerted a considerable amount of selection pressure for the development of ACHE insecticide resistance in RRV sugarbeet root maggot populations.

In August of 2021, the U.S. Environmental Protection Agency (EPA) revoked all food crop tolerances for chlorpyrifos, which has been the most commonly used postemergence insecticide active ingredient for postemergence SBRM control for several years. Therefore, it is critical that non-ACHE insecticide options be pursued to manage this serious economic pest.

In recent years, EPA approved registration of Midac FC for use in sugarbeet. Imidacloprid, the active ingredient in Midac FC, is a neonicotinoid insecticide. This class involves an entirely different mode of action (i.e., antagonism of the postsynaptic nicotine acetylcholine receptor in the central nervous system) for insect control from that of the long-used ACHE-based insecticides. Other neonicotinoids have been used as insecticidal seed treatments for sugarbeet insect pest control since 2008. One purported benefit of Midac FC is its compatibility for tank mixing with starter fertilizer formulations. Inclusion of starter fertilizer with sugarbeet planting is commonly practiced by Red River Valley producers, especially in the central and northern Valley. However, little is known about its potential impacts, either positive or negative, on insecticide performance, plant safety, or resulting crop yield.

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

Materials and Methods:

This field experiment was conducted near St. Thomas in rural Pembina County, ND during the 2022 growing season. Betaseed 8961 glyphosate-tolerant seed was used for all treatments in the trial, and it was planted on May 27, 2022 by using a 6-row Monosem NG Plus 4 7x7 planter set to deliver seed at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide by 35 long, with the four centermost rows treated. Insecticide was excluded from each of the outside rows (i.e., rows 1 and 6) of the planter, and those "guard rows" served as untreated buffers. Thirty-five-foot alleys between replicates were maintained weed-free by using periodic cultivation throughout the growing season. The experiment was arranged in a randomized complete block design with four replications of the treatments.

Midac FC was applied using dribble in-furrow (DIF) placement by orienting microtubes (1/4" outside diam.) directly into the open seed furrow. Inline Teejet™ No. 24 orifice plates were used to stabilize the output rate of the spray solutions from the microtubes. Most at-plant treatments included 10-34-0 fertilizer (i.e., 10, 34, and 0% nitrogen, phosphorus, and potassium, respectively), which was diluted to a 3:2 gallon ratio of fertilizer to water. Water used for all spray solutions in this experiment was adjusted to pH 6.0 several days before use. All planting-time liquid applications were delivered in a finished spray volume output of 5 GPA.

Non-fertilizer entries included Counter 20G at two application rates (i.e., 7.5 and 8.9 lb product/ac), and a true untreated check. A fertilizer-only check was also included as a control for comparative purposes. Counter 20G was evaluated as a stand-alone treatment and also in combination with a concurrent application of the fertilizer/water solution. Counter 20G was applied by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular application rates were regulated by using a planter-mounted SmartBox™ insecticide delivery system that had been calibrated on the planter before all applications.

Plant Stand Counts: To determine treatment impacts on seedling emergence and survival throughout the growing season, surviving plant stands were counted on June 21, and July 7 and 14, 2022 (i.e., 25, 41, and 48 days after planting [DAP], respectively). Plant stand assessments involved counting all living plants within each 35-ft-long row of each plot. Raw stand counts were then converted to plants per 100 linear row feet for the analysis.

Root injury ratings: Sugarbeet root maggot feeding injury ratings were conducted on August 2, 2022. 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 a dead plant) of Campbell et al. (2000).

Harvest: Plots were harvested on October 6, 2022. Immediately before harvest, all foliage was removed from plots by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were then extracted from soil using a mechanical harvester and weighed in the field using a harvester-mounted 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 plant stand, root injury rating, and harvest data were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2012). Means were compared by using Fisher's protected least significant difference (LSD) test at a 0.05 alpha level for declaring significant differences.

Results and Discussion:

The results from all three plant stand counts is presented in Table 1. Treatments are tabulated in descending order of mean surviving plant stand recorded at the final count (48 DAP). Thus, careful attention is required to assess stand count comparisons from the previous dates. Interpretation of this data should also be made considering the fact that impacts of the insecticide and fertilizer treatments on seedling establishment would be most apparent during the earlier stand counts. Conversely, the later, and especially the final stand counts would be more likely to reflect treatment impacts on seedling survival in relation to protection from SBRM larval feeding injury.

The highest plant densities at the first stand count (i.e., 25 DAP) were observed plots treated with an at-plant application of Counter 20G at its high (i.e., 8.9 lb product/ac) labeled rate; however, plant stands in most other insecticide treatments were not significantly lower than those in plots treated with that rate of Counter. Exceptions, in which stands were statistically lower than those recorded for plots treated with Counter at 8.9 lb, included the Midac/10-34-0 starter fertilizer tank mixture and the combination treatment comprised of Counter at 7.5 lb/ac and a concurrent application of starter fertilizer. Additionally, the stand counts recorded for those two lesser-performing treatments were not statistically different from the counts recorded in the untreated check or the fertilizer check.

By the time the 41 DAP counts were conducted (July 7), the majority of SBRM fly activity had ceased, suggesting that most of the infestation would have been about three weeks into the larval root-feeding period. The highest plant stands at 41 DAP were recorded in plots that received the treatment combination comprised of Poncho Beta-treated seed and a planting-time-applied tank mixture of Midac plus 10-34-0 starter fertilizer; however, there were no significant differences between any of the insecticide-treated plots in the experiment. Additionally, all treatments that included an insecticide, irrespective of whether starter fertilizer was included, resulted in significantly greater plant stands than those recorded in the untreated check and the fertilizer control.

Surviving plant stand counts conducted at 48 DAP corresponded closely to those conducted at 41 DAP in that the highest plant stands were recorded in plots planted with Poncho Beta-treated seed and an at-plant, DIF-applied tank mixture of Midac plus 10-34-0 starter fertilizer. Also reflective of the previous counts was that there were no significant differences in plant stands among insecticide-based treatments in the experiment. Interestingly, at this final stand count, the starter fertilizer check had significantly less plants per 100 ft than the untreated check.

Collectively, the data from this series of three plant stand counts suggests that 10-34-0 starter fertilizer itself can reduce or delay sugarbeet seedling emergence, at least under the light-textured soil conditions that characterized this field location. This finding corresponds with the results from previous work on similar treatments that included starter fertilizer.

Table 1. *Plant stand counts* from an evaluation of Poncho Beta insecticidal seed treatment and Midac FC® insecticide for sugarbeet root maggot control, St. Thomas, ND, ND, 2022

Treatment/form.[a]	Placement[b]	Rate (product/ ac)	Rate (lb a.i./ac)	Stand count[c] (plants / 100 ft) 25 DAP[c]	41 DAP[c]	48 DAP[c]
Poncho Beta + Midac FC + 10-34-0	Seed DIF	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	233.2 ab	220.0 a	225.2 a
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	224.8 bcd	207.5 a	215.7 a
Counter 20G	B	8.9 lb	1.8	240.7 a	209.6 a	215.2 a
Counter 20G	B	7.5 lb	1.5	232.5 abc	205.5 a	210.4 a
Poncho Beta + 10-34-0	Seed DIF	 5 GPA	68 g a.i./ unit seed	229.8 abc	215.2 a	206.2 a
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	220.7 cd	206.2 a	203.0 a
Check	-----	----	-----	228.0 bcd	165.2 b	142.3 b
10-34-0 fertilizer check	DIF	5 GPA	-----	217.5 d	157.0 b	115.4 c
LSD (0.05)				11.95	20.41	23.84

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 21 June, and 7 and 14 July, 2022 (i.e., 25, 41, and 48 days after planting [DAP], respectively).

Sugarbeet root maggot feeding injury rating results from this experiment are presented in Table 2. Average root injury ratings in the untreated check (6.68) and fertilizer-only check (7.35) indicated that a moderately high SBRM infestation was present for the study. All insecticide treatments provided significant reductions in root maggot larval feeding injury when compared to that recorded for the untreated check and fertilizer-only check.

Table 2. *Larval feeding injury* from an evaluation of Poncho Beta® insecticidal seed treatment and Midac FC® insecticide for sugarbeet root maggot control, St. Thomas, ND, 2022

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	3.65 c
Counter 20G	B	8.9 lb	1.8	3.90 bc
Poncho Beta + Midac FC + 10-34-0	Seed DIF	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	3.95 bc
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	4.45 bc
Counter 20G	B	7.5 lb	1.5	4.78 bc
Poncho Beta + 10-34-0	Seed DIF	 5 GPA	68 g a.i./ unit seed	4.93 b
Check	-----	----	-----	6.68 a
10-34-0 fertilizer check	DIF	5 GPA	-----	7.35 a
LSD (0.05)				1.199

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]Carrier for at-plant treatments that included starter fertilizer involved a 3:2 gal. ratio of H_2O to liquid 10-34-0 fertilizer. Output volume was 5 GPA.
[b]Seed = insecticidal seed treatment; B = 5-inch band at planting; 3" TB = 3-inch band over open seed furrow at planting; DIF = dribble in-furrow at planting

The lowest root maggot feeding injury ratings (i.e., greatest SBRM control) in this trial occurred in plots that received a combination treatment consisting of a planting-time banded application of Counter 20G at its moderate, 7.5-lb rate, with a concurrent application of starter fertilizer. However, the only treatment to which that combination was superior in providing SBRM control was the Poncho Beta plus 10-34-0 starter fertilizer treatment.

Yield data from this experiment are provided in Table 3. The top-yielding treatment in the trial, with regard to both recoverable sucrose yield and root tonnage, was the combination of Poncho Beta-treated seed plus a DIF-applied tank mixture of Midac FC and starter fertilizer. Combining these two pest management tools (i.e., Poncho Beta-treated seed and Midac FC) increased gross economic return by $191/ac over Poncho Beta alone and by $60/ac over Midac alone. Additionally, plots managed with the Poncho Beta/Midac/starter fertilizer combination increased recoverable sucrose yield by 3,721 lb and root yield by 11.5 tons per acre, and generated $713/ac in additional revenue per acre when compared to the fertilizer-only check. These results suggest that this combination could be a beneficial planting-time management approach that could be coupled with an effective postemergence insecticide component to manage high SBRM infestations.

All other treatments that included an insecticide produced similar levels of recoverable sucrose yield and root tonnage which were not significantly different from the top-yielding Poncho Beta/Midac/starter fertilizer combination. However, the highest overall gross economic return in the experiment was generated by plots treated with Counter 20G at planting by using its high labeled rate of 8.9 lb product per acre, which generated $21/ac more revenue than the Poncho Beta/Midac/starter fertilizer combination.

Two other concerning results in this study involved the inclusion of 10-34-0 starter fertilizer. In treatments that involved a planting-time application of Counter 20G at 7.5 lb product per acre, the inclusion of a DIF application of 10-34-0 fertilizer resulted in a $74 reduction in gross revenue when compared to the revenue generated by the stand-alone treatment of Counter without the fertilizer. Even more striking was that the 10-34-0 starter fertilizer check produced significantly lower recoverable sucrose yield and root tonnage (i.e., by 20.2% and 18.4%, respectively), as well as a gross revenue loss of $271/ac when compared to the untreated check.

Table 3. *Yield parameters* from an evaluation of Poncho Beta® insecticidal seed treatment and Midac FC® insecticide for sugarbeet root maggot control, St. Thomas, ND, 2022

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 + Midac FC + 10-34-0	Seed DIF	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	8,836 a	27.1 a	17.20 a	1,704
Counter 20G	B	8.9 lb	1.8	8,793 a	26.4 ab	17.53 a	1,725
Counter 20G	B	7.5 lb	1.5	8,600 a	25.4 ab	17.72 a	1,711
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	8,383 a	25.3 ab	17.37 a	1,637
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	8,341 a	24.9 ab	17.55 a	1,644
Poncho Beta + 10-34-0	Seed DIF	 5 GPA	68 g a.i./ unit seed	7,730 a	23.3 b	17.49 a	1,513
Check	-----	----	-----	6,412 b	19.2 c	17.53 a	1,262
10-34-0 fertilizer check	DIF	5 GPA	-----	5,115 c	15.6 d	17.20 a	991
LSD (0.05)				1,257.0	3.50	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]Carrier for at-plant treatments that included starter fertilizer involved a 3:2 gal. ratio of H_2O to liquid 10-34-0 fertilizer. Output volume was 5 GPA.
[b]Seed = insecticidal seed treatment; B = 5-inch band at planting; 3" TB = 3-inch band over open seed furrow at planting; DIF = dribble in-furrow at planting

Overall results of this trial suggest that, for growers intending on applying Counter 20G at planting and also including a concurrent application of 10-34-0 starter fertilizer, it is advisable to dilute the fertilizer to at least the 3:2 gallon (i.e., 3 gallons of fertilizer to 2 gallons of water) ratio used in this study, or even further, especially if planning on including a planting-time application of Counter 20G. Results also suggest that combining Poncho Beta-treated seed with an application of Midac FC plus 10-34-0 starter fertilizer may improve SBRM control and resulting yield and gross revenue over that of either Poncho Beta or Midac FC alone, although the improvements observed in 2022 were not statistically significant.

It should be noted that previous NDSU research suggests that Midac FC performs at a comparable level to that of the moderate rate of Counter 20G (i.e., 7.5 lb product/ac). Thus, if planting-time insecticide protection is limited to Midac FC, the grower should plan on making a postemergence rescue insecticide application to augment SBRM control, especially in areas where economically moderately high or greater root maggot infestations are expected. Finally, most of the treatments tested in this trial need further testing to determine the repeatability of these results. This is especially the case concerning the safety of combining Counter 20G applications with concurrent starter fertilizer applications.

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EXPERIMENTAL INSECTICIDE SCREENING TRIALS TO IDENTIFY SUGARBEET ROOT MAGGOT CONTROL ALTERNATIVES

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Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) is an annual economic threat to sugarbeet production on well over 85,000 acres in the Red River Valley (RRV) growing region. Unfortunately, the geographic distribution and intensity of SBRM infestations have consistently increased over the past five years. Another concern regarding this pest is that a limited number of insecticide products are currently registered by the U.S. Environmental Protection Agency (EPA) for insect management in sugarbeet. As a result, RRV sugarbeet producers have had to rely heavily on the same insecticide mode of action (i.e., acetylcholinesterase [ACHE] inhibition) to manage this pest for well over four decades.

The commonly occurring severe root maggot infestations that occur in central and northern portions of the RRV often necessitate two to three applications of these materials each growing season to protect the crop from major economic loss. This long-term use of multiple applications of ACHE-inhibiting insecticides has exerted intense selection pressure for the development of insecticide resistance in root maggot populations in the RRV. Although no cases of SBRM resistance to these materials have been detected, research is critically needed to develop alternative materials and strategies for root maggot management to ensure the long-term sustainability and profitability of sugarbeet production for growers affected by this pest. This research involved two experiments that were carried out to achieve the following objectives: 1) test several natural and/or botanical insecticides for efficacy at managing the sugarbeet root maggot; and 2) evaluate commercially available, EPA-registered conventional chemical insecticides that are currently not registered for use in sugarbeet to determine if their performance would warrant future pursuit of labeling for sugarbeet root maggot control.

Materials and Methods:

This research involved two experiments (i.e., Study I and Study II) that were carried out on a commercial sugarbeet field site near St. Thomas (Pembina County), ND. Study I was planted on May 26 and Study II was planted on May 27, 2022, and both experiments were established with Betaseed 8961 glyphosate-tolerant sugarbeet seed by using a 6-row Monosem NG Plus 4 7x7 planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide by 35 feet long. The four centermost rows of each plot received an assigned treatment, whereas the outer "guard" rows (i.e., rows one and six) on each side of each plot were untreated, and served as buffer rows. Thirty-five-foot-wide alleys between replicates were maintained weed-free via cultivation throughout the growing season. Both studies were arranged in a randomized complete block design with four replications of the treatments. Counter 20G (granular) insecticide was used for comparative purposes as a planting-time SBRM management standard in both experiments. Counter 20G was applied by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. Granular application rates were regulated by using a planter-mounted SmartBox™ electronically-controlled insecticide delivery system calibrated on the planter immediately before all applications. Study-specific materials and methods for the two respective experiments are described below, and they are followed by descriptions of materials and methods used for root injury assessments, plot harvest, and data analyses that were common to both studies.

<u>Study I</u>: Experimental planting-time insecticides in Study I included the following: 1) Aztec 4.67G (active ingredients: tebupirimifos and cyfluthrin, an organophosphate and a pyrethroid insecticide, respectively); 2) Delegate WG (active ingredients: a combination of spinetoram-J and spinetoram-L, nicotinic acetylcholine receptor modulators); 3) Ecozin Plus 1.2%ME (active ingredient: azadirachtin, a neem tree-derived insect antifeedant and growth disruptor); 4) Index (active ingredients: chlorethoxyfos and bifenthrin, an organophosphate and a pyrethroid insecticide, respectively); and 5) Smart Choice 5G (active ingredients: also chlorethoxyfos and bifenthrin).

All planting-time liquid insecticides in Study I were delivered in 3-inch T-bands over the open seed furrow by using a planter-mounted spray system calibrated to deliver a finished spray volume output of 5 gallons per acre (GPA) through TeeJet™ 400067E nozzles. Water used as a carrier for all planting-time liquid insecticide applications in Study I was adjusted to pH 6.0 about one week before planting.

Experimental postemergence insecticides evaluated in Study I included the following sprayable liquid products: 1) Abba Ultra (active ingredient: abamectin, a chloride channel activator); 2) Delegate WG (described above); 3) Dibrom 8 Emulsive (active ingredient: naled, an organophosphate insecticide); 4) Endigo ZCX (active ingredients: thiamethoxam and lambda cyhalothrin, a neonicotinoid and a pyrethroid); and 5) Vectobac 12AS (active ingredient: *Bacillus thuringiensis* subspecies *israeliensis*, an insect-pathogenic bacterium).

All experimental postemergence insecticides were compared with Yuma 4E (active ingredient: chlorpyrifos, an organophosphate) as a postemergence insecticide standard. Postemergence sprays were broadcast-applied on June 17 (i.e., about 2 days after peak SBRM fly activity) by using a tractor-mounted, CO_2-propelled spray system equipped with an 11-ft boom that was calibrated to deliver a finished spray volume output of 10 GPA through TeeJet™ 110010VS nozzles. The water used as a carrier for all postemergence liquid insecticide sprays in Study I was adjusted to pH 6.0 at least one week before applications.

Study II: All insecticides in Study II were applied as planting-time treatments. Counter 20G was included as a planting-time granular standard, and it was applied at its moderate rate of 7.5 lb product per acre as described above. Planting-time liquid insecticides in Study II included the following: 1) Mustang Maxx (active ingredient: zeta-cypermethrin, a pyrethroid insecticide); 2) Vantacor (active ingredient: chlorantraniliprole, a anthranilic diamide), and 3) Verimark (active ingredient: cyantraniliprole, also a anthranilic diamide). All liquid insecticides were applied by using dribble in-furrow (DIF) placement, which involved directing the spray solution into the open seed furrow through microtubes (1/4" outside diam.). Inline Teejet™ No. 18 orifice plates were used to stabilize the spray output volume, and the system was calibrated to deliver the spray solution at 5 GPA. The water used as a carrier for all liquid insecticide sprays in Study I was adjusted to pH 6.0 at least one week before applications.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in Study I on August 3 and in Study II on August 10, 2022 by 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 a dead plant) of Campbell et al. (2000).

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. Study I was harvested on October 5, and Study II was harvested on October 6, 2022. Foliage was removed from plots immediately before harvest by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were extracted from the soil using a mechanical harvester, and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (Moorhead, MN) for sucrose content and quality analysis.

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

Results and Discussion:

Study I: It is important to note that most of the insecticide entries in both of these trials were single-component (i.e., either at-plant-only or postemergence-only) control tools, which are not recommended as stand-alone control programs in areas such as St. Thomas, where severe SBRM infestations are common. Also, it also should be emphasized that the application timing of postemergence insecticide sprays in Study I (i.e., 2 days after peak SBRM fly activity) was not planned, but rather a result of wet early-spring soil conditions that delayed planting operations and subsequently led to atypically late seedling emergence. As a result, the postemergence insecticide applications in Study I had to be delayed until plants had emerged and were large enough for application equipment to be run through the plots without covering them with soil. The late application timing likely diminished the efficacy of all postemergence liquid spray applications in Study I.

Sugarbeet root maggot feeding injury rating data for Study I appear in Table 1. Root injury ratings in the untreated check plots averaged 6.9 on the 0 to 9 scale of Campbell et al. (2000), which indicated the presence of a high SBRM infestation for this experiment. Entries that provided the greatest levels of root protection (i.e., lowest SBRM feeding injury ratings) included the following (listed in descending order of SBRM control performance): Counter 20G, Aztec 4.67G, Index, and Smart Choice 5G. There were no significant differences in the levels of root protection from SBRM feeding injury among those treatments. That is a very encouraging result; however, it should be pointed out that Counter 20G, the industry standard in the trial, was applied at its moderate rate (7.5 lb product/ac) rate, and not its maximum labeled rate of 8.9 lb product per acre. Other treatments in the experiment that provided statistically significant reductions in SBRM feeding injury, as compared to that recorded from the untreated check plots, included Ecozin Plus and Delegate WG; however, Counter and Aztec provided statistically greater root protection than Ecozin and Delegate. All postemergence sprays (Abba Ultra, Delegate WG, Dibrom, Endigo ZCX, and Yuma 4E), as well as the planting-time application of Vectobac, failed to provide a statistically significant reduction in SBRM feeding injury when compared to the injury that occurred in the untreated check plots.

Table 1. ***Larval feeding injury ratings*** **from an evaluation of registered and experimental at-plant and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study I)**

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G	B	7.5 lb	1.5	3.15 e
Aztec 4.67G	B	4.45 lb		3.23 e
Index	DIF	17.1 fl oz		3.90 de
Smart Choice 5G	B	7.4 lb		4.03 de
Ecozin Plus	DIF	56 fl oz		4.95 cd
Delegate WG	DIF	6 fl oz	0.0938	5.38 bc
Abba Ultra	2 d Post-peak Broadcast	10 fl oz		5.70 abc
Yuma 4E	2 d Post-peak Broadcast	1 pt	0.5	5.78 abc
Dibrom	2 d Post-peak Broadcast	1 pt	1.65	5.98 abc
Vectobac 12AS	DIF	2 pt		6.00 abc
Delegate WG	2 d Post-peak Broadcast	6 fl oz	0.0938	6.08 abc
Endigo ZCX	2 d Post-peak Broadcast	4.5 fl oz	0.031	6.40 ab
Check	---	---	---	6.90 a
LSD (0.05)				1.273

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 at planting

Yield data from Study I are shown in Table 2. The highest recoverable sucrose yields in the experiment were achieved with the following treatments: 1) Counter 20G, banded at planting at its moderate rate of 7.5 lb product/ac; 2) Aztec 4.67G, banded at planting at 4.45 lb/ac; 3) Index, applied DIF at planting at 17.1 fl oz/ac; and 4) Smart Choice 5G, which was banded at planting at a rate of 7.4 lb/ac. There were no statistically significant differences in recoverable sucrose yield between those treatments; however, plots treated with either Counter, Aztec, or Index produced significantly greater sucrose yields than all other treatments in Study I, except Smart Choice. Results from treatment comparisons in relation to root yield closely corresponded to those on recoverable sucrose, with the exception that Counter 20G produced significantly greater root tonnage than Smart Choice.

In addition to providing favorable levels of SBRM control, the top three *experimental* treatments in Study I, which included Aztec, Index, and Smart Choice, also generated gross revenue increases of $629, $408, and $459 per acre, respectively, above that recorded for the untreated check. The economic benefits from most of the experimental planting-time insecticides were encouraging. Aztec, for example, generated a comparable revenue increase over the untreated check to that of Counter 20 G (i.e., $661/ac). Vectobac did not appear to provide any SBRM larval control or yield benefits in this experiment. Therefore, future work on it or similar materials should probably involve a different bacterial strain or a higher application rate, or possibly focus more on managing the adult stage of the root maggot.

Overall, the results from Study I illustrated the importance of timing for postemergence liquid insecticide applications. As shown in Tables 1 and 2, the overall performance patterns in relation to both SBRM feeding injury and yield indicated that most of the single, at-plant insecticide treatments tended to perform better than the single postemergence spray treatments. This is likely a result of the postemergence sprays having been applied two days after peak SBRM fly activity. As alluded to above in the Materials and Methods section, this was not the intended application timing for the foliar sprays. Rather, it was an unfortunate result of excessive wet soils in early spring that delayed planting and subsequently led to delayed postemergence spray applications.

Table 2. ***Yield parameters*** **from an evaluation of registered and experimental at-plant and postemergence insecticides for sugarbeet root maggot control,, St. Thomas, ND, 2022 (Study I)**							
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return ($/ac)**
Counter 20G	B	7.5 lb	1.5	9,241 a	29.3 a	16.93 a	1,731
Aztec 4.67G	B	4.45 lb		8,918 a	29.0 ab	16.55 a	1,699
Index	DIF	17.1 fl oz		8,238 a	26.8 ab	16.60 a	1,478
Smart Choice 5G	B	7.4 lb		7,474 ab	24.0 bc	16.68 a	1,529
Delegate WG	DIF	6 fl oz	0.0938	6,244 bc	20.7 cd	16.25 a	982
Ecozin Plus	DIF	56 fl oz		5,981 bc	20.2 cd	16.05 a	1,055
Endigo ZCX	2 d Post-peak Broadcast	4.5 fl oz	0.031	5,948 bc	19.6 cd	16.18 a	1,279
Dibrom	2 d Post-peak Broadcast	1 pt	1.65	5,747 bc	19.0 cd	16.35 a	948
Check	---	---	---	5,637 c	18.8 cd	16.23 a	1,070
Abba Ultra	2 d Post-peak Broadcast	10 fl oz		5,492 c	18.5 d	16.13 a	898
Vectobac 12AS	DIF	2 pt		5,233 c	17.8 d	15.98 a	922
Delegate WG	2 d Post-peak Broadcast	6 fl oz	0.0938	4,854 c	16.1 d	16.33 a	892
Yuma 4E	2 d Post-peak Broadcast	1 pt	0.5	4,793 c	16.2 d	16.13 a	931
LSD (0.05)				1,783.4	5.24	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 at planting

It should be pointed out that, due to space constraints, just one industry standard at-plant insecticide and one standard foliar liquid product could be included in Study I. Moderate rates of Counter 20G (i.e., 7.5 lb/ac) and Yuma 4E (i.e., 1 pt/ac) each were chosen as standards because the goal of this work was to determine if any prospective experimental insecticide product would provide at least moderate SBRM control that was comparable to Counter or Yuma. Therefore, the encouraging results achieved with several experimental insecticides in comparison to these insecticides should be understood within this context.

Another important consideration regarding in Study I was that all insecticide-treated entries were single-application treatments, which is never recommended for SBRM management under the high to severe root maggot pressure that typically develops in the northern RRV. The overall goal of this experiment was simply to determine if any of the experimental insecticides tested have potential to provide a measurable level of root protection and associated yield benefits in relation to managing this pest. Once candidate insecticide materials with such potential are identified, future research will focus on integrating them into control programs that may include both planting-time insecticide protection (i.e., a granular, sprayable liquid, or seed treatment insecticide) and postemergence additive protection to optimize SBRM management methodology.

Study II: Plant stand data from Study II appear in Table 3. At the first stand count, which was conducted at 25 days after planting (DAP), excellent plant populations were recorded for most treatments, except those treated at planting with either Mustang Maxx or the tank-mixed combination of Mustang Maxx plus Exponent (the insecticide synergist). Surprisingly, both of those treatments had significantly lower average plant stands than the untreated check. The reason for those stand deficiencies is unclear at this point, and bears further investigation.

At 34 DAP, the highest stand counts were observed in plots treated at planting with either Counter 20G, Verimark at 10 fl oz/ac, or Verimark at 5 oz/ac. There were no significant differences among those treatments, but each had significantly greater plant stands than all other treatments in Study II. Other treatments that resulted in significantly greater plant stands than those recorded in the untreated check plots included Mustang Maxx (i.e., with and without Exponent), and the high (2.5 fl oz/ac) rate of Vantacor. The low (1.2 fl oz/ac) rate of Vantacor was the only insecticide treatment that failed to provide a significant level of plant survival when compared to the untreated check at 34 DAP.

In stand counts conducted at 52 DAP, all insecticide treatments, except Vantacor at its low (i.e., 1.2 fl oz/ac) rate resulted in significantly greater surviving plant stands in comparison to the untreated check. The highest stands were recorded in plots treated with Counter 20G or Verimark (i.e., either 5 or 10 fl oz/ac). The combination treatment of Mustang Maxx plus Exponent had numerically greater average plant stands than when Mustang was applied without the synergist, which suggested that Exponent could have been providing some performance improvement, but the difference was not statistically significant.

Table 3. *Plant stand counts* from an evaluation of registered and experimental planting-time granular and liquid insecticides for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study II)						
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Stand count[b] (plants / 100 ft)**		
				25 DAP[c]	**34 DAP[c]**	**52 DAP[c]**
Counter 20G	B	7.5 lb	1.5	223.9 a	226.8 a	214.3 a
Verimark	DIF	10 fl oz	0.13	224.5 a	221.6 a	213.2 a
Verimark	DIF	5 fl oz	0.065	220.2 a	220.2 a	199.8 ab
Mustang Maxx + Exponent	DIF	4 fl oz 8 fl oz	0.025	195.5 c	188.4 b	179.1 bc
Mustang Maxx	DIF	4 fl oz	0.025	209.3 b	194.6 b	155.0 cd
Vantacor	DIF	2.5 fl oz	0.098	221.4 a	187.1 b	139.3 d
Vantacor	DIF	1.2 fl oz	0.047	217.0 ab	180.0 bc	134.5 de
Check	---	---	---	221.3 a	167.1 c	107.5 e
LSD (0.05)				10.61	15.01	30.48

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band at planting; DIF = dribble in-furrow at planting
[b]Surviving plant stands were counted on 3, 22, and 29 June, 2022 (i.e., 25, 34, and 52 days after planting [DAP], respectively).

As shown in Table 4, root maggot feeding injury in the untreated check plots of Study II averaged 7.15 on the 0 to 9 scale of Campbell et al. (2000), which suggested the presence of a relatively high SBRM infestation for this research. Most insecticide-based treatments in the experiment resulted in significant reductions in SBRM feeding injury when compared to the untreated check.

The lowest average SBRM feeding injury in Study II was observed in plots treated at planting with Counter 20G banded at its moderate rate of 7.5 lb product per acre. This treatment was superior to all other insecticides in Study II with regard to protection from SBRM larval feeding injury. However, favorable performance was achieved by Verimark at both application rates (i.e., 5 and 10 fl oz/ac), and Mustang Maxx when it was tank mixed with Exponent. Interestingly, the inclusion of Exponent with Mustang Maxx resulted in significantly greater root protection than when the Exponent was excluded.

Although not significant, plots treated with Vantacor at 2.5 fl oz per acre had numerically lower SBRM feeding injury than those that received the Vantacor at 1.2-oz rate. Root injury ratings in plots treated with the low rate of Vantacor were not statistically different from those in the untreated check plots.

Table 4. *Larval feeding injury ratings* from an evaluation of registered and experimental planting-time granular and liquid insecticides for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study II)				
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Root injury (0-9)**
Counter 20G	B	7.5 lb	1.5	2.65 e
Verimark	DIF	5 fl oz	0.065	3.85 d
Mustang Maxx + Exponent	DIF	4 fl oz 8 fl oz	0.025	4.10 d
Verimark	DIF	10 fl oz	0.13	4.15 d
Mustang Maxx	DIF	4 fl oz	0.025	5.50 c
Vantacor	DIF	2.5 fl oz	0.098	5.73 b
Vantacor	DIF	1.2 fl oz	0.047	6.38 ab
Check	---	---	---	7.15 a
LSD (0.05)				0.848

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = 5-inch band at planting; DIF = dribble in-furrow at planting

Yield results from Study II appear in Table 5. Performance patterns with regard to treatment impacts on yield parameters in this trial corresponded closely with those observed in SBRM feeding injury rating results, and are reason for optimism regarding the future of managing this pest. Plots treated with the industry standard insecticide, Counter 20G, at its moderate rate (7.5 lb product/ac) produced the highest recoverable sucrose and root yields in the experiment, and generated $731/ac greater gross economic return than the untreated check. Verimark treatments also resulted in excellent sucrose and root yields that were not statistically different from those from the Counter-treated plots.

Table 5. *Yield parameters* from an evaluation of registered and experimental planting-time granular and liquid insecticides for sugarbeet root maggot control, St. Thomas, ND, 2022 (Study II)							
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose (%)**	**Gross return ($/ac)**
Counter 20G	B	7.5 lb	1.5	8,264 a	26.7 a	16.60 ab	1,520
Verimark	DIF	10 fl oz	0.13	7,840 ab	24.5 ab	16.95 a	1,484
Verimark	DIF	5 fl oz	0.065	7,540 ab	24.5 ab	16.50 bcd	1,379
Mustang Maxx + Exponent	DIF	4 fl oz 8 fl oz	0.025	7,132 b	23.2 b	16.58 abc	1,302
Mustang Maxx	DIF	4 fl oz	0.025	5,775 c	19.0 c	16.35 b-e	1,040
Vantacor	DIF	1.2 fl oz	0.047	4,806 d	15.9 d	16.18 de	860
Vantacor	DIF	2.5 fl oz	0.098	4,733 d	15.7 d	16.20 cde	848
Check	---	---	---	4,460 d	15.0 d	16.08 e	789
LSD (0.05)				954.6	2.94	0.384	

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

[a]B = 5-inch band at planting; DIF = dribble in-furrow at planting

Similar to the observations from SBRM feeding injury assessments, tank mixing Mustang Maxx with Exponent resulted in significantly (23.5%) greater recoverable sucrose yield and an increase of 4.2 tons per acre in root yield in comparison to Mustang applied without the insecticide synergist. Combining Mustang Maxx and Exponent also resulted also resulted in a gross revenue increase of $262 per acre when compared to Mustang-treated plots where Exponent was excluded.

It is encouraging that the experimental treatments involving Verimark in Study II provided similar levels of root maggot control, in relation to root protection from SBRM feeding injury, yield, and revenue, to that of the moderate rate of Counter 20G. The fact that the insecticide synergist, Exponent significantly improved the performance of Mustang Maxx is also promising.

Overall, the findings of these two experiments suggest that these new insecticide approaches may have value as components of multi-insecticide programs for managing high SBRM infestations in the future. Although some of the experimental treatments achieved comparable performance levels to those observed with industry standards (e.g., Counter 20G, Mustang Maxx, Yuma 4E) in these two studies, it should be repeated that Counter (both studies) and Yuma (Study I) were applied at moderate rates, not their maximum use rates. As such, further testing should be carried out on these and other experimental materials to identify potential alternatives to the currently used products. Alternative insecticide options could help prevent or delay the development of insecticide resistance in SBRM populations to currently used chemistries, and could also provide viable tools for growers to sustainably and profitably manage this pest if currently available conventional insecticides become unavailable due to regulatory action.

Finally, it should also be noted that Yuma 4E, which contains the active ingredient chlorpyrifos, was included in this research for comparative purposes. All food crop uses of chlorpyrifos-containing insecticide products, including Yuma 4E, have been cancelled by the U.S. Environmental Protection Agency. Therefore, the application of such products ***is against the law***. The application of any product containing chlorpyrifos could result in a substantial fine and condemnation of the affected field(s), as well as condemnation and disposal of any piles containing roots harvested from those fields.

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SPRINGTAIL CONTROL IN SUGARBEET: EFFICACY OF GRANULAR, SPRAYABLE LIQUID, AND SEED-APPLIED INSECTICIDES

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Introduction:

Springtails are wingless, nearly microscopic, insect-like organisms that belong to the Collembola, a primitive order of Arthropods. Subterranean springtails are also blind, spending their entire lives below the soil surface (Boetel et al. 2001). In sugarbeet production systems, subterranean springtails tend to thrive in heavy soils with high levels of soil organic matter, and multiple species within at least two genera have been identified as damaging sugarbeet in North Dakota and eastern Montana. Cool and wet weather can be conducive to springtail damage because those conditions slow sugarbeet seed germination and seedling development, rendering young seedlings extremely vulnerable to attack by springtails that are tolerant to the moisture and cold. In such cases, these pests can cause major sugarbeet stand and yield losses if not properly controlled.

Subterranean springtails have been recognized as a serious threat to sugarbeet production in the central and southern Red River Valley of Minnesota and North Dakota since the late-1990s. Impacts from these pests on the sugarbeet crop are most evident in early spring, and usually involve wilting and dying seedlings within irregular-shaped patches within the field. The size of damaged areas within a field can range from a few-hundred square feet to patches that can exceed 10 acres.

We conducted a field experiment in Clay County, Minnesota to achieve the following objectives in relation to springtail control: 1) screen the performance of Counter 20G, a conventional granular insecticide, at three different application rates; 2) compare the efficacy of T-banded and dribble in-furrow applications of Mustang Maxx; 3) evaluate Midac FC as a liquid insecticide option; 4) compare the efficacy provided by neonicotinoid insecticidal seed treatments (i.e., Cruiser, NipsIt Inside, and Poncho Beta); 5) determine if springtail management in sugarbeet can be optimized by combining planting-time applications of Midac and Mustang Maxx with Poncho Beta-treated seed; and 6) assess Movento HL as a postemergence rescue insecticide treatment for springtail control.

Materials & Methods:

This experiment was established in a commercial sugarbeet field near Glyndon (Clay County), MN. Plots were planted on July 6, 2022 by using a 6-row Monosem NG Plus 4 7x7 planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Betaseed 8961, a glyphosate-tolerant sugarbeet 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 ten replications of the treatments. *NOTE: Two-row plots are the preferred experimental unit size in springtail trials because infestations of these pests are usually patchy. A smaller test area increases the likelihood of uniform springtail densities among plots within replicates of an experiment.*

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

Midac FC was applied by using dribble-in-furrow (DIF) placement, and Mustang Maxx was applied either in 3-inch T-bands or by using DIF placement. T-band placement of Mustang Maxx was achieved by orienting the output fan of each nozzle (TeeJet™ 450067E) directly perpendicular to the row, and nozzle height was adjusted on each row to achieve the desired 3-inch band width over the open seed furrow. Dribble in-furrow applications were made by orienting microtubes (1/4" outside diam.) directly into the open seed furrow. Inline Teejet™ No. 18 orifice plates were used to provide backpressure for stabilizing the output rate of spray solutions from the microtubes.

Plant stand counts: Treatment efficacy was compared by conducting counts of surviving plants in each plot because subterranean springtails cause early-season stand losses that can lead to yield reductions. Stand counts involved counting all living plants within each of two 25-ft-long rows per plot. Counts were conducted on July 19 and 27, and August 9, 2022, which were 13, 21, and 34 days after planting (DAP), respectively.

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. All plots were harvested on October 12, 2022. Foliage was removed from plots immediately before harvest by using a commercial-grade mechanical defoliator. All beets from both 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: Raw data from plant stand counts were converted to plants per 100 linear row feet for the analysis. All stand count 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 0.05 level of significance.

Results and Discussion:

Plant stand count data for this trial appear in Table 1. The treatments are presented in descending order of performance as observed at the last stand count (34 DAP). As such, the best-performing treatment, according to sugarbeet plant stand protection at 34 DAP, is listed in the top row.

At the initial stand count (13 DAP), the highest stand counts were recorded in plots protected by Poncho Beta-treated seed plus a postemergence 10-inch band of Movento HL (2.5 fl oz/ac). However, it should be pointed out that Poncho Beta was responsible for the stand protection in this treatment at this count date, because Movento was not applied until July 28 (i.e., 9 days after these counts).

Other treatments with excellent plant stands at 13 DAP included the following (listed in descending order of recorded stand count at 13 DAP):

1) Poncho Beta-treated seed plus Mustang Maxx (T-banded at planting, 4 fl oz/ac);
2) Counter 20G (planting-time band, 5.9 lb product/ac);
3) Counter 20G (planting-time band, 7.5 lb product/ac); and
4) NipsIt Inside-treated seed.

All insecticide treatments, except the DIF application of Mustang Maxx, provided statistically significant levels of springtail control (i.e., protection from stand loss associated with springtail feeding injury) when compared to the untreated check plots at 13 DAP. Relatively low stand counts (i.e., high stand losses) were also recorded in plots established with the treatment combination of Poncho Beta-treated seed plus a DIF application of Mustang Maxx. Those counts were not statistically different from the Mustang-only plots when the insecticide was applied DIF, thus suggesting that dribble-in-furrow may not be the optimal placement method for applying Mustang Maxx. Another interesting result at 13 DAP was that the treatment combination of Poncho Beta-treated seed plus a T-band application of Mustang Maxx resulted in significantly greater surviving plant stands than those recorded for either Poncho Beta alone or the T-banded application of Mustang Maxx alone. Additionally, in the direct comparison of dribble-in-furrow versus T-band placement of Mustang Maxx, the latter was superior in protecting plants from mortality associated with springtail damage.

At 21 DAP, excellent plant stands were being maintained by several treatments. The highest average plant densities per 100 row ft were recorded in plots treated with a planting-time application of Counter 20G at a moderate rate of 5.9 lb product per acre. Excellent stands, which were not significantly different from that of the 5.9-lb Counter 20G treatment, were also observed in the following treatments (listed in descending order of average plant stand at 21 DAP):

1) Poncho Beta-treated seed plus Movento HL (postemergence 10-inch bands, 2.5 fl oz/ac);
2) Counter 20G (planting-time band, 7.5 lb product/ac);
3) Poncho Beta-treated seed plus Mustang Maxx (T-banded at planting, 4 fl oz/ac);
4) Cruiser-treated seed;
5) Poncho Beta-treated seed;
6) Counter 20G (planting-time band, 4.5 lb product/ac); and
7) Poncho Beta-treated seed plus Midac FC (DIF, 13.6 fl oz/ac).

Table 1. ***Plant stand counts*** **from an evaluation of planting-time, seed-applied, and postemergence foliar insecticides for springtail control, Glyndon, MN, 2022**						
Treatment/form.	**Placement[a]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Stand count[b] (plants / 100 ft)**		
				13 DAP[c]	**21 DAP[c]**	**34 DAP[c]**
Poncho Beta + Mustang Maxx	Seed 3" TB	4 fl oz	68 g a.i./ unit seed 0.025	176.2 ab	185.4 ab	179.2 a
Counter 20G	B	7.5 lb	1.5	164.6 abc	187.6 ab	172.4 ab
Poncho Beta + Movento HL	Seed 10" Post B	2.5 fl oz	68 g a.i./ unit seed 0.078	176.6 a	192.8 ab	172.4 ab
Poncho Beta + Midac FC	Seed DIF	13.6 fl oz	68 g a.i./ unit seed 0.18	160.2 bc	171.0 ab	170.8 ab
Counter 20G	B	5.9 lb	1.2	166.2 abc	196.4 a	167.2 ab
Cruiser 5FS	Seed		60 g a.i./ unit seed	155.2 c	180.0 ab	162.2 ab
Poncho Beta	Seed		68 g a.i./ unit seed	154.2 c	176.8 ab	158.0 b
NipsIt Inside	Seed		60 g a.i./ unit seed	164.4 abc	168.6 b	158.0 b
Counter 20G	B	4.5 lb	0.9	153.2 c	172.4 ab	155.0 b
Poncho Beta + Mustang Maxx	Seed DIF	4 fl oz	68 g a.i./ unit seed 0.025	88.8 de	109.8 cd	112.0 c
Mustang Maxx	3" TB	4 fl oz	0.025	98.8 d	108.4 cd	106.8 c
Midac FC	DIF	13.6 fl oz	0.18	97.4 d	112.2 c	106.8 c
Mustang Maxx	DIF	4 fl oz	0.025	76.6 ef	101.2 cd	83.8 d
Check	---	---	---	63.2 f	82.4 d	62.0 e
LSD (0.05)				16.39	27.74	17.92

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

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

[b]Surviving plant stands were counted on July 19 and 27, and Aug. 9 (i.e., 13, 21, and 34 days after planting [DAP], respectively).

[c]DAP = Days after planting

Plots planted with NipsIt Inside insecticidal seed treatment had significantly lower plant stands in comparison to that recorded in plots treated with Counter 20G at 5.9 lb product per acre at 21 DAP; however, they did not differ statistically from any of the other seven above-listed treatments at that stand count date. All of the aforementioned eight treatments, including NipsIt Inside and Counter 20G (i.e., all application rates) resulted in significantly greater numbers of surviving plants at 21 DAP than the following treatments: 1) Poncho Beta-treated seed plus Mustang Maxx, applied DIF at 4 fl oz/ac; 2) Mustang Maxx alone at 4 fl oz/ac (i.e., both DIF and 3-inch T-band); 3) Midac FC applied alone, DIF at 13.6 fl oz/ac; and 4) the untreated check. However, the only treatments that failed to provide a significant stand improvement compared to the untreated check at 21 DAP were both single planting-time treatments of Mustang Maxx (i.e., DIF and 3" T-band), and the combination treatment comprised of Poncho Beta plus the DIF application of Mustang Maxx.

Results from the final stand counts, which were conducted at 34 DAP, were somewhat similar to those taken at 21 DAP. All insecticide-treated plots had greater plant stands than the untreated check; however, the largest average number of surviving plants was recorded in plots protected by the combination treatment of Poncho Beta-treated seed plus a planting-time application of Mustang Maxx that was delivered in 3-inch T-bands. That treatment resulted in a final average plant stand that was nearly three times that recorded for the untreated check.

Other treatments that resulted in favorable final plant stands that were not statistically different from the top treatment included the following (listed in descending order of surviving plant stand at 34 DAP):

1) Counter 20G (planting-time band, 7.5 lb product/ac);
2) Poncho Beta-treated seed plus Movento HL (postemergence, 10-inch bands, 2.5 fl oz/ac);
3) Poncho Beta-treated seed plus Midac FC (DIF, 13.6 fl oz/ac);
4) Counter 20G (planting-time band, 5.9 lb product/ac); and
5) Cruiser-treated seed.

Treatment combination of Poncho Beta seed plus a 3-inch T-band of Mustang Maxx also resulted in surviving plant stands that were significantly (60%) greater than those in plots treated with the Poncho Beta/Mustang Maxx combination when the Mustang was applied DIF. Similarly, in plots treated with a stand-alone application of Mustang Maxx, surviving stands were significantly (27.4%) greater when the insecticide was applied as a 3-inch T-band than when it was delivered by using DIF placement.

There were no significant differences in surviving plant stands among seed treatment insecticides at 34 DAP, although plots planted with Cruiser-treated seed were the only seed treatment-protected plots in which plant stands were not significantly different from the top treatment at 34 DAP. Similarly, there were no statistically significant differences among application rates of Counter 20G, although the higher rates (i.e., 7.5 and 5.9 lb product/ac) were the only Counter treatments that were not statistically outperformed by the top-performing treatment (i.e., Poncho Beta/Mustang Maxx, 3" T-band) with respect to surviving plant stands at 34 DAP. This finding suggests that producers planning on using Counter 20G for at-plant protection in high-risk areas for losses associated with springtail damage should apply the insecticide at a minimum of 5.9 lb product per acre.

Yield results from this experiment appear in Table 2. NOTE: as stated in the Materials and Methods section of this report, this trial was planted at an unusually late date (i.e., July 6; shortly after the infestation was detected), which resulted in atypically low yields for even the most effective insecticide treatments in this trial. However, the overall performance patterns observed in relation to yield parameters provided excellent insights on the efficacy of the insecticides tested.

Table 2. *Yield parameters* from an evaluation of planting-time, seed-applied, and postemergence foliar insecticides for springtail control, Glyndon, MN, 2022

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 3" TB	4 fl oz	68 g a.i./ unit seed 0.025	4,631 a	17.0 a	15.19 ab	738
Counter 20G	B	5.9 lb	1.2	4,576 ab	17.0 a	15.10 ab	718
Counter 20G	B	7.5 lb	1.5	4,444 ab	16.3 ab	15.21 a	709
NipsIt Inside	Seed		60 g a.i./ unit seed	4,417 ab	16.1 ab	15.26 a	708
Poncho Beta + Movento HL	Seed 10" Post B	2.5 fl oz	68 g a.i./ unit seed 0.078	4,396 ab	16.0 ab	15.26 a	711
Counter 20G	B	4.5 lb	0.9	4,329 ab	16.5 ab	14.77 bc	654
Cruiser 5FS	Seed		60 g a.i./ unit seed	4,249 ab	15.8 ab	15.10 ab	667
Poncho Beta + Midac FC	Seed DIF	13.6 fl oz	68 g a.i./ unit seed 0.18	4,181 b	15.3 b	15.24 a	670
Poncho Beta	Seed		68 g a.i./ unit seed	4,176 b	15.2 bc	15.35 a	674
Midac FC	DIF	13.6 fl oz	0.18	3,658 c	13.7 cd	15.02 abc	569
Mustang Maxx	3" TB	4 fl oz	0.025	3,539 c	13.1 d	15.10 ab	559
Poncho Beta + Mustang Maxx	Seed DIF	4 fl oz	68 g a.i./ unit seed 0.025	3,338 c	12.9 d	14.61 cd	498
Mustang Maxx	DIF	4 fl oz	0.025	3,230 c	12.8 d	14.26 de	464
Check	---	----	---	2,574 d	10.5 e	13.98 e	354
LSD (0.05)				432.3	1.55	0.424	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]B = banded at planting; T-band = 3" swath over open seed furrow at planting; Seed = insecticidal seed treatment

Yield results corresponded closely with the patterns observed in the last two counts of surviving plant stands. For example, the highest recoverable sucrose yield, root tonnage, and gross economic return were achieved by protecting plots with a combination of Poncho Beta-treated seed plus a planting-time 3-inch T-band of Mustang Maxx at its maximum labeled rate of 4 fl oz per acre. That treatment increased sucrose yield by over 2,000 lb, added nearly seven tons of root yield, and provided a gross revenue increase of $384 when compared to the untreated check. Other treatments that provided excellent yield benefits, and which were not significantly different from the top-yielding treatment (i.e., Poncho Beta/Mustang Maxx, 3-inch T-band) in generating either recoverable sucrose yield or root tonnage included the following:

1) Counter 20G (planting-time band, 5.9 lb product/ac);
2) Counter 20G (planting-time band, 7.5 lb product/ac);
3) NipsIt Inside seed treatment;
4) Poncho Beta-treated seed plus Movento HL (postemergence, 10-inch bands, 2.5 fl oz/ac);
5) Counter 20G (planting-time band, 4.5 lb product/ac); and

6) Cruiser-treated seed.

The top-yielding treatment (i.e., Poncho Beta-treated seed plus a 3-inch T-band of Mustang Maxx), as well as all of the above-listed treatments, resulted in significantly greater recoverable sucrose yield and root tonnage than the stand-alone applications of Midac FC, Mustang Maxx (i.e., either DIF or 3” T-band), and the combination treatment comprised of Poncho Beta-treated seed plus DIF-applied Mustang Maxx. This pattern reflected stand count results, and it also has been observed in previous testing; however, the dramatic superiority of the 3-inch T-band over DIF placement of Mustang Maxx in this experiment was somewhat surprising.

An important overall finding from this trial was that the top-yielding treatments, which were not significantly different from each other in recoverable sucrose or root yield, provided gross revenue increases ranging between $313 and $385 per acre when compared with the untreated check. Additionally, even the lowest-yielding insecticide treatment (i.e., Mustang Maxx, applied DIF) resulted in a revenue increase of $110/ac.

Collectively, these findings demonstrate the significance of subterranean springtails as serious economic pests of sugarbeet and also illustrate the importance of effectively managing them. Sugarbeet producers planning to grow sugarbeet in areas with a known history of springtail infestations should seriously consider using one of the better-performing control tools from this trial. If choosing to use a planting-time application of Mustang Maxx, it is strongly recommended that the product be applied in 3-inch T-bands to optimize performance. If that is not a practical option, it may be advisable to equip the planter with granular application equipment, and protect the crop from springtail infestations with planting-time bands of Counter 20G. Growers choosing to use Counter 20G in a springtail risk area should apply it at a rate between 5.9 and 7.5 lb product per acre.

Growers interested in using Midac FC for springtail control should probably integrate it with a neonicotinoid-treated seed treatment until its efficacy against these pests is better understood and characterized. Finally, the positive results from using Movento HL as a postemergence rescue insecticide treatment for springtail control in this trial are encouraging, but this the first such observation on Movento for springtail management. Further research is needed to determine the repeatability of those results. Additionally research should be continued on several other treatments in this study to identify consistently effective tools for managing subterranean springtails in the Red River Valley sugarbeet production area.

Acknowledgments:

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

Location:	St. Thomas (Pembina County), ND – Lessard Farm – *Sugarbeet Root Maggot Trials*	
Seed variety:	Betaseed 8961	
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 = 2.9%	pH = 8.0
Soil texture:	41.0% sand 41.0% silt	18.0% clay
Previous crop:	Wheat (2021)	
Soil preparation:	Field cultivator (1x)	
Planting depth:	1.25"	
Herbicides applied:	June 20	Roundup PowerMAX (2 pt/ac) + Outlook (17.5 fl oz/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)
	July 13	Roundup PowerMAX (2 pt/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)
Fungicides applied:	August 4	Badge (2 pt/ac) + Inspire XT (7 fl oz/ac)
	August 15	Manzate (1.6 qt/ac) + Super Tin (8 fl oz/ac)
Rainfall (after seedbed preparation)**:**	May 27	0.01”
	May 29	0.24”
	May 30	0.73”
	May 31	0.07”
	Total/May	**1.05”**
	June 10	0.07”
	June 12	0.14”
	June 14	1.15”
	June 20	0.09”
	June 21	0.02”
	June 24	1.78”
	June 25	0.04”
	June 29	0.03”
	Total/June	**3.32”**
	July 4	1.17”
	July 6	0.06”
	July 10	0.21”
	July 11	0.01”
	July 14	0.21”
	July 16	0.13”
	July 19	2.16”
	July 22	0.38”
	July 23	0.14”

July 26	0.34”
July 27	0.03”
Total/July	**4.84”**
August 11	0.03”
August 15	0.06”
August 18	0.59”
August 19	0.16”
August 23	0.74”
August 24	0.02”
August 27	0.21”
Total/August	**1.81”**
September 15	0.32”
September 16	0.99”
September 20	0.04”
September 23	0.04”
September 24	0.07”
Total/September	**1.46”**
October 2	0.01”
October 3	0.04”
Total/October	**0.05”**

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

Location: Glyndon (Clay County), MN – Brett Kuehl Farm

Seed variety: Betaseed 8961

Plot size: Two 25-ft long rows

Design: Randomized complete block, 4 replications

Soil name: Colvin silty clay loam

Soil test: Organic matter = 3.7% pH = 8.3

Soil texture: 21.5% sand 55.0% silt 23.5% clay

Previous crop: Soybeans (2021)

Soil preparation: Field cultivator (3x)

Planting depth: 1.25"

Planting date: July 6

Herbicides applied: August 5 Cornerstone 5 Plus (1.875 qt/ac) + Outlook (12 fl oz/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)

Fungicides applied: June 3 Manzate (1.6 qt/ac) + Super Tin (8 fl oz/ac)

Rainfall:	July 10	0.66”
(after seedbed	July 14	0.19”
preparation)**:**	July 15	0.87”
	July 16	0.11”
	July 18	0.23”
	July 19	0.16”
	July 21	0.07”
	July 23	0.02”
	July 26	0.08”
	July 31	0.37”
	Total/July	**2.76”**
	August 5	2.02”
	August 6	0.01”
	August 12	0.69”
	August 18	0.11”
	August 19	0.76”
	August 21	0.01”
	August 26	0.72”
	August 27	0.01”
	August 28	0.04”
	Total/August	**4.37”**
	September 9	0.12”
	September 15	0.07”
	September 16	0.02”
	September 17	0.02”
	September 19	0.16”
	September 23	0.14”
	September 24	0.04”
	Total/September	**0.57”**
	October 12	0.03”
	Total/October	**0.03"**

Stand counts: July 19 and 27, and Aug. 9 (13, 21, and 34 days after planting, resp.)
Harvest date: October 12
Yield sample size: two 25-ft rows (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 2022

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The eigth annual fungicide practices live polling questionnaire was conducted using Turning Point Technology at the 2023 Winter Sugarbeet Growers' Seminars held during January and February 2023. Responses are based on production practices from the 2022 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 2022 was calculated from Table 5 at between 400 and 599 acres.

Survey respondents were asked about soilborne disease and control practices. Fifty-seven percent said their fields were affected by Rhizoctonia, 13% said Aphanomyces was the biggest issue, twelve percent said they had issues with multiple disease including Rhizoctonia, Aphanomyces, Fusarium and Rhizomania, 14% said they had no soilborne disease issues and two percent listed Fusarium as their biggest issue while one percent said Rhizomania was their biggest soilborne disease problem (Table 8). Additionally, participants were asked about the prevalence of Rhizoctonia in sugarbeet with which preceding crops. Fifty two percent of respondents said they saw more rhizoctonia when soybeans preceded their sugarbeet crop. Eighteen percent reported more Rhizoctonia following edible beans, 11% saw more Rhizoctonia following any field corn, five percent said any crop, 4% said small grains and other crop and 1% stated sweet corn or potatoes as the crop preceding sugarbeets they saw the most Rhizoctonia develop (Table 9). Of the respondents to the question regarding whether a specialty variety was used for Rhizoctonia, 65% respondents said yes they did use a specialty variety for Rhizoctonia while 35% said no (Table 10).

Participants were asked what methods were used to control Rhizoctonia and 40% said they used a seed treatment only, 22% used a seed treatment and a POST fungicide and another 26% used a seed treatment plus an in-furrow fungicide while 10% also said they used a seed treatment, in-furrow fungicide and a POST fungicide while one percent used a seed treatment followed by an in-furrow spray and two POST applications (Table 11). Eighty eight percent of respondents used a Kabina seed treatment while 5% used Vibrance, 3% used Metlock Suite + Vibrance, 3% used Systiva, and 1% used Metlock Suite and Kabina (Table 12). Of the respondents who applied an in-furrow fungicide, 57% used Azteroid, 6% used Quadris or generic, 3% used other and one percent used Headline or Zanthion; 34% of respondents used no fungicide in-furrow (Table 13).

Respondents were asked what POST fungicides were used to control Rhizoctonia and 37% did not use a POST fungicide to control Rhizoctonia. Forty one percent used Quadris or generic, 6% used Azteroid, 10% used Proline, four percent used Priaxor and 2% used Excalia while one percent used other (Table 14). Participants were then asked to grade the effectiveness of the POST fungicides that were used. Thirty nine percent were unsure of their results, 41% said they had good results, 8% reported fair results, 11% said the fungicides performed excellently and 2% said they performed poorly (Table 15). Respondents were also asked how they applied POST fungicide and 26% stated they used a band application and 32% used a broadcast application while 42% said that they did not use a POST application (Table 16). Seventy six percent of growers reported that they used an in-furrow starter fertilizer while 24% did not (Table 17). Seventy seven percent of respondents used 10-34-0, 15% used an other starter fertilizer, six percent used Redline and 3 percent used Paralign (Table 18).

Participants were also asked about use of waste lime to control Aphanomyces. Seventy one percent of participants did not use waste lime in their fields while 18% used between 6 and 10 tons/acre while 11% used less than 5 tons/acre (Table 19). The growers were asked how effective their waste lime application was. Sixty three percent of respondents did not apply lime, 16% said they had good results and another 13% were unsure of their results, 4% said excellent and 4% reported fair results (Table 20). One of the survey questions also asked if growers had used a specialty variety for Aphanomyces in 2021. Fifty five percent of respondents said no and 45% said yes (Table 21).

Survey respondents were asked about how many acres were planted to CR+ in 2022. Forty two percent said they planted no CR+ acres, 7% planted between 1% and 20%, 25% reported planting between 21% and 50% while 17% planted between 51% and 60% of their acres to CR+ varieties and 5% planted between 61 and 70% of their acres to CR+ varieties and two percent planted more than 70% of their acres to CR+ varieties (Table 22). Growers were then asked to rate the effectiveness of CR+ varieties in controlling CLS. Forty one percent of growers did not use CR+ varieties, 33% said their CLS control was excellent, 15% reported good CLS control, four percent reported fair levels of effectiveness, two percent said poor while another 6% were unsure (Table 23). Growers were also asked about CLS control on non-CR+ varieties. Fifty nine percent of respondents said that had good control, 17% said fair levels of CLS control, 16% said excellent, seven percent did not use traditional varieties and one percent were unsure (Table 24).

Survey participants were then asked a series of questions regarding their CLS fungicide practices on CR+ varieties on sugarbeet in 2022. Thirty percent said that they used 3 sprays to control CLS, 25% used four applications, 20% used two applications, 11% used zero applications, 8% used one application, 5% used five applications while >1% used more than seven applications (Table 25). Survey participants were also asked how many CLS applications were made to control CLS on non-CR+ varieties. Thirty percent said four applications, 23% used three applications, 20% used five applications, 13% used six applications, seven percent said two applications, four percent said zero applications, while two percent each said one spray and seven sprays on non-CR+ varieties (Table 26). Respondents were then asked about the effectiveness of their CLS sprays. Seventy two percent said they had good results, 17% said they had excellent results, nine percent reported fair results while one percent each reported poor results or no applications (Table 27).

Respondents were asked about when their CLS application started and ended. Forty six percent of participants said that they began their applications between July 1 and 10, 24% said they started before July 1, 22% said it was between July 11 and 20, 6% said between July 21 and July 31 and 1% said between August 1 and 10 and after August 10 (Table 28). Fifty three percent of respondents said that their last CLS spray was between September 1 and 10, 22% said between August 21 and 31, 17% said between September 11 and 20 and 8% said between August 11 and 20 (Table 29). Growers were also asked if they used fungicide mixtures for all of their CLS applications. Eighty five percent said yes while 15% said no (Table 30).

Sixty one percent of survey respondents made 100% of their CLS applications by ground application. Sixteen percent made 81-99% of their applications from the ground, another 10% made between 61 and 80% from the ground. Nine percent made 0% percent of their CLS applications from the ground while five percent had between 41% and 60% of their application made by ground rig (Table 31).

Of the total fungicide applications for CLS, 63% did not use an aerial applicator, 22% used an aerial applicator for1-20% of their applications while five percent respectively made between 21-40%, 41-60% and 100% of their applications from an aerial application (Table 32).

Regarding water usage in gallons per acre as applied by tractor, 54% of respondents used 16-20 gallons per acre, 28% used 11-15 gallons per acre, 16% used more than 20 gallons per acre, 1% used 6-10 gallons per acre and >1%used 1-5 gallons per acre (Table 32).

Table 1. 2023 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2022.

County	Number of Responses	Percent of Responses
Barnes	-	-
Becker	-	-
Cass	3	10
Clay	11	38
Norman/Mahnomen	10	35
Ransom	-	-
Richland	-	-
Steele	-	-
Trail	5	17
Wilkin/Otter Tail	-	-
Total	29	100

Table 2. 2023 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2022.

County	Number of Responses	Percent of Responses
Cavalier	-	-
Grand Forks	4	8
Kittson	6	12
Marshall	6	12
Nelson	-	-
Pembina	14	28
Polk	-	-
Ramsey	-	-
Walsh	19	38
Other	1	2
Total	50	100

Table 3. 2023 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2022.

County	Number of Responses	Percent of Responses
Grand Forks	15	25
Mahnomen	-	-
Marshall	4	7
Nelson	2	3
Pennington/Red Lake	-	-
Polk	29	48
Steele	-	-
Traill	3	5
Walsh	3	5
Other	5	8
Total	61	101

Table 4. 2023 Wahpeton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2022.

County	Number of Responses	Percent of Responses
Cass	1	2
Clay	3	7
Grant	4	10
Otter Tail	-	-
Ransom	-	-
Richland	11	26
Roberts	-	-
Stevens	-	-
Traverse	3	7
Wilkin	20	48
Total	42	100

Table 5. 2023 Willmar Grower Seminar - Number of survey respondents by county growing sugarbeet in 2022.

County	Number of Responses	Percent of Responses
Chippewa	30	40
Kandiyohi	7	9
Pope	-	-
Redwood	2	3
Renville	22	29
Stearns	1	1
Stevens	2	3
Swift	6	8
Other	5	7
Total	75	100

Table 5. Total sugarbeet acreage operated by respondents in 2022.

		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	23	-	-	4	22	26	17	4	13	4	9
Grafton	46	2	11	7	15	17	11	9	15	9	4
Grand Forks	63	3	10	6	8	29	16	16	13	-	-
Willmar	73	7	11	15	11	18	12	10	10	4	3
Total	205	4	9	9	12	22	14	11	12	4	3

Table 6. What crop preceded most of your sugarbeet acreage in 2022?

Location	Respondents	Field Corn	Sweet Corn	Dry Bean	Peas	Potato	Soybean	Wheat	Other
		% of respondents							
Fargo	27	4	-	-	-	-	15	78	4
Grafton	44	-	-	9	-	9	2	80	-
Grand Forks	64	-	-	-	-	6	11	81	2
Wahpeton	42	21	-	-	-	-	24	55	-
Willmar	73	70	14	-	-	-	15	1	-
Total	250	24	4	2	-	3	13	53	1

Table 7. What was your most serious production problem?

Location	Respondents	Aph	CLS	Emergence	Fusarium	Herbicide Injury	Rhizoc	Rhizomania	Root Maggot	Weeds
		% of respondents								
Fargo	24	-	8	17	-	13	-	-	4	58
Grafton	42	2	26	12	-	-	7	2	7	43
Grand Forks	59	-	3	14	-	-	9	-	10	64
Wahpeton	40	-	3	43	-	-	28	-	-	28
Willmar	76	1	5	12	-	-	12	3	-	67
Total	241	1	8	18	-	1	12	1	4	55

Table 8. What soil-borne diseases affected your sugarbeet production in 2022?

		Root disease					
Location	Respondents	Rhizoctonia	Aphanomyces	Fusarium	Rhizomania	All	None
		% of respondents					
Fargo	24	46	8	8	4	25	8
Grafton	44	59	18	2	-	2	18
Grand Forks	62	50	11	2	2	13	23
Willmar	73	66	14	1	1	12	6
Total	203	57	13	2	1	12	14

Table 9. With which of the preceding crops did you see the most rhizoctonia in 2022?

Location	Respondents	Edible Beans	Field Corn	Sweet Corn	Potatoes	Small Grains	Soybeans	Any Crop	Other
		% of respondents							
Fargo	13	8	-	-	-	-	77	8	8
Grafton	34	38	-	-	-	3	44	9	6
Grand Forks	49	29	4	-	4	10	45	4	4
Willmar	67	3	24	2	-	-	57	15	-
Total	163	18	11	1	1	4	52	10	3

Table 10. Did you use a specialty variety to control Rhizoctonia in 2022?

Location	Respondents	Yes	No
		---------------------% respondents---------------------	
Fargo	24	71	29
Grafton	42	62	38
Grand Forks	59	83	17
Total	71	65	35

Table 11. 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	21	29	38	33	-	-
Grafton	43	37	26	19	19	-
Grand Forks	62	31	31	27	8	3
Wahpeton	40	88	8	3	3	-
Willmar	70	27	30	27	14	1
Total	236	40	26	22	10	1

Table 12. Which seed treatment did you use to control Rhizoctonia solani in 2022?

		Seed treatment				
Location	Respondents	Kabina	Metlock Suite + Kabina	Vibrance	Systiva	Metlock Suite + Vibrance
		-----------------------------------% of respondents----------------------------------				
Fargo	22	96	-	5	-	-
Grafton	39	85	-	8	3	5
Grand Forks	54	87	2	4	4	4
Total	115	88	1	5	3	3

Table 13. Which fungicide did you apply in-furrow to control R. solani in 2022?

		In-furrow fungicide use				
Location	Respondents	Azteroid	Quadris or Generic	Headline or Xanthion	Other	None
		------------------------------% of respondents----------------------------				
Fargo	19	53	11	-	-	37
Grafton	46	59	7	2	2	30
Grand Forks	54	57	4	-	4	35
Total	119	57	6	1	3	34

Table 14. Which POST fungicide did you use to control R. solani in 2022?

		POST fungicide							
Location	Respondents	Azteroid	Azterknot	Excalia	Quadris or generic	Proline	Priaxor	Other	None
		--% of respondents--							
Fargo	22	-	-	14	37	14	-	-	37
Grafton	42	5	-	-	41	24	7	2	21
Grand Forks	55	4	-	-	49	2	7	-	38
Willmar	69	10	-	2	38	6	-	-	45
Total	188	6	-	2	41	10	4	1	37

Table 15. How effective were your POST fungicides at controlling Rhizoctonia solani in 2022?

		Effectiveness of fungicides				
Location	Respondents	Excellent	Good	Fair	Poor	Unsure
		------------------------------% of respondents----------------------------				
Fargo	18	11	56	6	-	28
Grafton	41	20	56	10	2	12
Grand Forks	55	9	55	5	2	29
Willmar	65	6	15	11	2	66
Total	179	11	41	8	2	39

Table 16. How did you apply POST fungicides to control Rhizoctonia in 2022?

Location	Respondents	Band	Broadcast	None
		-----------------------------------% respondents--------------------------------		
Fargo	23	17	44	39
Grafton	43	16	58	26
Grand Forks	60	28	33	38
Willmar	72	33	11	56
Total	198	26	32	42

Table 17. Did you apply any in-furrow starter fertilizer in 2022?

		Variety type	
Location	Respondents	Yes	No
		---------------------% respondents---------------------	
Fargo	27	85	15
Grafton	46	78	22
Grand Forks	63	94	6
Wahpeton	39	39	62
Total	175	76	24

Table 18. Which starter fertilizer did you use in 2022?

		Starter Fertilizer Type			
Location	Respondents	10-34-0	Paralign	Redline	Other
		------------------------------% of respondents----------------------------			
Fargo	20	80	-	5	15
Grafton	42	69	-	7	24
Grand Forks	53	81	6	6	8
Total	115	77	3	6	15

Table 19. What rate of precipitated calcium carbonate (waste lime) did you use in 2022?

		Lime use rate		
Location	Respondents	None	>5 T/A	6-10 T/A
		------------------------------% of respondents----------------------------		
Fargo	26	62	-	39
Grafton	42	76	5	19
Grand Forks	58	81	-	19
Willmar	72	64	28	8
Total	198	71	11	18

Table 20. How effective was waste lime at controlling aphanomyces in 2022?

		Waste lime effectiveness					
Location	Respondents	Excellent	Good	Fair	Poor	Unsure	No Lime
		------------------------------% of respondents----------------------------					
Fargo	22	14	23	-	-	9	55
Grafton	44	5	18	2	-	11	64
Grand Forks	59	5	12	2	-	17	64
Willmar	72	-	17	7	-	11	65
Total	197	4	16	4	-	13	63

Table 21. Did you use a specialty variety to control Aphanomyces in 2022?

Location	Respondents	Yes	No
		---------------------% respondents---------------------	
Fargo	25	60	40
Grafton	43	47	54
Grand Forks	58	38	62
Total	126	45	55

Table 22. What percentage of your acres were planted to CR+ varieties in 2022?

Location	Respondents	0%	1%-20%	21%-50%	51%-60%	61%-70%	70%+
		------------------------------------% of respondents---------------------------------					
Fargo	25	12	4	32	24	12	8
Grafton	43	33	5	35	23	5	-
Grand Forks	58	62	10	16	9	2	-
Total	126	42	7	25	17	5	2

Table 23. How effective was CLS control on CR+ varieties in 2022?

		CR+ effectiveness					
Location	Respondents	Excellent	Good	Fair	Poor	Unsure	Did not use
		------------------------------------% of respondents-----------------------------------					
Fargo	23	39	26	9	-	9	17
Grafton	46	48	20	2	2	-	28
Grand Forks	58	19	7	4	2	9	60
Total	127	33	15	4	2	6	41

Table 24. How effective was CLS control on non-CR+ varieties in 2022?

		CR+ effectiveness					
Location	Respondents	Excellent	Good	Fair	Poor	Unsure	Did not use
		------------------------------% of respondents----------------------------					
Fargo	23	4	78	17	-	-	-
Grafton	43	7	61	21	-	-	12
Grand Forks	57	28	49	14	-	2	7
Total	123	16	59	17	-	1	7

Table 25. How many fungicide application did you make on CR+ varieties to control CLS in 2022?

Location	Respondents	Number of applications								
		0	1	2	3	4	5	6	7	>7
		------------------------------------% of respondents------------------------------								
Fargo	23	4	9	30	35	13	9	-	-	-
Grafton	41	15	32	27	27	-	-	-	-	-
Grand Forks	45	20	-	22	24	24	9	-	-	-
Wahpeton	41	-	5	20	24	49	2	-	-	-
Willmar	71	11	-	11	38	31	7	-	-	1
Total	221	11	8	20	30	25	5	-	-	>1

Table 26. How many fungicide application did you make on non-CR+ varieties to control CLS in 2022?

Location	Respondents	Number of applications								
		0	1	2	3	4	5	6	7	>7
		-----------------------------% of respondents-------------------------								
Fargo	22	-	-	5	23	59	14	-	-	-
Grafton	43	2	2	28	54	14	-	-	-	-
Grand Forks	56	-	4	2	23	55	16	-	-	-
Willmar	68	10	-	-	4	9	37	35	4	-
Total	189	4	2	7	23	30	20	13	2	-

Table 27. How effective were your fungicide applications on CLS in 2022?

Location	Respondents	Effectiveness of CLS sprays					
		Excellent	Good	Fair	Poor	Unsure	No applications
		-----------------------------% of respondents-------------------------					
Fargo	23	13	83	-	-	-	4
Grafton	44	5	82	11	2	-	-
Grand Forks	56	29	61	11	-	-	-
Total	123	17	72	9	1	-	1

Table 28. What date was your first CLS application?

Location	Respondents	Date of first CLS application					
		Before July 1	July 1-10	July 11-20	July 21-31	August 1-10	After August 10
		-----------------------------% of respondents------------------------------					
Fargo	24	13	67	21	-	-	-
Grafton	44	-	18	50	25	5	2
Grand Forks	58	9	54	29	7	2	-
Wahpeton	42	50	41	10	-	-	-
Willmar	73	40	55	6	-	-	-
Total	241	24	46	22	6	1	1

Table 29. What date was your last CLS application in 2022?

Location	Respondents	Date of last CLS application: Before August 1	August 1-10	August 11-20	August 21-31	Sept 1-10	Sept 11-20	Later than Sept 20	Made zero or 1 CLS applications
		--------% of respondents--------							
Fargo	24	-	-	-	42	33	25	-	-
Grafton	46	-	-	4	17	54	24	-	-
Grand Forks	59	-	-	2	17	56	20	3	2
Willmar	39	5	3	5	31	44	13	-	-
Total	72	-	-	8	22	53	17	-	-

Table 30. Did you use fungicide mixtures for all of your CLS applications?

Location	Respondents	Yes	No
		--------% respondents--------	
Fargo	24	17	83
Grafton	44	14	86
Grand Forks	59	15	85
Total	127	15	85

Table 31. What percent of total fungicide applications for CLS were made by ground application?

Location	Respondents	0%	1%-20%	21%-40%	41%-60%	61%-80%	81%-99%	100%
		--------% of respondents--------						
Fargo	22	9	-	-	14	5	18	55
Grafton	45	11	-	-	-	16	20	53
Grand Forks	58	7	-	-	5	7	12	69
Total	125	9	-	-	5	10	16	61

Table 32. 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	23	57	13	4	17	-	-	9
Grafton	43	58	21	12	-	-	-	9
Grand Forks	58	72	16	2	5	-	-	5
Willmar	69	61	30	4	4	-	-	-
Total	193	63	22	5	5	-	-	5

Table 33. How many gallons per acre of water per acre did you use to apply CLS fungicides by tractor?

Location	Respondents	1-5	6-10	11-15	16-20	20+
		--------% of respondents--------				
Fargo	24	4	-	58	29	8
Grafton	41	-	2	56	42	-
Grand Forks	58	-	4	41	45	10
Wahpeton	39	-	-	10	77	13
Willmar	69	-	-	-	65	35
Total	231	>1	1	28	54	16

EVALUATION OF AT-PLANTING FUNGICIDE TREATMENTS FOR CONTROL OF *RHIZOCTONIA SOLANI* ON SUGARBEET IN 2022

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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 take advantage of multiple control options to reduce Rhizoctonia crown and root rot (Windels et al. 2009).

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 4.8%. Field plots were fertilized for optimal yield and quality. A moderately susceptible variety (Crystal 803RR) with a 2-year average Rhizoctonia rating of 4.7 (Brantner and Moomjian 2022) 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 a Rau seedbed finisher. The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 25 at 4.5-inch seed spacing. Counter 20G (8.9 lb/A) was applied at planting for control of sugarbeet root maggot. For the control of weeds, glyphosate (4.5 lb ae/gallon, 28 fl oz/A) was applied on June 13, and Sequence (glyphosate + S-metolachlor, 2.5 pt/A) with additional glyphosate (8 fl oz/A) was applied on July 07. Cercospora leaf spot was controlled by Inspire XT + Manzate Pro-Stick (7 fl oz + 2 lbs/A) on July 18, Supertin + Topsin M (8 + 10 fl oz/A) on Aug 3, and Proline 480 SC + Manzate Pro-Stick (5.7 fl oz + 2 lbs/A) on Aug 17.

Plant stands were evaluated beginning June 06 (12 days after planting [DAP]) through July 14 (50 DAP) by counting the number of plants in the center two rows of each plot. On Sept 20, 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. Standard rates of Allegiance + Thiram and 45 g/unit Tachigaren were on all seed. In-furrow fungicides in 3 gal water mixed with 3 gal 10-34-0 were applied down the drip tube in a total volume of 6 gal/A.

Application	Product	Active ingredient (FRAC Group)	Rate[Y]
None	-	-	-
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	AZterknot	Azoxystrobin (11) + Extract of *Reynoutria sachalinensi* (P 05)	16.6 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

[Y] 5.7 fl oz AZteroid FC3.3 and 9.5 fl oz Quadris contain 67 and 70 g azoxystrobin, respectively; 16.6 fl oz AZterknot contain 102 g azoxystrobin and 59 g extract of *R. sachalinensi*; 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 5.82 and 4.73 in. for April and May, which was much greater than the 30-year average of 1.33 and 2.83 in., respectively. The saturated soils resulted in delayed planting; however, moist conditions at planting allowed for the rapid emergence of sugarbeet seedlings and generally high plant populations of 191 plants per 100 ft. of row averaged across all treatments in this trial on June 13 (19 DAP). Only a few rainfall events occurred in June, July, and August resulting in total rainfall of 2.78, 1.66, and 0.46 in., respectively; this is less than the 30-year average of 3.9, 3.19, and 2.72 in., respectively.

There were significant ($P < 0.05$) differences among treatments for plant stands at 12, 43, and 50 DAP; however, there were no significant differences by the time of harvest. On June 06 (12 DAP), Azteroid FC3.3 had the highest plant stand of 159 plants per 100 ft of row and Kabina ST and Propulse had the lowest plant stands of 119 and 112, respectivley (Table 2). All other treatments had a similar number of plants after emergence. Generally, in-furrow treatments had a greater number of plants compared to seed treatments over the time period (Figure 1). Moist soils at planting typically contribute to lessening seedling injury associated with in-furrow products as seen in previous years (Chanda and Brantner 2016, 2017; Lien et al. 2020). However, it is not unusual for stand establishment to be reduced for in-furrow fungicides compared to seed treatments if planting conditions are dry (Brantner and Chanda 2018, 2020; Chanda and Brantner 2019; Lien et al. 2022).

Cooler temperatures and lack of rain in the early part of June did not favor the establishment of Rhizoctonia inoculum in the soil and resulted in moderately low disease pressure throughout the season in 2022. There were no significant differences ($P > 0.05$) among treatments for severity and incidence of Rhizoctonia crown and root rot (RCRR), % sucrose, yield, and recoverable sucrose. However, based on the contrast analysis, in-furrow treatments had statistically lower severity of RCRR than the seed treatments (Table 3) and numerically slightly higher yield and recoverable sucrose per acre.

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 25, 2022 at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Treatment and rate (Application type)[z]	Plants per 100 ft row [y,x] June 06 12 DAP	June 13 19 DAP	June 20 26 DAP	June 30 36 DAP	July 07 43 DAP	July 14 50 DAP
§Quadris	148 ab	203	192	189	191 a	194 a
§Headline SC	155 ab	198	190	185	187 a-c	189 ab
§Priaxor	142 a-c	195	190	188	186 a-d	189 ab
§AZteroid FC[3.3]	159 a	200	191	187	188 ab	187 a-c
§Elatus WG	144 ab	203	189	186	185 a-e	185 a-d
¥Metlock Suite + Zeltera	137 a-c	190	183	178	179 a-f	181 a-e
§Proline 480 SC	134 b-d	191	183	175	175 b-f	180 a-e
§AZterknot	145 ab	192	181	178	180 a-f	180 a-e
¥Vibrance	131 b-d	197	188	181	182 a-e	179 b-e
¥Zeltera	134 b-d	182	178	173	173 c-f	175 b-e
Nontreated Control	149 ab	188	179	173	175 b-f	173 c-e
¥Kabina	119 cd	178	173	173	171 ef	172 de
¥Systiva	133 b-d	186	178	173	172 d-f	172 de
§Propulse	112 d	174	174	171	168 f	170 e
LSD	24	-	-	-	14	15
P-value	**0.0196**	0.1260	0.2851	0.1736	**0.0317**	**0.0367**

Contrast analysis of Seed Treatments vs. In-furrow Treatments [w]						
Mean of Seed treatments	131	187	180	176	175	176
Mean of In-furrow treatments	142	194	186	182	182	184
P-value	**0.0220**	0.0580	0.0599	**0.0354**	**0.0171**	**0.0070**

z Treatments were applied as seed treatment or in-furrow application

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 rate (Application type)[z]	Plant Stand at Harvest[y]	Plant Loss (%)[x]	RCRR Severity (%)[w]	RCRR Incidence (%)[w]	Sugar (%)[t]	SLM (%)[t]	Sucrose (lb/ton)	Yield (tons/A)	Sucrose (lb/A)
§Priaxor	170	13.0	5.8	26.3	18.1	1.02	341	27.0	9186
§AZterknot	166	13.2	6.6	23.8	17.5	1.05	329	28.5	9382
§Elatus WG	174	14.4	7.1	20.0	17.5	1.08	329	27.9	9192
¥Zeltera	154	15.5	7.2	23.8	17.2	1.07	322	25.8	8301
§Quadris	169	16.5	5.7	21.3	17.3	1.15	322	29.0	9311
¥Systiva	155	16.9	11.6	35.0	17.6	1.03	331	27.2	8999
§Headline SC	163	17.1	13.4	33.8	17.1	1.23	317	28.7	9113
§Propulse	152	17.2	6.5	30.0	17.5	1.13	328	25.6	8409
§Proline 480 SC	157	17.6	7.6	26.3	17.1	1.09	320	27.7	8860
¥Kabina	147	17.9	12.5	30.0	17.4	1.13	326	27.6	8961
§AZteroid FC3.3	161	19.2	8.8	21.3	17.7	1.22	329	26.1	8562
¥Vibrance	158	19.4	16.1	37.5	16.9	1.07	317	28.4	9009
¥Metlock Suite + Zeltera	153	19.4	10.8	25.0	17.5	1.21	326	25.4	8295
Nontreated Control	152	19.4	11.9	30.0	18.0	1.03	340	27.5	9373
LSD	-	-	-	-	-	-	-	-	-
P-value	0.0708	0.9358	0.2745	0.4220	0.8480	0.3490	0.8370	0.2440	0.5206

[v] **Contrast analysis of Seed Treatments vs. In-furrow Treatments**									
Mean of Seed treatments	153	17.8	11.6	30.3	17.3	1.10	324	26.9	8713
Mean of In-furrow treatments	164	16.0	7.7	25.3	17.5	1.12	327	27.6	9002
P-value	**0.0033**	0.3490	**0.0226**	0.1102	0.5828	0.6913	0.6531	0.2539	0.2092

[z] Treatments were applied as seed treatment or in-furrow application

[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

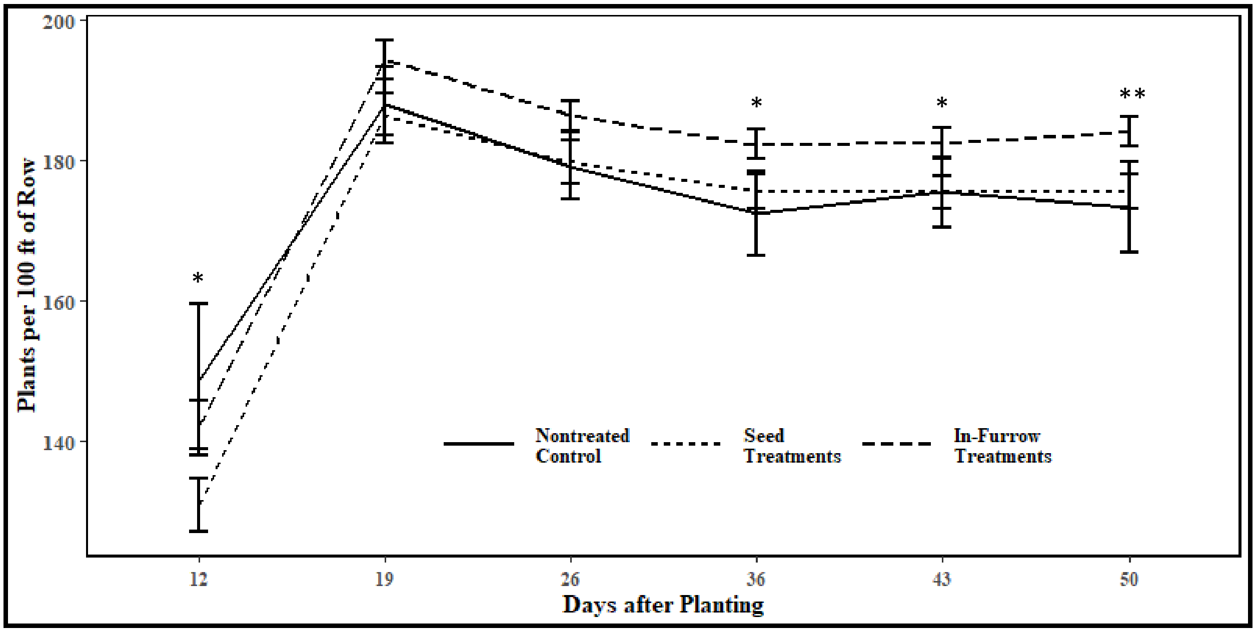

Figure 1. Emergence and stand establishment in 2022 comparing the averages of seed treatments and in-furrow fungicides compared to the nontreated control in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2 in Crookston, MN.

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IDENTIFICATION OF RESISTANCE-BREAKING VARIANTS OF BEET NECROTIC YELLOW VEIN VIRUS IN SUGARBEET

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Rhizomania is a devastating disease of sugarbeet caused by BNYVV, 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). The disease significantly impacts sugarbeet yield and thus affects growers' economy. 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). To manage the disease, *Rz1* and other sources of resistance were discovered and adapted to the regional cultivars which provided considerable disease resistance. However, in a few years, resistance-breaking strains of BNYVV began to appear, starting 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). Research studies have 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).

Currently the disease is managed by host resistance; however, rhizomania is being observed in sugar beet production fields indicating the appearance of resistance-breaking variants of BNYVV. Rhizomania disease management primarily relies on resistance genes bred into commercial varieties specifically developed against BNYVV (Rush et al., 2006). There is no commercial chemistry exist to manage the disease. The disease is a major concern because of the emergence of resistance-breaking (RB) strains of BNYVV in the Red River Valley and southern Minnesota sugar beet growing areas and around the world. The objective of this study was to evaluate rhizomania suspicious soil and beet samples from Minnesota and North Dakota sugar beet production fields to identify resistance-breaking via soil-baiting assay by growing different sugar beet cultivars such as susceptible, *Rz1*, and *Rz1Rz2* for genotype comparison.

Materials and Methods

Beet and soil samples were obtained from the sugarbeet production areas of North Dakota and Minnesota courtesy of agriculturists from the American Crystal Sugar Company, Minn-Dak Farmrs Cooperative, and Southern Minnesota Beet Sugar Cooperative. Sugarbeet seeds were obtained from SESVanderhave. For healthy control, 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.

Results and Discussion

Rhizomania symptomatic beet and corresponding soil samples were obtained from sugar beet fields of Minnesota and North Dakota. Hairy roots from beets were carefully collected and washed 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. Positive and negative controls were included in each plant with diagnosis. Out of 73 beets, 23 tested positive (31%) based on ELISA analysis (Table 1). Each beet was tested in three replicates an average was used for plotting analysis. The beets 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 field.

Location	Beet infected/tested	Soil samples
Minnesota	23 / 63	5 locations
North Dakota	0 / 10	2 locations
Total number of samples	23 / 73	7 locations

Recovery of BNYVV from rhizomania-infested soil samples was accomplished using soil-baiting assay by growing different sugar beet cultivars representing susceptible, Rz1, and Rz1Rz2 sugar beet genotypes. BNYVV was detected in the roots of bait plants using ELISA. For each sugar beet cultivars were planted in three replicates and three technical replicates were used for ELISA analysis, and the average value was used for plotting. Positive and negative controls were included in each plant with diagnosis. Soil samples were obtained from rhizomania suspicious fields from seven different locations. Out of seven locations, only one location appeared positive for rhizomania in susceptible cultivar, whereas soil from another location tested slightly positive for BNYVV in susceptible, Rz1, and Rz1Rz1 cultivars (Table 2). As the next step, total RNA was extracted, constructed RNA-Seq libraries and sequenced using Next-Generation sequencing. Data analysis revealed the presence of reads matching to BNYVV, and other soil-borne viruses indicating mixed infections. The role of co-existing viruses in the mixed infection on disease complexity needs to be investigated.

Table.2. Rhizomania evaluation in field soil samples from Minnesota and North Dakota. Detection of BNYVV in the roots of bait plants using ELISA. Symbols ++ refers to intensely positive, + refers to moderately positive, +/- refers to slightly positive, and – refers to negative for BNYVV.

Soil samples	Susceptible	Rz1	Rz1+Rz2
Location-1	-	-	-
Location-2	+/-	+/-	+/-
Location-3	+	-	-
Location-4	-	-	-
Location-5	-	-	-
Location-6	-	-	-

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

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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. Management of CLS must incorporate integrated practices such as conventional tillage, crop rotations, 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-resistant samples of *C. beticola* across sugarbeet growing regions in Minnesota and North Dakota (Secor et al. 2021), the use of highly tolerant sugarbeet varieties (i.e., CR+ varieties) may be vital in managing CLS disease (Mettler and Bloomquist 2021, 2022) as well as managing fungicide resistance (Mettler and Bloomquist 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 contact the leaf or petiole of a sugarbeet, the fungus initiates infection. 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). Moreover, the development of 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). Additionally, Bhuiyan et al. (2021) showed that infection of *C. beticola* and the hypersensitive response of the host is delayed in a CLS tolerant variety compared to a susceptible variety, implying that the development of conidia is also delayed. In field conditions, Metzger (2021) reported that the final CLS disease severity of CR+ varieties is significantly less compared to susceptible varieties in the 2020 MDFC CLS Nursery near Foxhome, MN. Two trials in separate locations were also conducted in 2020 and 2021 by the SMBSC to determine the best fungicide program to pair with varieties with differing levels of CLS tolerance. Mettler and Bloomquist (2021, 2022) 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.

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 variety (Crystal 808RR) with a 2-year average Cercospora rating of 4.9 (Niehaus and Moomjian 2021) and a CR+ variety (BTS 8018) with a 2-year average Cercospora rating of 2.4 (Brantner and Moomjian 2022) 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 24. Plant stands were evaluated June 27 by counting the number of plants in the right four rows of each plot to verify an average plant population of 150 plants per 100 ft of row for BTS 8018 and 191 plants per 100 ft of row for Crystal 808. On July 13 (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 modified duster created from a power drill and 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 2021 growing season.

Fungicide treatments (see tables) were applied to the right 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 bi-weekly or approximately every 10 days, depending on weather conditions and the prior treatment. Fungicide applications began when weather was conducive for disease development and coincided with canopy closure, except for the first applications on Jul 08, 5 days prior to inoculation. Fungicide treatments were applied on July 08, July 18, July 27, Aug 04 or Aug 08, Aug 22, and Sept 06. CLS disease severity was evaluated beginning Aug 01 and continued through Sept 22 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). Additionally, leaf spots (n = 100) were collected from each variety on Aug 29 and placed in a humidity chamber for 48 hours to identify the causal pathogens; values were then used to adjust each rating to represent the amount of CLS present in each plot. On Sept 27, plots were defoliated, and the two right-most rows of each plot were harvested mechanically and weighed for root yield due to stand establishment issues that occurred early on and negatively impacted the center two rows. 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 4.2.0, R Core Team 2022). CLS severity, sugar, and sucrose per ton were analyzed with the package *stats* (v 4.2.0) using analysis of variance with replication as a random effect, and Fisher's protected least significant difference (LSD) test was used for post hoc analysis at a 0.05 level of significance with the package *agricolae* (v 1.3-5) to separate treatment means. Yield, sucrose per acre, and revenue were analyzed with the package *rstatix* (v 0.7.0) using analysis of covariance with plant stands as the covariate. Pairwise comparisons, partial Eta-squared (η_g^2), and the estimated marginal means of each treatment were produced based on average plant stands for each variety using the package *emmeans* (v 1.8.1-1). Partial Eta-squared is a measure of the strength of association between plant stands and the independent variables (i.e., yield, sucrose per acre, and revenue).

RESULTS AND DISCUSSION

Frequent rainfall early in the spring resulted in delayed planting. Even though the moist soils and slightly above average temperatures in June allowed for the rapid growth of sugarbeets and the production of true leaves, the timing of canopy closure was delayed compared to previous years. Following inoculation, the site received 0.41 in. of rain; additionally, prolonged warm temperatures and high humidity provided conditions that favored the establishment of the Cercospora inoculum. The first leaf spot caused by a *Cercospora* spp. in the trial was identified on July 18. However, abnormally dry conditions and above-average temperatures during August and September resulted in low disease pressure mid to late-season. Macroscopic identification of conidia after Aug 29 indicated that 71%, 13%, and 2% of leaf spots collected from BTS 8018 were caused by *Alternaria* spp., *Cercospora* spp., and *Stemphylium* spp., respectively. Leaf spots collected from Crystal 808 indicated that 1%, 98%, and 1% were caused by *Alternaria* spp., *Cercospora* spp., and *Stemphylium* spp., respectively. Disease pressure progressed in the moderately susceptible nontreated control to a level above the known economic threshold of 3% severity by the end of the season. Standard fungicide programs significantly reduced CLS severity for Crystal 808 (P < 0.0001). Disease pressure for BTS 8018 was minimal throughout the season, and CLS severity was not significant (P = 0.7672) and very low regardless of the fungicide spray program. Variable plant stands between treatments significantly correlated with yield (R = 0.89, P < 0.0001) and warranted an analysis of covariance and adjustment of treatment means. Based on the analysis of covariance, there were no significant differences for yield, sucrose per acre, and revenue for either of the varieties. However, after transforming treatment means to the estimated marginal means based on the average plant stand for the respective variety, there were numerical differences in the Crystal 808 variety where the nontreated control resulted in the lowest yield, sucrose per acre, and revenue.

Table 1. Effects of fungicide spray programs on CLS disease, harvestable yield, and sucrose quality of sugarbeets in a CLS-infested field trial planted on May 24, 2022 at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Treatment(s)[z] and timing[y]	CLS Severity (0-10)[x]	Sugar (%)	Sucrose (lbs/ton)	Yield (tons/A)[w]	Sucrose (lb/A)[w]
CR+ Highly tolerant variety (BTS 8018); 2-year Cercospora rating = 2.4					
Provysol **A +** Manzate Pro-Stick **ABDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	0.3	17.2	321	23.6	7539
Provysol **A +** Manzate Pro-Stick **AD** + Super Tin **BF** + Topsin 4.5 FL **B** + Proline 480 SC **D** + Priaxor **F**	0.3	17.4	324	22.5	7262
Provysol **A +** Manzate Pro-Stick **A** + Super Tin **C** + Topsin 4.5 FL **C** + Proline 480 SC **F** + Priaxor **F**	0.3	17.7	332	22.0	7355
Provysol **B +** Manzate Pro-Stick **BDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	0.3	17.4	326	22.0	7181
Provysol **B +** Manzate Pro-Stick **BE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **E** + Priaxor **F**	0.3	17.7	332	22.0	7279
Provysol **B +** Manzate Pro-Stick **B** + Super Tin **C** + Topsin 4.5 FL **C** + Proline 480 SC **F** + Priaxor **F**	0.3	17.4	325	21.9	7106
Provysol **C +** Manzate Pro-Stick **CE** + Super Tin **DF** + Topsin 4.5 FL **D** + Proline 480 SC **E** + Priaxor **F**	0.3	17.2	321	22.7	7284
Provysol **C +** Manzate Pro-Stick **C** + Super Tin **D** + Topsin 4.5 FL **D** + Proline 480 SC **F** + Priaxor **F**	0.3	18.4	345	23.2	7992
Proline 480 SC **C** + Manzate Pro-Stick **C** + Super Tin **F** + Priaxor **F**	0.3	17.6	331	21.6	7129
Proline 480 SC **D** + Manzate Pro-Stick **D** + Super Tin **F** + Priaxor **F**	0.3	17.7	333	21.8	7212
Proline 480 SC **E** + Manzate Pro-Stick **E** + Super Tin **F** + Priaxor **F**	0.3	17.8	333	22.6	7537
Provysol **D +** Manzate Pro-Stick **D** + Super Tin **E** + Topsin 4.5 FL **E** + Proline 480 SC **F** + Priaxor **F**	0.3	17.7	332	22.7	7520
Proline 480 SC **F** + Priaxor **F**	0.3	17.6	329	22.4	7366
Nontreated Control	0.3	17.6	330	21.7	7136
P-value	0.7672	0.5181	0.5190	0.8479	0.6171
η_g^2	-	-	-	0.16	0.21
Moderately susceptible variety (Crystal 808); 2-year Cercospora rating = 4.9					
Provysol **A +** Manzate Pro-Stick **ABDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	1.1 d	16.9	317	27.6	8728
Provysol **B +** Manzate Pro-Stick **BDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	1.4 d	17.8	335	25.1	8412
Provysol **C +** Manzate Pro-Stick **CE** + Super Tin **DF** + Topsin 4.5 FL **D** + Proline 480 SC **E** + Priaxor **F**	2.3 c	16.9	316	27.4	8649
Provysol **D +** Manzate Pro-Stick **D** + Super Tin **E** + Topsin 4.5 FL **E** + Proline 480 SC **F** + Priaxor **F**	2.8 bc	17.6	330	25.4	8392
Super Tin **DF** + Topsin 4.5 FL **D** + Proline 480 SC **E** + Manzate Pro-Stick **E** + Priaxor **F**	3.2 b	17.1	321	26.3	8442
Nontreated Control	6.9 a	16.5	309	24.7	7653
P-value	<0.0001	0.1230	0.1321	0.8713	0.9635
η_g^2	-	-	-	0.1	0.05

[z] Treatment rates per acre are as follows: Provysol = 4 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.

[y] Application letter code for the following dates: **A**= Jul 08, **B**= Jul18, **C**= Jul 27, **D**= Aug 04 or Aug 08, **E**= Aug 22, **F**= Sept 06

[x] Values within a column followed by the same letter are not significantly different

[w] Values are estimated marginal means based on average plant stands for the respective variety

Table 2. Revenue associated with fungicide spray programs to manage CLS of sugarbeets in a CLS-infested field trial planted on May 24, 2022 at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Treatment(s)[z] and timing[y]	Gross Rev. ($/ton)[x,v]	Gross Rev. ($/A)[w,x,v]	Fung. Cost ($/A)[w]	Net Rev. ($/A)[v]
CR+ Highly tolerant variety (BTS 8018); 2-year Cercospora rating = 2.4				
Provysol **A +** Manzate Pro-Stick **ABDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	61.2	1430	107	1323
Provysol **A +** Manzate Pro-Stick **AD** + Super Tin **BF** + Topsin 4.5 FL **B** + Proline 480 SC **D** + Priaxor **F**	62.4	1389	94	1295
Provysol **A +** Manzate Pro-Stick **A** + Super Tin **C** + Topsin 4.5 FL **C** + Proline 480 SC **F** + Priaxor **F**	65.2	1447	81	1366
Provysol **B +** Manzate Pro-Stick **BDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	63.1	1384	101	1284
Provysol **B +** Manzate Pro-Stick **BE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **E** + Priaxor **F**	64.9	1423	94	1329
Provysol **B +** Manzate Pro-Stick **B** + Super Tin **C** + Topsin 4.5 FL **C** + Proline 480 SC **F** + Priaxor **F**	62.5	1364	81	1284
Provysol **C +** Manzate Pro-Stick **CE** + Super Tin **DF** + Topsin 4.5 FL **D** + Proline 480 SC **E** + Priaxor **F**	61.0	1384	94	1290
Provysol **C +** Manzate Pro-Stick **C** + Super Tin **D** + Topsin 4.5 FL **D** + Proline 480 SC **F** + Priaxor **F**	69.6	1615	81	1534
Proline 480 SC **C** + Manzate Pro-Stick **C** + Super Tin **F** + Priaxor **F**	64.6	1390	59	1331
Proline 480 SC **D** + Manzate Pro-Stick **D** + Super Tin **F** + Priaxor **F**	64.9	1410	59	1351
Proline 480 SC **E** + Manzate Pro-Stick **E** + Super Tin **F** + Priaxor **F**	65.4	1484	59	1426
Provysol **D +** Manzate Pro-Stick **D** + Super Tin **E** + Topsin 4.5 FL **E** + Proline 480 SC **F** + Priaxor **F**	65.1	1471	81	1390
Proline 480 SC **F** + Priaxor **F**	63.6	1429	46	1383
Nontreated Control	64.0	1387	0	1387
P-value	0.2367	0.3963	-	0.1703
η_g^2	0.3	0.26	-	0.32
Moderately susceptible variety (Crystal 808); 2-year Cercospora rating = 4.9				
Provysol **A +** Manzate Pro-Stick **ABDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	59.2	1638	107	1531
Provysol **B +** Manzate Pro-Stick **BDE** + Super Tin **CF** + Topsin 4.5 FL **C** + Proline 480 SC **D** + Priaxor **F**	66.0	1658	101	1558
Provysol **C +** Manzate Pro-Stick **CE** + Super Tin **DF** + Topsin 4.5 FL **D** + Proline 480 SC **E** + Priaxor **F**	59.0	1618	94	1524
Provysol **D +** Manzate Pro-Stick **D** + Super Tin **E** + Topsin 4.5 FL **E** + Proline 480 SC **F** + Priaxor **F**	64.3	1639	81	1558
Super Tin **DF** + Topsin 4.5 FL **D** + Proline 480 SC **E** + Manzate Pro-Stick **E** + Priaxor **F**	61.0	1603	69	1534
Nontreated Control	57.1	1410	0	1410
P-value	0.9583	0.9803	-	0.9925
η_g^2	0.06	0.04	-	0.03

[z] Treatment rates per acre are as follows: Provysol = 4 fl oz, Manzate Pro-Stick = 2 lb, Super Tin 4L = 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.

[y] Application letter code for the following dates: **A**=8 Jul, **B**=18 Jul, **C**=27 Jul, **D**=4 Aug or 8 Aug, **E**=22 Aug, **F**=6 Sept

[x] Values within a column followed by the same letter are not significantly different

[w] Revenue is based on the November 2022 ACSC beet payment; fungicide cost is based on 2022 prices and does not include application costs

[v] Values are estimated marginal means based on average plant stands for the respective variety

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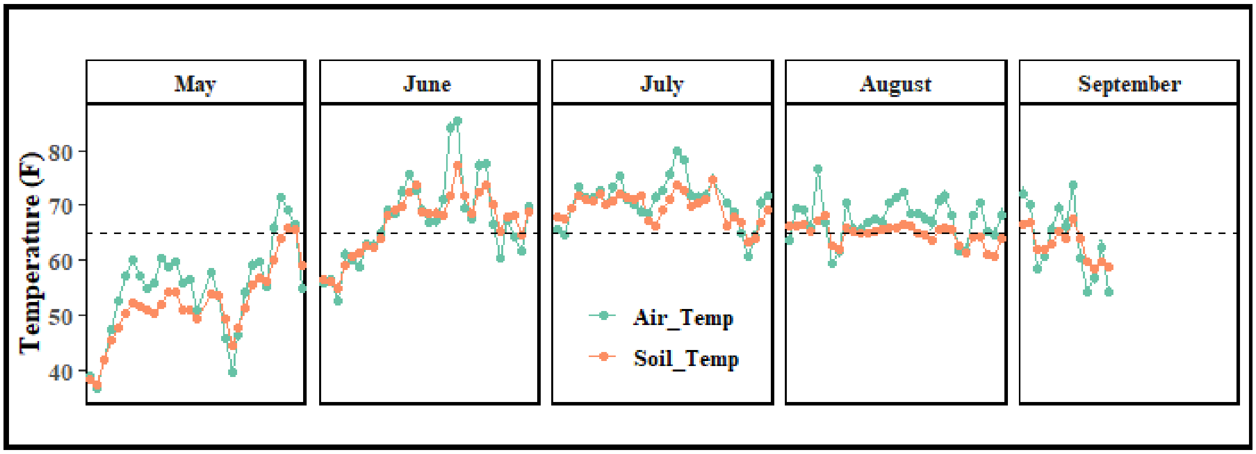

Figure. 1. Daily mean air temperature and 4-inch soil temperature collected at the NWROC weather station in Crookston, MN for the 2022 growing season. The dotted line represents 65°F.

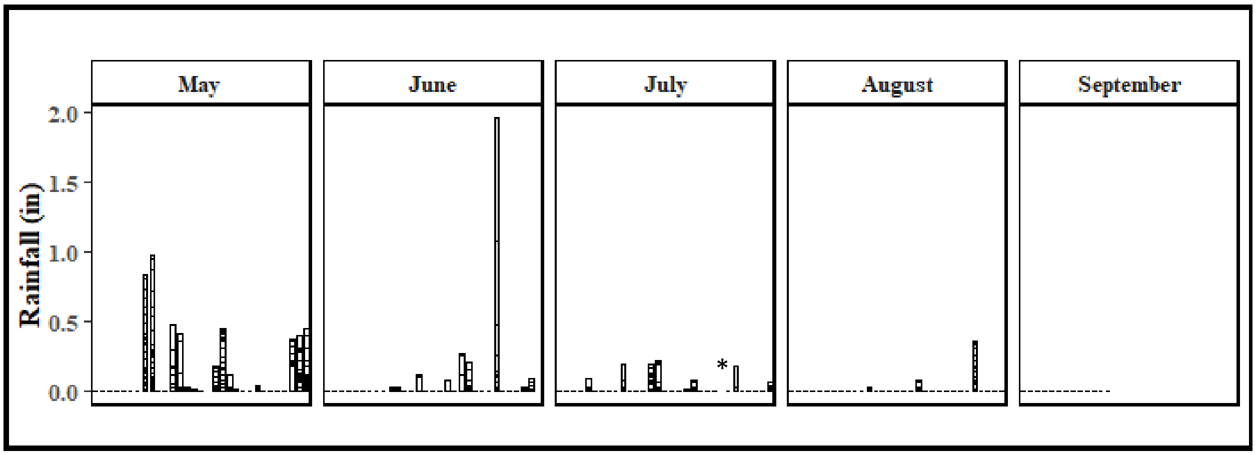

Figure 2. Daily rainfall totals collected at the NWROC weather station in Crookston, MN for the 2022 growing season.
*Missing Data: 0.65 in received on June 24, 2022.

VARIETY TESTING

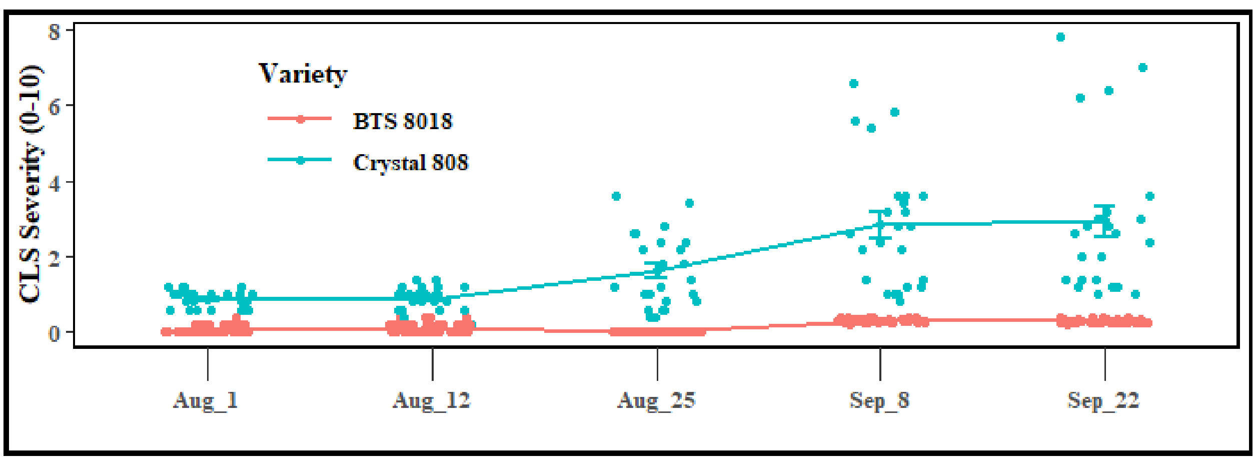

Figure 3. CLS disease severity ratings throughout the 2022 growing season for sugarbeet varieties sown in an CLS inoculated field trial at the University of Minnesota, NWROC, Crookston, MN.

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

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Introduction

Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola* Sacc., is the most widespread foliar disease in sugar beet (*Beta vulgaris* L.). Significant losses can occur under warm and humid environments with yield losses as high as 42 - 50% (Verreet et al., 1996). Application of fungicide and growing resistant cultivars are two main measures for controlling the disease but using host resistance 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., 2022).

In this research, we evaluated all available *B. maritima* accessions and a few germplasm lines from other wild relatives for resistance to CLS, and then used genotype data through SNPs covering the whole genome of sugarbeet to identify genomic regions associated with the resistance based on genome-wide association study (GWAS).

Materials and methods

A total of 602 *B. vulgaris* accession from NPGS (National Plant Germplasm System) and USDA-ARS sugarbeet genetics program at Fargo, ND were used and planted in Foxhome, MN for field evaluation of resistance to Cercospora leaf spot. The accessions included 582 lines from wild beet *B. maritima* and the remaining 20 genotypes from subspecies *B. macrocarpa* (10 lines), *B. atriplicifolia* (4 lines), *B. patula* (2 lines), *B. macrorhiza* (1 lines), *B. palonga* (1 line), *Patellifolia procumbens* (1 line) and *P. webbiana* (1 line). Accessions were collected from 25 countries and were divided into seven regions of the world **(Table 1)**. Whereas nine accessions had no geographic information available.

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 (25), Morocco (31), Tunisia (1)	57
Asia	China (1), India (3), Israel (1)	5
Northern Europe	Denmark (21), Ireland (47), Jersey Island (1), UK (106)	175
Southern Europe	Croatia (1), Cyprus (1), Greece (56), Italy (103), Portugal (6). Spain (11), Turkey (5)	183
Western Europe	Belgium (3), France (141), Germany (2), Netherlands, (2), Guernsey Island (1)	149
Eastern Europe	Poland (1), Russian Federation (2)	3
North America	United States	21

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 27th, 2022, in Foxhome, MN. Inoculation was performed on July 8th and repeated after two weeks. Disease ratings were made on September 12th using a 0 – 9 scale with 0 as immune (no CLS spots), 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).

For genotyping all accessions using GBS platform, 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 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* and other wild beet accessions, the computer program STRUCTURE (v.2.3.4) that implements model-based Bayesian cluster analysis was used, and 10 independent replicates for each putative subpopulation ranging from k = 2 –10 under the admixture model was assessed using a burn-in period of 50,000 and 50,000 Markov Chain Monte Carlo (MCMC) replications. To infer the optimal clusters/sub-populations, the best K value representing the optimum number of sub-populations was estimated as Delta K (ΔK) based on the change in the log probability of data between successive structure iterations using Structure Harvester (https://taylor0.biology.ucla.edu/structureHarvester/). In addition, the discriminant analysis of principal components (DAPC) that implemented using the R package “adegenet” was also used to verify results 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

CLS evaluation

The wild beet germplasm showed high variation for response to CLS in the crop season of 2022 (Fig. 1). Out of the 602 wild beet accessions planted, 236 (39%) showed a resistance response with disease ratings of 3 or less included 17 accessions having near immune reaction. A total of 274 (45%) accessions showed moderately resistant to moderately susceptible reaction type, and these accessions could be pivotal for further detecting quantitative trait loci (QTL) of CLS resistance. A total of 33 wild beet accessions were found susceptible to CLS with disease ratings of 7 to 9. In addition, a total of 59 accessions could not be evaluated in the field this year due to the tiny size of plants or matured too early with no green leaves at time of disease rating. Overall, CLS evaluation from this year indicated the high levels of resistance in *B. maritima* and proved the concept of using wild beet as resistance source for sugarbeet improvement. Utilization of *B. maritima* accessions also has the benefit of increasing genetic base of sugarbeet.

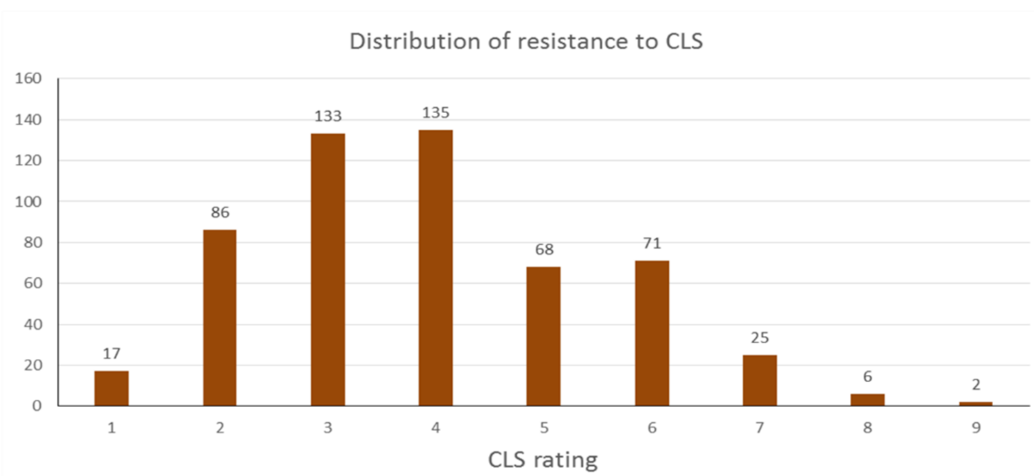

Fig. 1. Distribution of resistance to Cercospora leaf spot (CLS) in wild beet accessions evaluated in Foxhome, MN in 2022.

Based on origin of the *B. maritima* accession used in the evaluation, the highest number of resistant lines were collected from Italy (54), followed by France (53) and United Kingdom (35) including England and Wales. It is also noted that amongst the countries with more than 20 accessions, the highest percentage of resistant was observed in lines collected from Denmark where 66% of the accessions showed resistant response followed by Italy with 52% of the genotypes resistant to CLS (Fig. 2).

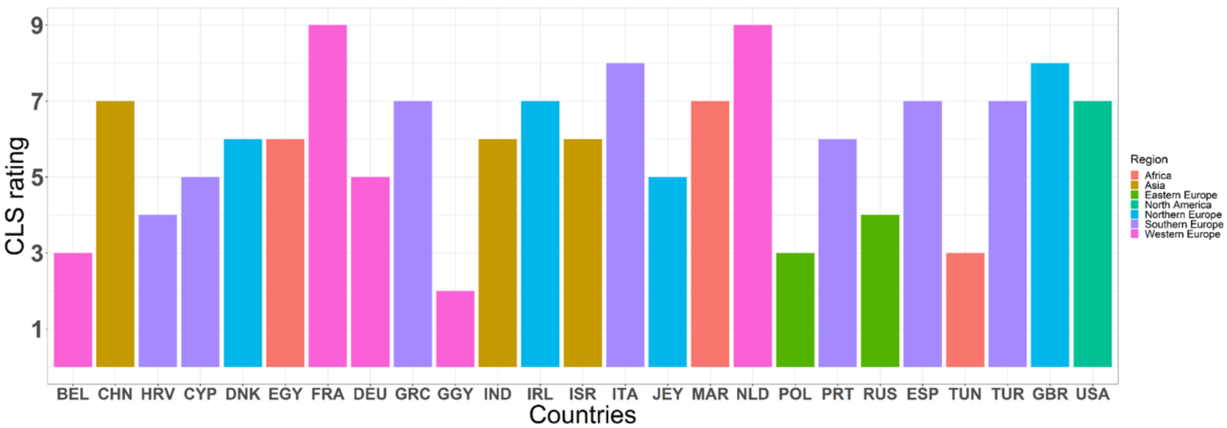

Fig. 2. Distribution of resistance to Cercospora leaf spot (CLS) in wild beet accessions based on geographic location of accessions collected. CLS evaluation was conducted in Foxhome, MN in 2022.

Genotypic data

A set of 520K raw SNPs were generated by the GBS platform. After the initial QC based on missing percentage and filtration of minor allele frequency (MAF) greater than 5%, a set of 147,764 markers were selected and distributed across all nine chromosomes (**Fig. 3**). 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).

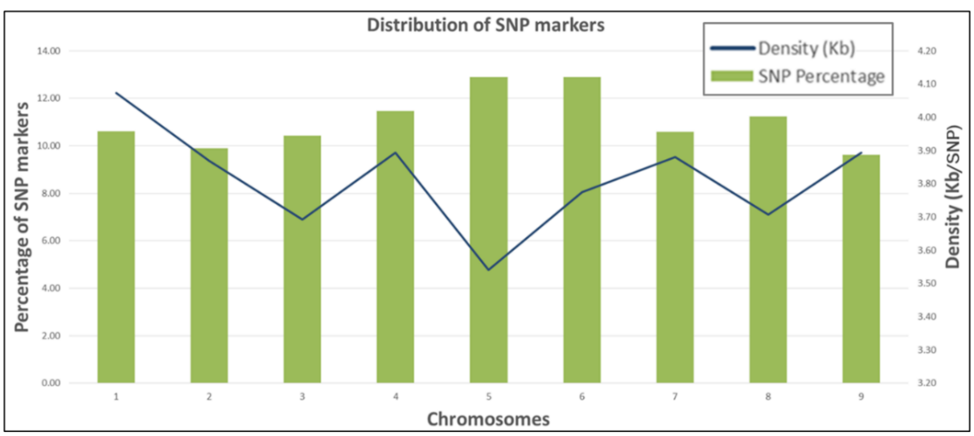

Fig. 3. Distribution of SNP markers across the genome.

Population structure

The STRUCTURE program identified 5 sub-populations in the whole *B. maritima* germplasm used in the current study with majority of accessions in the two sub-populations (Fig. 4). The sub-populations were mostly admixed though lines from the country tend to be closer to each other (Fig. 5).

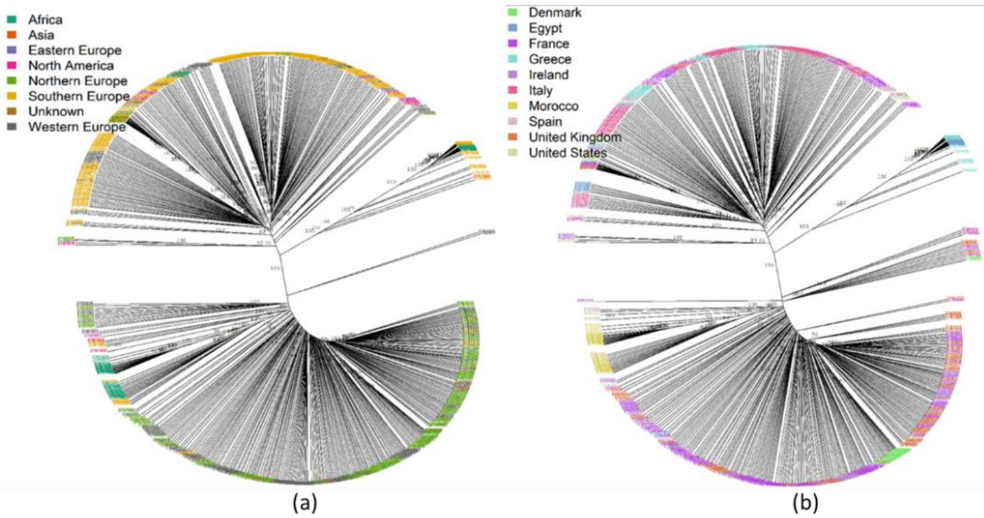

Fig. 4. Population structure of 602 wild beet accessions. (a) regional-based. (b) country based.

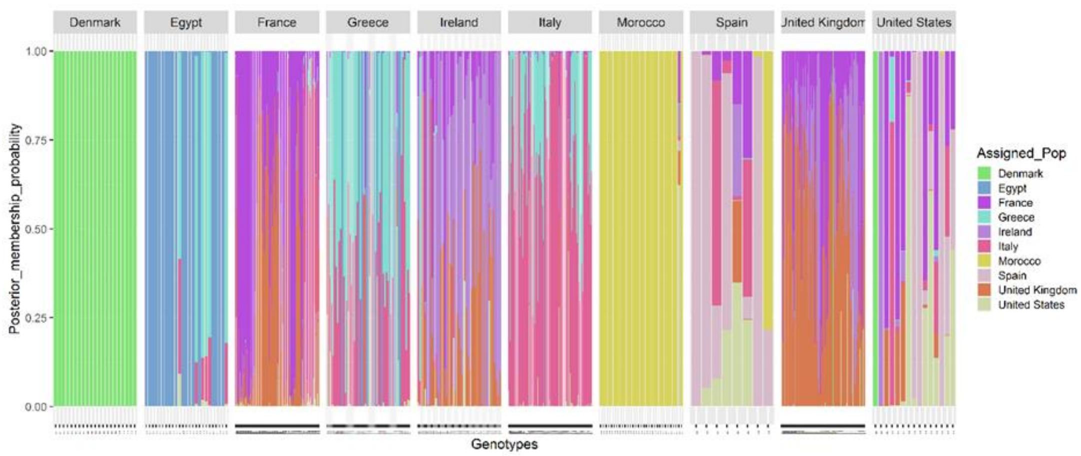

Fig. 5. Population structure of 602 wild beet accessions to show admixture and similarity of accessions from the same country.

Genome-wide association study (GWAS)

A total of 15 SNPs from all nine chromosomes were found significantly associated with CLS resistance based on the threshold of $P < 0.0001$. The highest number of significant markers were detected on the chromosome 8, followed by chromosome 2. The chromosomes 1, 3, 4, 5, 6, and 7 all harbored a single SNP associated with the resistance. Each marker explained 3 to 7% of the total phenotypic variation **(Table 2 and Fig. 6)**.

Table 2. Genomic regions significantly associated with resistance to CLS in wild beet accessions.

SNP	Allele	Chromosome	pseudo-molecule position*	LOD	Favorite allele	Effect	PVE (%)#
S1_8696154	T/C	1	8,696,154	4.1	T	-0.46	3.51
S2_26158536	G/C	2	26,158,536	4.5	G	-0.53	2.84
S2_39167159	G/A	2	39,167,159	4.3	G	-0.59	3.53
S2_39167176	G/A	2	39,167,176	4.3	G	-0.59	3.53
S3_31075893	T/A	3	31,075,893	4.4	T	-0.55	2.51
S4_11695614	A/G	4	11,695,614	4.2	A	-0.45	3.11
S5_52583161	A/C	5	52,583,161	4.2	A	-0.44	2.05
S6_5240439	A/G	6	5,240,439	4.4	G	-0.76	2.85
S7_32060319	T/G	7	32,060,319	4.2	T	-0.53	3.97
S8_38260846	T/C	8	38,260,846	5.3	T	-0.48	4.34
S8_1230157	A/T	8	1,230,157	4.5	T	-0.43	2.87
S8_21922678	G/A	8	21,922,678	4.3	G	-0.73	3.09
S8_14178686	T/C	8	14,178,686	4.1	C	-0.38	3.22
S9_6019498	G/T	9	6,019,498	4.4	T	-0.78	3.18
S9_6024336	G/T	9	6,024,336	4.1	T	-0.70	2.79

***pseudo-molecule position is according to McGrath et al. (2022).**
#PVE = phenotypic variation explained

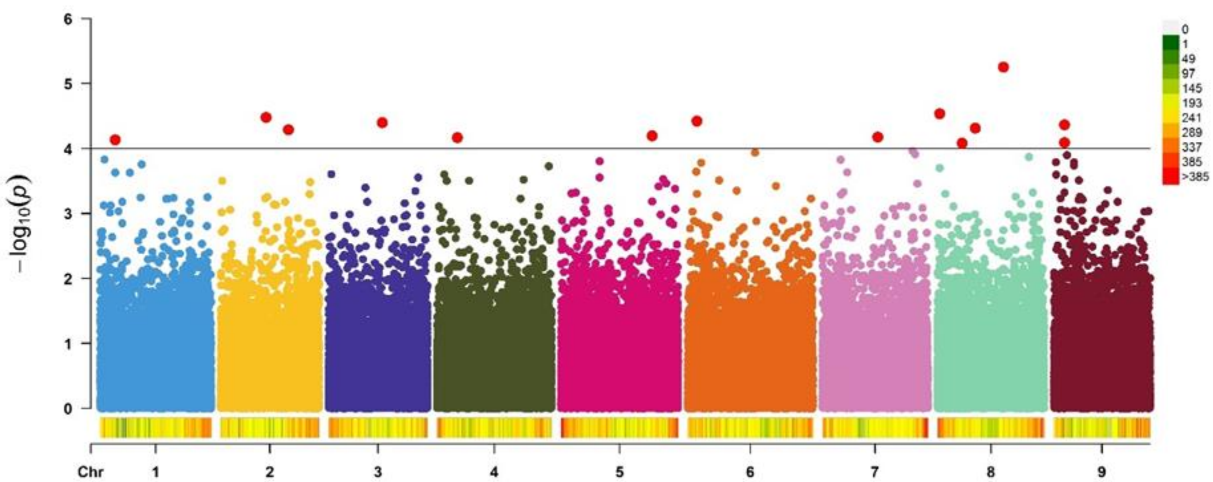

Fig. 6. Manhattan plots of GWAS showing genomic regions significantly associated with resistance to CLS in wild beet accessions.

Similar to our report, the significant markers to CLS resistance have been reported on all nine chromosomes (Weiland & Koch, 2004). Previously, Five QTL on chromosomes 1, 2, 3 and 9 with the phenotypic variability ranging from 7% - 18.3% (Nilsson et al., 1999); Seven QTL on five chromosomes with minor and major effects (Schäfer-Pregl et al., 1999); four minor effect QTL on three chromosomes (Koch et al., 2000); four QTL on four different chromosomes i.e. 3, 4, 7 and 9 explaining phenotypic variance ranging from 6.2% to 25.1% (Setiawan et al., 2000) and four QTL, two major and two minor on four chromosomes (Taguchi et al., 2011). CLS resistance is quantitative and polygenic with 4-5 genes involved in disease expression (Nielsen et al., 1997; Smith & Gaskill, 1970).

Candidate gene predictions and function annotations

Candidate genes with their putative proteins/enzymes associated with significant loci from GWAS were predicted using the Phytozome_13 database available at https://phytozome-next.jgi.doe.gov (McGrath et al., 2022). The reference genome was screened 2.5kb up and downstream the significant markers with putative functions that could be related to the trait were selected as candidates. Putative genes in 15 genomic regions were scanned and resulted in 16 genes according to sequence assembly EL10.2 **(Table 3)**.

Table 3. Candidate genes with putative proteins/enzymes

Gene	Chromosome	SNP	Protein/Enzyme
Bevul.1G028900	1	S1_8696154	Zinc finger, CCHC-type
Bevul.2G092000	2	S2_26158536	RNA-binding protein with serine-rich domain 1 (RNPS1)
Bevul.2G129400	2	S2_39167159	NAC DOMAIN CONTAINING PROTEIN 38
Bevul.2G129900	2	S2_39167176	Leucine rich repeat (LRR)
Bevul.3G145000	3	S3_31075893	MLO-LIKE PROTEIN
Bevul.4G062900	4	S4_11695614	Protein kinase domain
Bevul.5G170000	5	S5_52583161	disease resistance protein RPS2 (NB-ARC & LRR)
Bevul.6G031400	6	S6_5240439	F-box-like protein
Bevul.7G103000	7	S7_32060319	Glycoside hydrolase, Pectin lyase fold/virulence factor
Bevul.8G106900	8	S8_38260846	Zinc finger, CCHC-type
Bevul.8G010000	8	S8_1230157	MYB
Bevul.8G008200	8	S8_1230157	F-box domain proteins
Bevul.8G081100	8	S8_21922678	programmed cell death protein 5 (PDCD5, TFAR19)
Bevul.8G064200	8	S8_14178686	F-box domain
Bevul.8G037100	9	S9_6019498	ACYL CARRIER PROTEIN/ZINC FINGER PROTEIN
Bevul.8G035800	9	S9_6024336	RIBOSOMAL PROTEIN S6 KINASE

Among these genes, 10 were annotated for functional proteins directly involved in plants disease resistance and defense mechanism. The proteins related to these genes included *Leucine-rich repeat (LRR) domains, Protein kinase domain, F-box domain Proteins, NAC domain containing protein, disease resistance protein RPS2 (NB-ARC & LRR), Zinc finger C2H2-type proteins domain,* and *programmed cell death protein 5 (PDCD5, TFAR19)*. While the remaining 6 genes were reported to play key roles in plants defense via controlling signaling and regulatory pathways in plants. The putative proteins/enzymes related to these candidate genes include *RNA-binding protein with serine-rich domain 1 (RNPS1), MLO like protein, Glycoside hydrolase family Pectin lyase fold/virulence factor, MYB encoding protein, Acyl carrier protein/Zinc finger protein,* and *Ribosomal protein s6 kinase proteins.*

Acknowledgements

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SENSITIVITY OF *CERCOSPORA BETICOLA* TO FOLIAR FUNGICIDES IN 2022

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Leaf spot, caused by the fungus *Cercospora beticola*, is an endemic disease of sugarbeet produced in the Northern Great Plains area of North Dakota and Minnesota that reduces both yield and sucrose content. The disease is controlled by crop rotation, resistant varieties and timely fungicide applications. *Cercospora* leaf spot usually appears in the last half of the growing season, and multiple fungicide applications are necessary for disease management. Fungicides are used at high label rates and are alternated for best efficacy, but in recent years, mixtures are becoming more important. The most frequently used fungicides are Tin (fentin hydroxide), Topsin (thiophanate methyl), Eminent (tetraconazole), Proline (prothioconazole), Inspire (difenoconazole), Headline (pyraclostrobin) and Provysol (mefentrifluconazole). In 2022, 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 2022, extensive sensitivity monitoring was conducted for Tin, Eminent, Inspire, Proline, Provysol and Headline.

OBJECTIVES

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

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

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

4) Distribute results of sensitivity monitoring in a timely manner to the sugarbeet industry in order to make fungicide recommendations for disease management and fungicide resistance management for Cercospora leaf spot disease in our region.

METHODS AND MATERIALS

In 2022, with financial support of the Sugarbeet Research and Extension Board of MN and ND, we tested 648 *C. beticola* field isolates collected from throughout the sugarbeet production regions of ND and MN for sensitivity testing to Tin, Eminent, Inspire, Proline, Provysol and Headline. For this report we use the commercial name of the fungicides, but all testing was conducted using the technical grade active ingredient of each fungicide, not the formulated commercial fungicide. The term µg/ml is equivalent to ppm.

Sugarbeet leaves with Cercospora leaf spot (CLS) are collected from commercial sugarbeet fields by agronomists from American Crystal Sugar Company, Minn-Dak Farmers Cooperative and Southern Minnesota Beet Sugar Cooperative representing all production areas in ND and MN and delivered to our lab for processing. From each field sample, *C. beticola* spores were collected from a minimum of five spots per leaf from five leaves and mixed to make a composite of approximately 2500 spores. For Tin testing, a subsample of the spore composite was transferred to a Petri plate containing water agar amended with Tin at 1 ug/ml. Germination of 100 spores on the Tin amended water agar plates were counted 16 hours later and percent germination calculated. Germinated spores are considered resistant.

For triazole fungicide sensitivity testing, a radial growth procedure is used. A single spore subculture from the spore composite is grown on water agar medium amended with serial ten-fold dilutions of each technical grade triazole fungicide from 0.01 – 100 ppm. A separate test is conducted for each triazole fungicide. After 15 days, inhibition of radial growth is measured, and compared to the growth of *C. beticola* on non-amended water agar medium. This data is used to calculate an EC_{50} value for each isolate; EC_{50} is a standardized method of measuring fungicide resistance and is calculated by comparing the concentration of fungicide that reduces radial growth of *C. beticola* by 50% compared to the growth on non-amended media. Higher EC_{50} values mean reduced sensitivity to the fungicide. An RF (resistance factor) is calculated for each DMI fungicide by dividing the EC_{50} value by the baseline value so fungicides can be directly compared. Beginning in 2016, RF value calculations were increased to 10 ppm and in 2019 were increased to100 ppm to accommodate increased number of isolates with resistance to the DMI fungicides higher than 10 ppm.

For Headline resistance testing a PCR based molecular procedure was used to test for the presence of a specific mutation in *C. beticola* that imparts resistance to Headline. This procedure detects a specific mutation, G143A, which results in complete resistance to Headline. DNA is extracted from the remaining spore composite and tested by real-time PCR using primers specific for the G143A mutation. The test enables us to estimate the percentage of spores with the G143A mutation in each sample. The results are placed in five categories based on an estimate of the percentage of spores with the G143A mutation: S = no spores with G143A; S/r = <50 of the spores with G143A; S/R = equal number of spores with G143A; R/s >50% of the spores with G143A; and R = all spores with G143A**.** Each sample tested contains approximately 2500-5000 spores and the DNA from this spore pool will test for the G143A mutation from each spore. The PCR test is more sensitive and requires less interpretation than the previously used spore germination test. The PCR test will estimate the incidence of resistance in the population of spores tested, and give a better indication of Headline resistance in a field.

RESULTS AND DISCUSSION

CLS pressure was moderate in most locations in 2022 and many growers applied first fungicide application earlier than normal based on recommendations by cooperative agronomists. 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=648) representing all production areas and factory districts were tested for sensitivity to six fungicides: fentin hydroxide (Tin), tetraconazole (Eminent), difenoconazole (the most active part of Inspire), prothioconazole (Proline), mefentrifluconazole (Provysol) and pyraclostrobin (Headline).

TIN. Tolerance (resistance) to Tin was first reported in 1994 at concentrations of 1-2 µg/ml. At these levels, disease control in the field is reduced. The incidence of fields with isolates resistant to Tin at 1.0 µg/ml increased between 1997 and 1999, but the incidence of fields with resistant isolates has been declining since the introduction of additional fungicides for resistance management, including Eminent in 1999, Gem in 2002 and Headline in 2003. In 1998, the incidence of fields with isolates resistant to Tin at 1.0 µg/ml was 64.6%, and declined to less than 10% from 2002 to 2010. From 2011 to 2014 there was an increase in the number of fields with resistance **(Figure 1),** and from 2015 to 2017, the incidence of fields with isolates resistant to Tin increased from 38.5% to 97% (**Figure 1**). In 2018, the incidence of fields with isolates resistant to tin declined to 65.2% and declined again to 21.3% in 2019 (**Figure 1**). The incidence of fields with resistance to tin increased dramatically in 2020 (68.3%) and 2021 (98.9%) and remained high in 2022 **(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 remained high 2022. The incidence of fields with tin resistance increased in all factory districts (**Figure 2**). This increase in resistance is likely due to the increased and widespread use of tin. Because there is a fitness penalty with tin resistance, resistance will decline as tin usage declines.

DMI (triazoles). Resistance as measured by RF values in 2022 increased for for Provysol and increased slightly for Inspire.Inspire, Proline Eminent and Provysol (**Figure 3**). Resistanace to Proline decreased in 2022 (Figure 3). Interestingly, RF values for Eminent declined in 2022, and shifted to lower RF values (Figure 3). Percent of isolates with EC_{50} values >100 ppm were detected for Inspire (Figure 8) Proline (Figure 9) and Provysol, (Figure10), but not for Eminent (Figure 6). DMI fungicides (**Figure 4**), indicating continued increase of resistance levels. It is of interest to note that the number of isolates with resistance to Eminent >100 ppm decreased in 2021. Resistance as measured by RF values increased in all factory districts, with some variability (**Figure 4).** RF values were low and steady fo Proline, but these low RF values are likely due to using technical grade prothioconazole for testing instead of the active metabolic product desthioconazole.

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 2020, and continued in 2022 (**Figure 5**). Resistance to Headline did not decline in 2022 (**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. We do not know if there is a fitness penalty associated with the G143A mutation, but based on observation in other locations where QoI resistance due to the G143A mutation is widespread, it appears that isolates with the G143A mutation are stable and remain in the population.

SUMMARY

1. Resistance to Tin at 1.0 µg/ml almost disappeared in our region from 2003-2010, but has increased since 2011, probably due to increased use. Tin resistance declined in 2018 and 2019, increased in 2020 to 2021, and stabilized in 2022. The percentage of spores with resistance/field doubled in 2020 and increased by 144% in 2021 and stabilized in 2022 at 65%. Almost all field have tin resistance and efforts should continue to preserve this fungicide for CLS management.

2. This is where the action is. We now have four DMI fungicides available: Eminent, Proline, Inspire and Provysol. Resistance factors continue to increase for all DMI fungicides. Some isolates have EC_{50} values >100 ppm, which is very high, but Eminent levels >100 actually decreased. Resistance to DMI fungicides is present in all factory districts with some differences. Proline had much lower RF values, this may be due to the testing procedure used. DMI fungicides should be applied a mancozeb or copper mixing partner. Copper inhibits spore germination. A PCR test has been developed to detect DMI resistance, and we continue to validate this test for futue use.

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 2022 as in past years. These findings precluded the effective use of Headline for CLS management in 2022. Headline is not recommended for CLS management, but is used for frost protection.

4. We recommend continuing disease control recommendations currently in place including fungicide rotation, using high label rate of fungicides, mixtures with mancozeb or copper, scouting at end of the season to decide the necessity of a late application, using fungicide resistance maps for fungicide selection, using a resistant variety, spray intervals of 14 days, and applying fungicides to insure maximum coverage. Improvements in fungicide coverage using proper spray nozzles and spray parameters such as timing, rate, interval and coverage should be implemented.

5. We also recommend frist 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.

6.New varieties with higher levels of resistance were evaluated in the field with excellent disease resistance profiles. We urge the use of varieties with better CLS resistance. We did not receive enough samples of Cls samples CR+ varieties to evluate the impact of this genetic resistance on fungicide resistance.

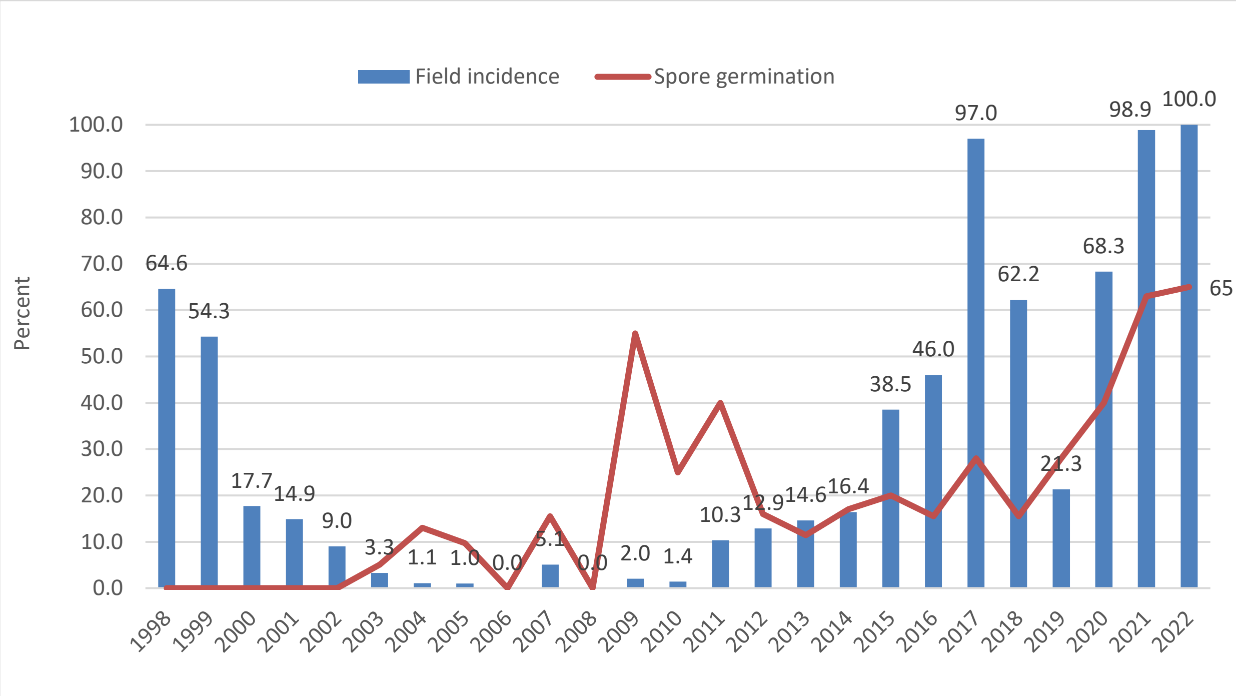

Figure 1. Incidence and severity of tin resistance in *C. beticola* isolates collected from sugarbeet fields in ND and MN from 1998 to 2022.

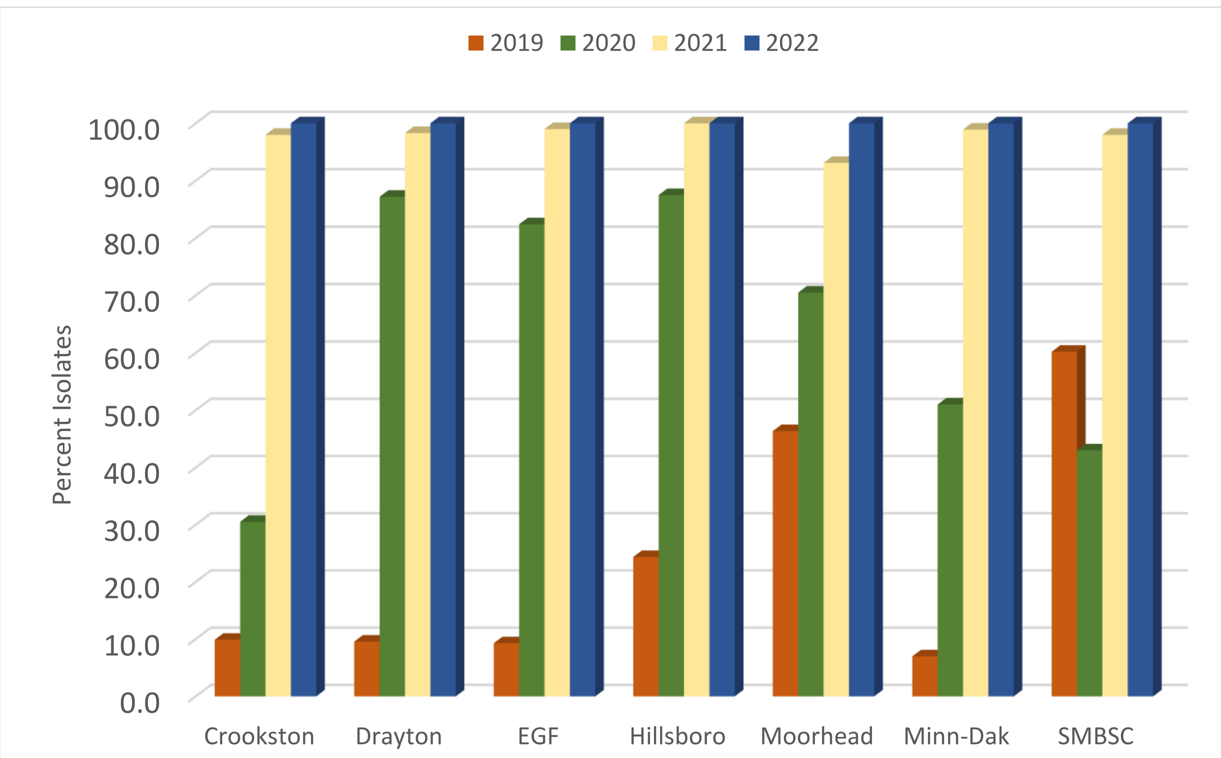

Figure 2. Incidence of fields with *C. beticola* isolates resistant to tin collected in ND and MN from 2019 to 2022 by factory district.

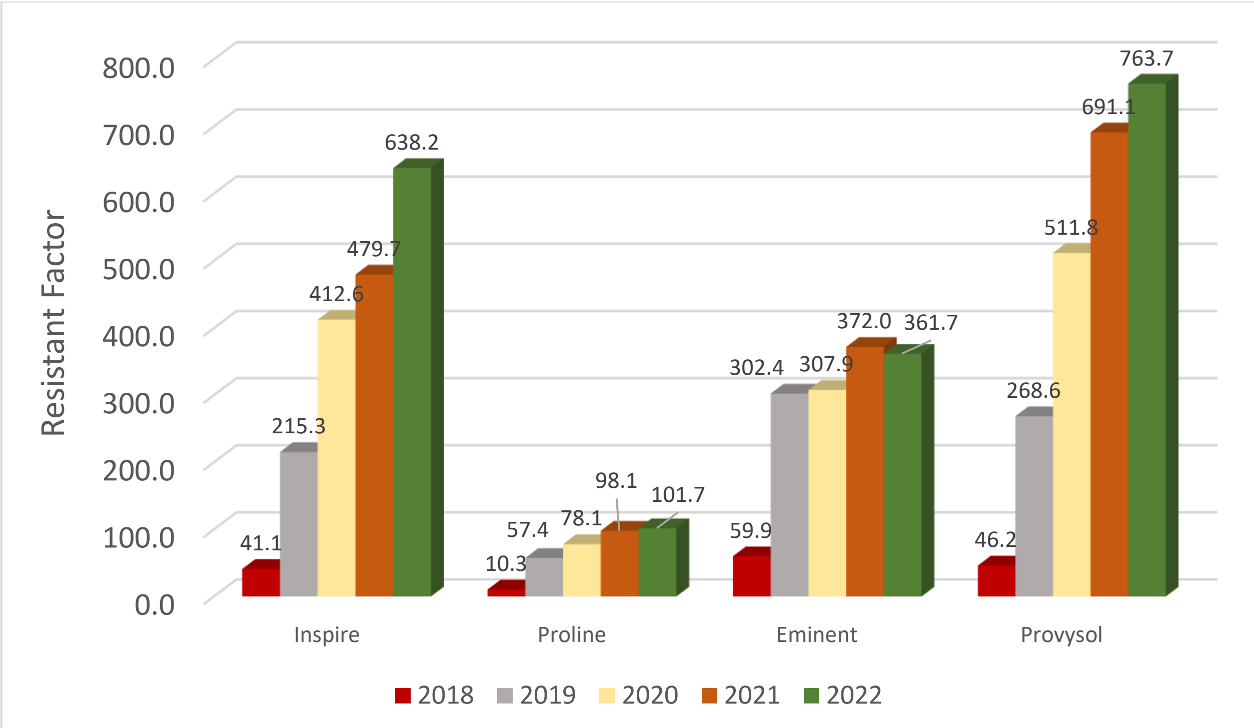

Figure 3. Resistance Factor of *C. beticola* isolates collected in ND and MN from 2018 to 2022 to Eminent, Inspire, Proline and Provysol.

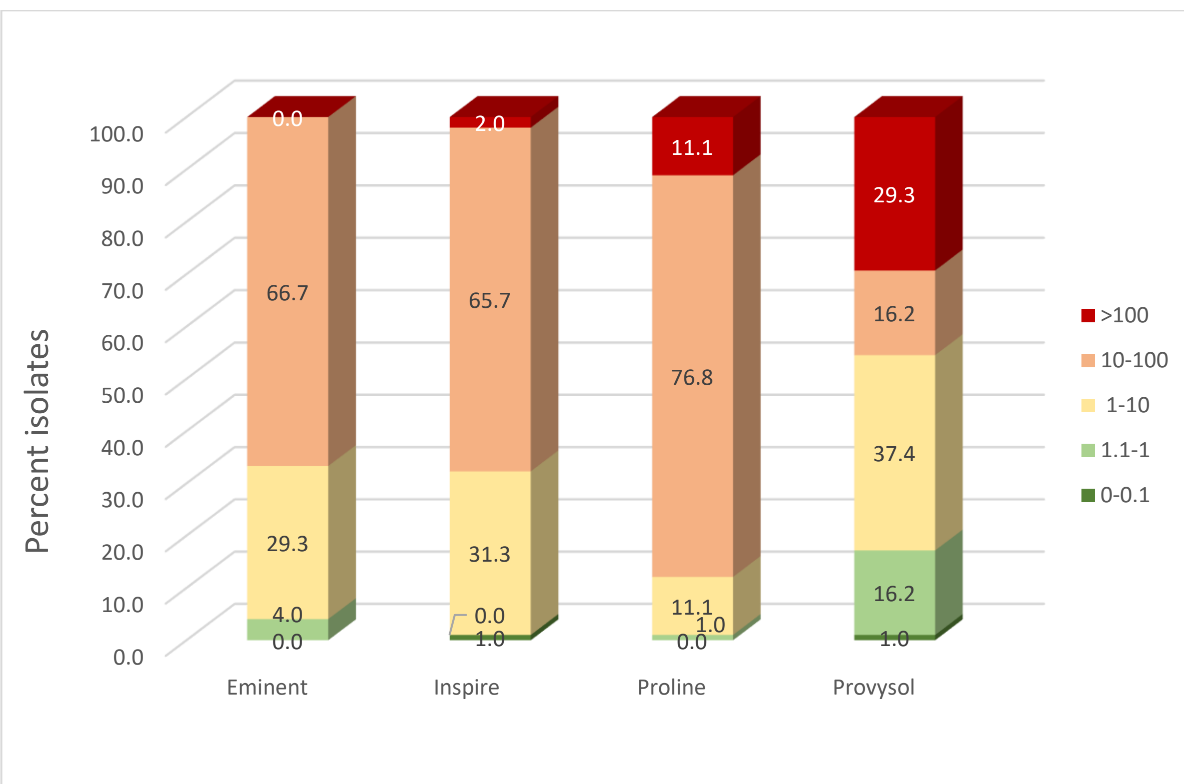

Figure 4. Distribution of sensitivity to Eminent, Inspire, Proline and Provysol of *C. beticola* isolates collected in 2022 as expressed by EC_{50} values.

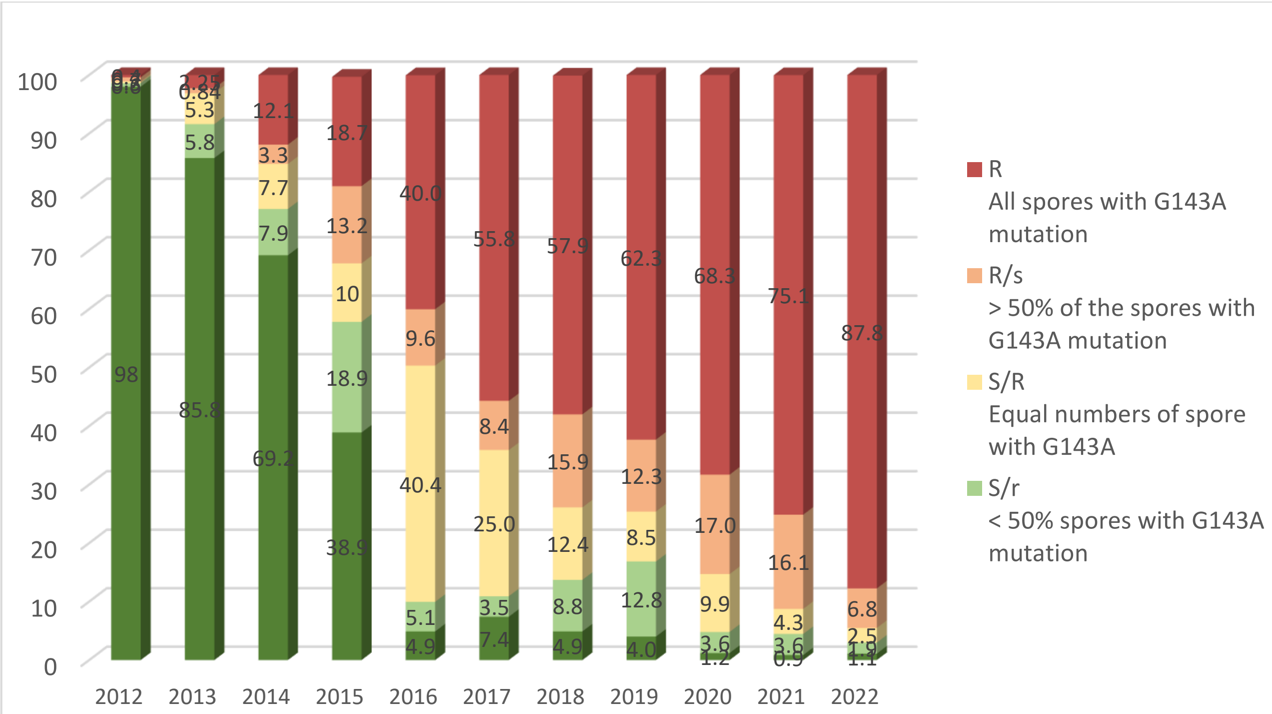

Figure 5. Sensitivity of *C. beticola* isolate populations collected in ND and MN to Headline from 2012 to 2022 as expressed by the percentage of spores with G143A mutation.

PRELIMINARY REPORT ON THE OPTIMIZATION OF FUNGICIDE APPLICATION TIMINGS FOR MANAGEMENT OF CERCOSPORA LEAF SPOT IN SUGAR BEET CR+ VARIETIES

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Sugar beet (*Beta vulgaris* L.) is an important crop in North America, contributing 55-60% of US sugar production. The Red River Valley of North Dakota and Minnesota produce more than half of the nation's sugar beets (USDA-ERS 2023). However, the crop is susceptible to Cercospora leaf spot (CLS) disease, caused *by Cercospora beticola*, which can reduce root yield and sucrose concentration and increases impurity concentrations resulting in reduced extractable sucrose and higher processing losses (Smith and Ruppel, 1973; Khan and Smith, 2005). Commercial varieties generally have only moderate levels of resistance and require fungicide applications to obtain acceptable levels of protection against Cercospora leaf spot (Miller et al., 1994) under moderate and high disease severity. Fungicides are an important management tool for CLS, and several applications may be required each year to protect yield and sugar. Recently, new varieties with increased CLS resistance are now available for growers in some areas and it is necessary to update fungicide timing recommendations. Therefore, the objective of this research is to evaluate fungicide application timings to control CLS in a standard susceptible sugar beet variety and two recently developed CLS resistant varieties containing the CR+ gene.

Materials and methods:

A field trial was conducted at Foxhome, MN in 2022. The experiment design was a split-plot design where varieties make up the main plots and fungicide treatments are the split plots. Field plots consisted of six 30-foot long rows spaced 22 inches apart. Plots were planted on 27 May with a variety susceptible to Cercospora Leaf Spot and two varieties highly tolerant to Cercospora Leaf Spot. Seeds were treated with Tachigaren and a treatment for controlling rhizoctonia. Seed spacing within the row was 4.7 inches. Weeds were controlled with herbicide applications (Nortron @ 6 pints) on 27 May, (Roundup Powermax @ 32fl oz; Outlook @ 12 fl oz; Class Act @ 1% v/v; Interlock @ 4 fl oz) 22 June and (Roundup Powermax @ 32 fl oz; Outlook 12 fl oz; Clean Slate @ 4 fl oz; Class Act @ 1% v/v; Interlock @ 4 fl oz) on 1 July as well as hand weeding throughout the summer. Quadris (14.3 fl oz) was applied on 28 June to control Rhizoctonia. Plots were inoculated on 8 July with C. beticola inoculum.

Fungicide spray treatments were applied with a CO_2 pressurized 4 nozzle boom sprayer with 11002 TT TwinJet nozzles calibrated to deliver 17 gallons per acre of solution at 60 p.s.i. to the middle four rows of plots. Most fungicide treatments were initiated on 7 July and were continued, based on treatment requirements, on 21 July, 1 August, 12 August, 25 August and 7 September.

Fungicide treatment list:

1. Non-treated check
2. Prior row closure + 10-14 days interval
3. Row closure + 10-14 days interval
4. Row closure + 28 days interval
5. Row closure + Daily infection value (DIV)
6. Disease onset
7. Disease onset + 28 days interval
8. Disease onset + DIV
9. 3-5% disease severity + 10-14 days interval
10. 3-5% severity + DIV

Cercospora leaf spot severity was rated on the leaf spot assessment scale of 1 to 10 (Jones and Windels, 1991). A rating of 1 indicated the presence of 1- 5 spots/leaf or 0.1% disease severity and a rating of 10 indicated 50% or higher disease severity. Cercospora leaf spot severity was assessed five times during the season. The rating performed on 12 September is reported.

Plots were defoliated mechanically and harvested using a mechanical harvester on 27 September. The middle two rows of each plot were harvested and weighed for root yield. Twelve to 15 representative roots from each plot, not including roots on the ends of the plot, were analyzed for quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. The data analysis was performed with the ANOVA procedure of the Agriculture Research Manager, version 2019.4 software package (Gylling Data Management Inc., Brookings, South Dakota). The least significant difference (LSD) test was used to compare treatments when the F-test for treatments was significant.

Results and discussion:

The development of *C. beticola* was slow at the beginning, with the first symptoms observed about 30 days post-inoculation (dpi) in the susceptible variety Crystal 572, and 43 dpi in the Cr+ varieties (ACH 973 and Beta 7029). On August 16, the CLS rating on the non-treated ACH 973 and Beta 7029 was 0.8 and 1.0, respectively, while the susceptible check Crystal 572 had reached 2.3, which was still below the CLS rating (6.0) at which economic losses typically occur. Warmer conditions in late August and early September usually results in more favorable conditions for rapid disease development, as indicated by a CLS rating of 4.5 and 8.8 for the non-treated susceptible check on August 29 and September 12, respectively. However, the CLS rating in both Cr+ varieties (ACH 973 and Beta 7029) did not increase further and remained under 2.0 (1.5 and 1.8) until the middle of September.

The varietal effect resulted in significantly better disease control in both Cr+ varieties, as shown in Figure 1 (data were normalized in percentage scale). Even the non-treated check did not exceed CLS severity of 2.0. Additionally, the treatment effect indicated that seven out of ten treatments were able to significantly control the disease (P=0.05), as depicted in Figure 2. The interactions between cultivar and treatment revealed that most of the interactions effectively controlled the disease, except for three treatments: Trt1 (non-treated check), Trt9 (at 3-5% severity with 10 to 14 days), and Trt10 (3-5% severity followed by DIV) in susceptible variety, as illustrated in Figure 3. Although disease control was better in Cr+ varieties, there was a notable contrast in plot yield. Susceptible Crystal 572 yielded statistically similar sugar yield as of Cr+ 'Beta 7029' however ACH 793 resulted in significantly lower yield. This high sucrose yield (lb/Acre) was found to be significantly affected by a high stand count in susceptible varieties, in contrast to both Cr+ varieties (average stand count more than 55 in Crystal 572).

Despite improved disease control in Cr+ varieties, there was a significant difference in sucrose yield. The susceptible variety Crystal 572 yielded statistically higher sugar (lb/acre) than ACH793 which was further found to be impacted by significantly lower stand count in Cr+ varieties compared to susceptible one. Regarding fungicide treatment, most treatments had resulted in similar root tonnage (ton/acre), sucrose concentration (%), and SLM (%) as the standard susceptible check except Trt-9, which was applied at 3-5% disease severity followed by 10-14 days interval. As expected, environmental ques had proven to be very important for disease control, as fungicide applications starting at 3-5% disease severity followed by DIV (Trt-8) had resulted in an economical control of disease in susceptible check costing just under $70.0.Summing up, *C. beticola* exhibited delayed growth in Cr+ varieties and all the fungicide treatments which applied before reaching 3-5% disease severity along with application made with close monitoring of DIV, effectively controlled the CLS.

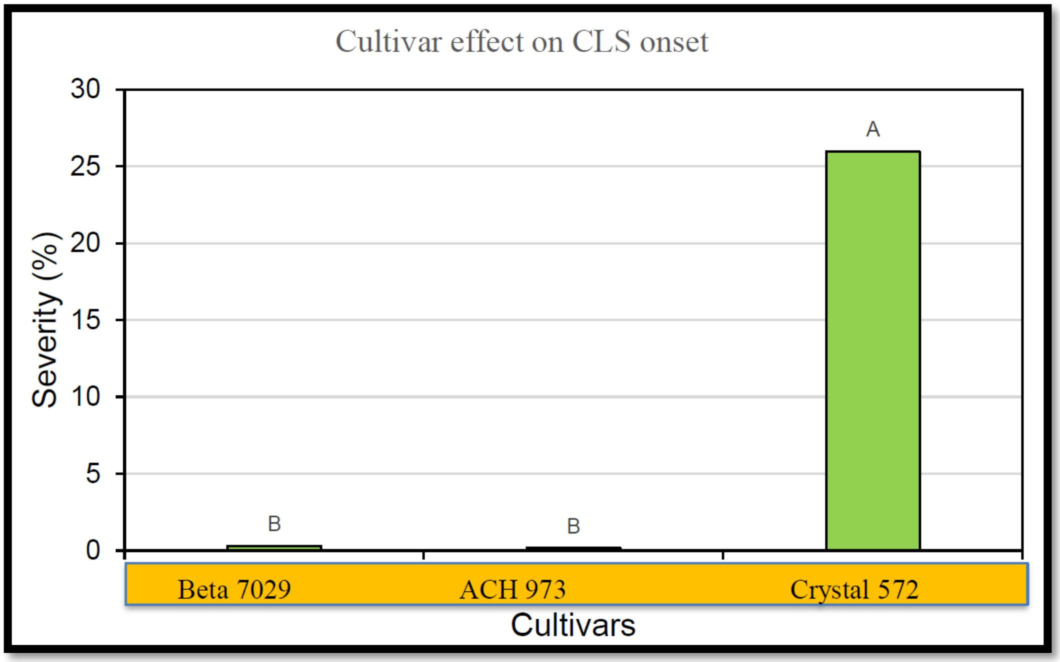

Fig 1: Varietal effect on Cercospora leaf spot control in sugar beets

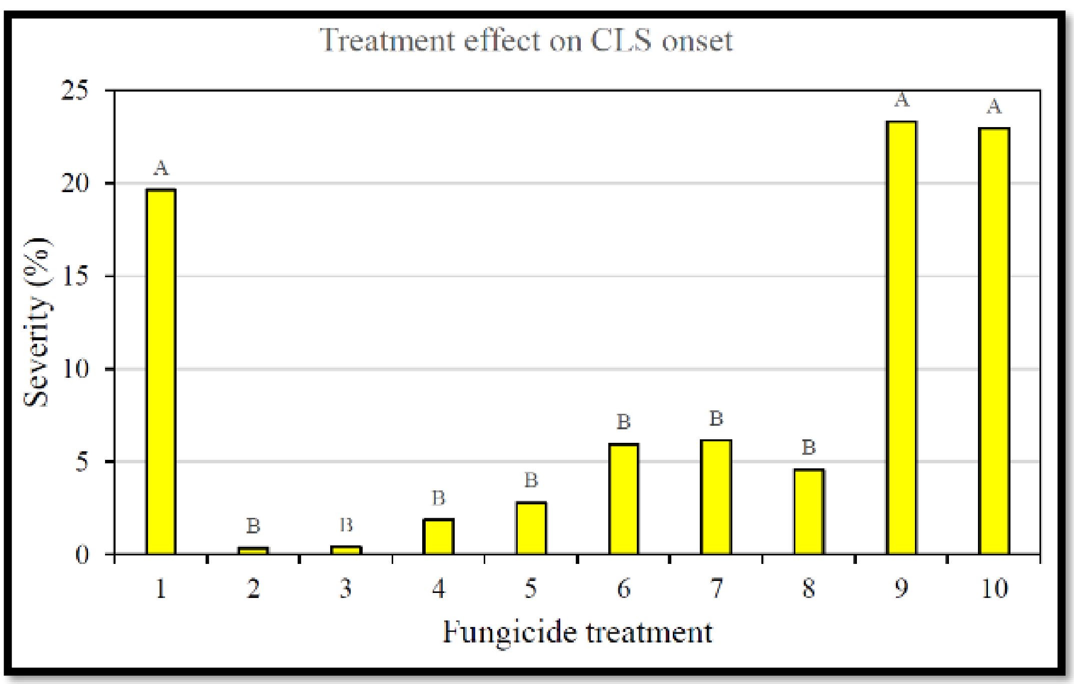

Fig 2: Fungicide treatment effect on control of Cercospora leaf spot in sugar beets

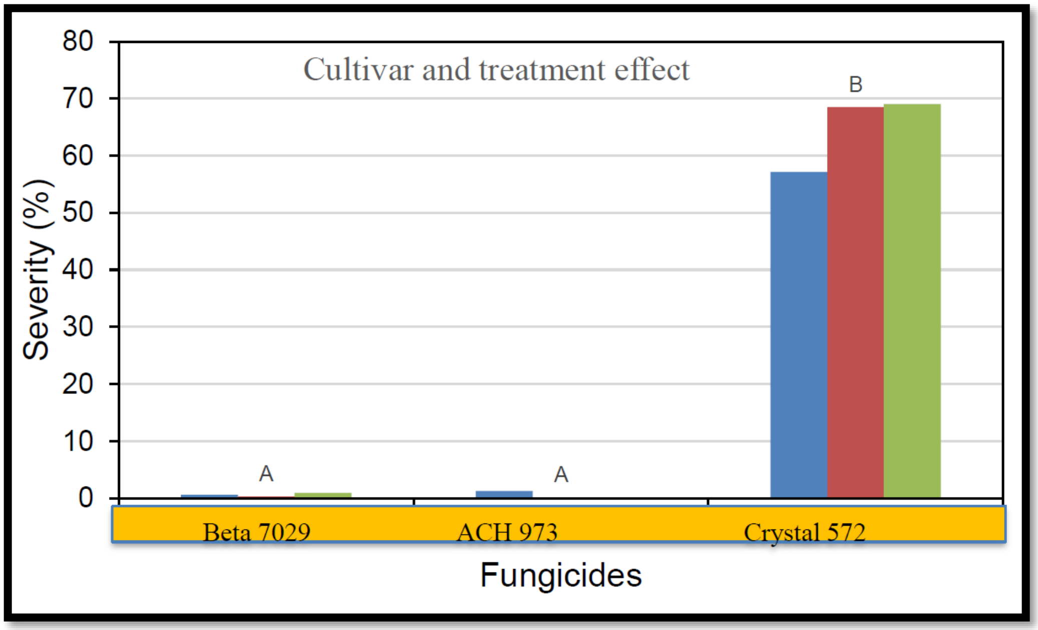

Fig3: Cultivar and treatment interactions effect on control of CLS in sugar beets

Treatment and rate/A amd timing	CLS rating	Root yield (Ton/Acre)	Sucrose %	Recoverable sucrose Lb/Ton	Lb/Acre
TABLE OF B (Fungicide Treatments) MEANS					
1 Untreated	4.0	24.73	19.509	366.23	9076.2
2 Super Tin;Badge SC;Minerva;Manzate Max;Inspire XT;Proline;Preference	1.8	24.88	19.799	373.03	9239.8
3 Super Tin;Badge SC;Minerva;Manzate Max;Inspire XT;Proline;Preference	2.5	28.14	19.595	368.43	10340.2
4 Super Tin;Badge SC;Minerva;Manzate Max;Inspire XT;Proline;Preference	2.4	24.56	19.888	369.93	9078.5
5 Super Tin;Badge SC;Minerva;Manzate Max;Inspire XT;Proline;Preference	2.7	26.81	19.520	368.36	9856.5
6 Super Tin;Badge SC;Minerva;Manzate Max;Inspire XT;Proline;Preference	4.0	24.10	19.787	372.82	8914.2
7 Super Tin;Badge SC;Minerva;Manzate Max;Inspire XT;Proline;Preference	1.8	25.71	20.126	381.43	9779.8
8 Super Tin;Badge SC;Minerva;Manzate Max;Inspire XT;Proline;Preference	2.2	25.04	19.380	364.55	9064.8
9 Super Tin;Badge SC;Minerva;Manzate Max;Inspire XT;Proline;Preference	1.7	26.76	19.628	370.68	9899.1
10 Treatment 10	3.8	22.08	20.315	384.66	8456.8
Untreated check					

References:

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VARIETY TESTING

NOTES

RESULTS OF AMERICAN CRYSTAL SUGAR COMPANY'S 2022 CODED OFFICIAL VARIETY TRIALS

Jason Brantner, Official Trial Manager Deborah L. Moomjian, Beet Seed Analyst

American Crystal Sugar Company Moorhead, Minnesota

American Crystal Sugar Company's (ACSC) coded Official Variety Trials (OVT) are designed to provide an unbiased evaluation of the genetic potential of sugarbeet variety entries under several different environments. The two-year average of these evaluations are then used to establish a list of approved varieties which ensures the use of high quality, productive varieties to maximize returns for growers and the cooperative as a whole.

This report presents data from the 2022 American Crystal OVTs and describes the procedures and cultural practices involved in the trials.

Table	Information in the Table
1	ACSC approved varieties for 2023
2	Multi-year performance of approved varieties (all locations combined)
3	Performance Data of RR 2023 Approved Varieties Under Aphanomyces Conditions (Relative to Susceptible Checks)
4	2017-2019 Conventional variety combined trials
5	Disease ratings for ACSC tested varieties (multiple diseases)
6	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
9-18	2022 Roundup Ready variety trials and combined trials
19-22	Approval calculations for ACSC market
23	Aphanomyces disease nursery ratings
24	Cercospora disease nursery ratings
25	Rhizoctonia disease nursery ratings
26	Fusarium disease nursery ratings
27	Herbicides and fungicides applied to official trials

Procedures and Cultural Practices

Sugarbeet official variety tests were conducted a t the ACSC growing region areas of the Red River Valley by ACSC personnel at the Technical Services Center.

All entries were assigned a code number by KayJay Ag Services. The seed then was sent to ACSC Technical Services Center at Moorhead for official testing. All Official Trials utilize seed identified by code numbers which prevents ACSC personnel from knowing variety names when conducting trials.

The 2022 official coded variety performance trials and disease nurseries were planted at 18 sites by American Crystal Sugar Company (ACSC) including 13 yield trial sites and five disease nurseries. Seven additional disease/insect nurseries were planted by third party cooperators. Thanks are extended to the dedicated Technical Services staff involved in the official trial plot care, harvest, and data analysis.

Results from the Official Variety Trial sites were good overall. Planting dates were two weeks later than typical but stands in the trials were good at most locations. Nine sites were used for variety approval calculations. One site (East Grand Forks) was lost from wind damage that occurred in mid-June. Buxton and Climax sites were very dry for much of the growing season including at harvest. Beets were small and data at these sites were compromised by excess harvest loss. The Perley site had severe Aphanomyces and high variability. Rhizoctonia crown and root rot was minimal in 2022. Revenue calculations in 2022 are based on a hypothetical $46.80 payment (5-year rolling average) at 17.5% sugar and 1.5% SLM not considering hauling or production costs.

Fusarium ratings are from sites at Moorhead and Sabin, MN. Rhizoctonia crown and root rot ratings are from nurseries at Crookston and Moorhead, MN and Saginaw, MI (BSDF). Aphanomyces root rot ratings are from naturally infested nurseries at Perley, Glyndon (Magno Seed), and Shakopee (KWS), MN. The Climax Aphanomyces site had no Aphanomyces disease pressure. Although the Perley site had high levels of Aphanomyces root rot, non-uniformity across the commercial trial resulted in high variability, so there are no yield results under Aphanomyces conditions for 2022. Cercospora leafspot ratings are from inoculated nurseries at Foxhome and Randolph (KWS), MN and Saginaw, MI (BSDF). Data from all three sites was highly correlated with ratings from a non-inoculated leafspot nursery at Averill, MN. Root aphid ratings are from a greenhouse assay at Shakopee, MN (KWS).

2022 harvest conditions were good overall, and beets dug well at most locations. Soil moisture levels varied from dry to wet depending on the location. Dry conditions along with small beets at Buxton and Climax resulted in excess harvest loss leading to high variability. The Alvarado site was challenging and slow-going due to wet, heavy soil.

The 2022 data have been combined with previous years' data and results are enclosed. Bolter data is presented as the number of bolters observed at a location for each variety. Results for the yield trials from individual sites are available in this report and on the internet.

Conventional trials were not planted in the 2022 OVT trials. Conventional varieties that were approved for 2020 - 2022 sales are permitted to continue in 2023 sales.

Yield trials were planted to stand at 4.5 inches. Starter fertilizer (10-34-0) was applied in-furrow (3 GPA in 6 GPA total volume) in all yield trials except St. Thomas. Plots were planted crosswise (90°) to the cooperators' normal farming operations, where possible. Plot row lengths for all official trials were maintained at 46 feet with about 40 feet harvested. Planting was performed with a 12-row SRES vacuum planter. The GPS controlled planter gave good single seed spacing which facilitated emergence counting. Seed companies had the option of treating seed with 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 Event (surfactant) and full rates of fungicides were applied using a pickup sprayer driven down the alleys. Two applications of Roundup (26 oz) were made at the 4-6 and 8-12 leaf stages. Hand weeding was used where necessary. All yield trials were treated with AZteroid in-furrow at planting (5.7 oz) and Quadris in a band during the 6-10 leaf stage (14 oz) for Rhizoctonia control.
Treatments used for Cercospora control in 2022 included Inspire XT/Manzate, Agri Tin/Incognito, Proline/Manzate, and Priaxor/Agri Tin. Ground spraying was conducted by ACSC technical staff using 20 GPA and 75-80 psi. The Ada site Cercospora applications were made by air.

Roundup Ready varieties with commercial seed 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 customized six-row harvester (Big Red) with increased cleaning capacity. All harvested beets of each plot were used for yield determination while one sample (approximately 25 lbs) for sugar and impurity analysis was obtained from each plot. Quality analysis was performed at the ACSC Technical Services quality lab in Moorhead.

Varieties were planted in nurseries in North Dakota, Minnesota, Michigan and Colorado to evaluate varieties for disease and insect susceptibility. ACSC adjusts the Cercospora, Aphanomyces, Rhizoctonia and Fusarium nursery data each year to provide a consistent target for variety approval criteria.

Acknowledgements

Thanks to the beet seed companies for their participation in the official variety testing program and to grower-cooperators. Thanks to dedicated Technical Services staff, Jon Hickel, Dan Walters, Earl Hodson, Alec Deschene, Nick Weller, Gary Hamann, and Clint Moe 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. Special thanks are extended to Dr. Mohamed Khan for Cercospora nursery inoculation, 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 Aphanomyces nursery data, KWS staff for Aphanomyces and Cercospora nursery data, and KayJay Ag Services for sampling and coding all variety entrie

Table 1.
Varieties Meeting ACSC Approval Criteria for the 2023 Sugarbeet Crop +++

Roundup Ready ®	Full Market	Aph Spec	Rhc Spec	High Rzm
BTS 8629	Yes Yes	Yes Yes		Hi Rzm Hi
BTS 8927	Yes	Yes		Rzm Hi
BTS 8961	Yes	Yes	New	Rzm Hi
BTS 8018	Yes	Yes		Rzm Hi
BTS 8034	Yes	Yes		Rzm Hi
BTS 8073	Yes	Yes		Rzm Hi
BTS 8092	New No	New	Yes	Rzm Hi
BTS 8100	New	New	New	Rzm Hi
BTS 8133		New	New	Rzm Hi
BTS 8156				Rzm
Crystal 572	Yes Yes	Yes Yes		Hi Rzm Hi
Crystal 684	Yes Yes	Yes Yes		Rzm Hi
Crystal 793	Yes Yes	Yes Yes		Rzm Hi
Crystal 912	Yes Yes	Yes Yes	Yes	Rzm Hi
Crystal 913	New New	New		Rzm Hi
Crystal 021	New	New	Yes Yes	Rzm Hi
Crystal 022	New	New	Yes	Rzm Hi
Crystal 026		New		Rzm Hi
Crystal 130			New	Rzm Hi
Crystal 134				Rzm Hi
Crystal 137			New	Rzm Hi
Crystal 138				Rzm
Hilleshög HM9528	Yes Yes	Yes		Hi Rzm
Hilleshög HIL9708	Yes Yes	Yes++	Yes	Rzm Hi
Hilleshög HIL9920	Yes Yes	Yes Yes		Rzm Hi
Hilleshög HIL2317	Yes Yes	Yes		Rzm Hi
Hilleshög HIL2320	New New			Rzm Hi
Hilleshög HIL2366		Yes		Rzm Hi
Hilleshög HIL2367				Rzm Hi
Hilleshög HIL2368			Yes	Rzm Hi
Hilleshög HIL2386		New		Rzm Hi
Hilleshög HIL2389				Rzm
Maribo MA717 Maribo	Yes Yes	Yes++		Hi Rzm Hi
MA902	New		New	Rzm Hi
Maribo MA932				Rzm
SV 265	Yes Yes			Hi Rzm Hi
SV 285	Yes	Yes		Rzm Hi
SV 203		Yes		Rzm
SX 1898	Yes New	Yes		Hi Rzm Hi
SX 1815	New			Rzm Hi
SX 1818				Rzm

2019 Conventional	Full Market	High Rzm
Crystal R761	Yes	Hi Rzm
Crystal 620	Yes	Hi Rzm
Crystal 840	Yes	Hi Rzm
Crystal 950	Yes	Hi Rzm
Hilleshög HM3035Rz	Yes	Rzm
SX 8869 Cnv	Yes	Hi Rzm
SV 48777	Yes	Hi Rzm

Aph Spec = variety meets Aphanomyces specialty requirements
Rhc Spec = variety meets Rhizoctonia specialty requirements Hi
Rzm = may perform better under severe Rhizomania.
New = newly approved

+++ Roundup Ready sugarbeets are subject to the ACSC RRSB Bolter Destruction Policy Created 11/8/2022
++ 2nd Year of not meeting Specialty Approval of previously approved Specialty variety. According to Approval Policy, may be sold as Specialty in 2023
+ 1st Year of not meeting Specialty Approval of previously approved Specialty variety. According to Approval Policy, may be sold as Specialty in 2023
Roundup Ready ® is a registered trademark of Monsanto Company.

Table 2. Performance Data of RR Varieties During 2021 & 2022 Growing Seasons (All Locations Combined) Approved for Sale to ACSC Growers in 2023 +++

Variety	Yrs Com	Rev/Ton ++ 22	Rev/Ton ++ 2 Yr	Rev/Ton ++ 2Y%	Rev/Acre ++ 22	Rev/Acre ++ 2 Yr	Rev/Acre ++ 2Y%	Rec/Ton 22	Rec/Ton 2 Yr	Rec/Acre 22	Rec/Acre 2 Yr	Yield 22	Yield 2 Yr	Sugar 22	Sugar 2 Yr	Molasses 22	Molasses 2 Yr	Emerg 22	Emerg 2 Yr	Bolters * 22	Bolters * 2 Yr	CR + 22	CR + 2 Yr	Aph Root+ 22	Aph Root+ 2 Yr	Rhizoc.+ 22	Rhizoc.+ 2 Yr	Fusarium+ 22	Fusarium+ 2 Yr	Rzm+
Previous Approved # locations		9	20		9	20		9	20	9	20	9	20	9	20	9	20	9	20	9	20	3	5	3	4	3	5	2	3	
BTS 8018	1	49.38	50.16	102	1447	1534	113	329	333	9656	10236	29.5	30.8	17.54	17.76	1.11	1.09	76	80	0	0	2.0	2.2	4.0	4.3	3.9	3.9	3.0	3.1	Hi
BTS 8034	1	45.34	45.96	94	1362	1475	108	315	319	9469	10255	30.0	32.2	17.02	17.18	1.27	1.22	77	80	0	0	2.3	2.4	3.9	3.6	4.5	4.2	2.2	2.4	Hi
BTS 8073	1	48.88	49.09	100	1461	1497	110	327	330	9787	10090	30.0	30.7	17.50	17.63	1.15	1.14	73	76	0	0	4.6	4.6	4.0	4.2	4.2	3.9	3.1	3.3	Hi
BTS 8092	1	46.04	47.63	97	1406	1509	111	318	325	9722	10318	30.7	31.9	17.01	17.34	1.14	1.10	74	77	0	0	4.3	4.4	3.9	4.0	3.6	3.7	3.9	4.0	Hi
BTS 8629	5	44.85	45.67	93	1385	1488	109	314	318	9687	10382	30.9	32.6	16.85	17.07	1.18	1.16	78	79	0	0	4.5	4.7	4.5	4.4	3.7	4.0	4.0	4.1	Hi
BTS 8927	2	52.46	52.47	107	1452	1512	111	339	341	9399	9856	27.8	29.0	17.97	18.09	1.03	1.04	79	75	0	0	4.4	4.4	4.0	4.3	4.1	3.9	3.1	3.6	Hi
BTS 8961	2	45.73	46.94	96	1369	1463	107	316	322	9478	10065	30.0	31.2	17.02	17.31	1.20	1.19	77	77	0	0	4.5	4.5	4.5	4.6	3.7	3.7	2.9	3.1	Hi
Crystal 021	NC	46.11	47.35	97	1390	1505	110	318	324	9577	10310	30.1	31.9	17.06	17.35	1.18	1.16	71	74	0	0	2.1	2.2	3.7	4.0	3.6	3.5	3.4	3.8	Hi
Crystal 022	1	52.56	52.15	107	1449	1496	110	339	340	9376	9799	27.7	28.9	18.04	18.08	1.08	1.08	73	76	1	1	4.6	4.8	4.0	4.4	4.1	3.8	3.2	3.4	Hi
Crystal 026	NC	47.52	47.74	98	1430	1516	111	322	325	9691	10331	30.0	31.8	17.30	17.45	1.18	1.19	77	79	0	0	4.7	4.6	3.8	3.7	3.3	3.3	2.8	2.8	Hi
Crystal 572	6	51.53	51.21	105	1424	1477	108	336	337	9292	9746	27.7	29.0	17.92	17.97	1.14	1.14	78	79	1	2	4.5	4.6	4.6	4.5	4.3	4.1	2.9	3.1	Hi
Crystal 684	4	44.38	45.14	92	1411	1472	108	312	316	9945	10358	32.0	32.8	16.83	17.04	1.23	1.22	75	78	0	0	4.6	4.6	3.8	3.7	4.2	4.0	2.3	2.5	Hi
Crystal 793	4	49.98	50.64	103	1476	1551	114	331	335	9773	10289	29.6	30.8	17.61	17.83	1.08	1.08	76	78	0	0	4.1	4.1	3.8	3.8	4.7	4.5	3.0	2.9	Hi
Crystal 912	1	44.59	46.32	95	1433	1549	114	313	320	10047	10734	32.2	33.6	16.82	17.18	1.19	1.16	76	78	0	0	4.8	5.0	3.4	3.7	3.3	3.5	3.7	3.9	Hi
Crystal 913	2	49.53	50.44	103	1458	1519	111	329	334	9702	10098	29.5	30.3	17.58	17.82	1.13	1.11	75	76	0	0	3.7	3.9	3.8	4.1	4.2	4.1	3.1	3.4	Hi
Hilleshög HIL2317	2	48.84	49.36	101	1371	1411	104	327	331	9185	9468	28.1	28.7	17.40	17.62	1.06	1.09	75	75	0	0	5.1	4.8	3.9	4.5	4.7	4.7	5.7	5.9	Hi
Hilleshög HIL2320	1	47.65	47.29	97	1403	1407	103	323	324	9528	9654	29.6	29.9	17.26	17.33	1.12	1.15	77	80	0	0	5.0	4.9	4.0	4.3	3.9	3.8	4.7	4.6	Hi
Hilleshög HIL2366	1	46.59	47.78	98	1351	1416	104	319	325	9263	9648	29.0	29.7	17.08	17.38	1.12	1.12	77	81	0	0	5.0	5.0	4.3	5.1	3.9	4.0	4.8	4.7	Hi
Hilleshög HIL2367	NC	47.72	47.76	98	1356	1399	103	323	325	9226	9564	28.7	29.5	17.30	17.42	1.15	1.17	75	78	0	0	4.8	4.8	4.2	4.6	3.9	4.0	4.2	4.2	Hi
Hilleshög HIL2368	NC	49.55	50.19	103	1154	1247	91	329	333	7696	8310	23.6	25.1	17.58	17.80	1.13	1.14	54	68	0	0	4.6	4.6	4.6	4.9	3.5	3.2	4.3	4.4	Hi
Hilleshög HIL9708	5	47.55	47.61	97	1342	1372	101	323	325	9127	9387	28.4	29.0	17.23	17.34	1.11	1.11	80	80	0	0	4.9	4.8	4.4	5.4	3.8	3.8	3.8	4.3	Rzm
Hilleshög HIL9920	4	48.16	49.17	100	1383	1440	106	325	330	9342	9692	28.8	29.4	17.34	17.63	1.12	1.13	77	76	0	0	4.9	4.8	4.3	4.5	4.6	4.6	5.7	5.6	Hi
Hilleshög HM9528RR	7	46.64	46.19	94	1368	1380	101	319	320	9374	9558	29.4	29.9	17.07	17.11	1.10	1.12	77	76	0	0	4.8	4.6	4.1	4.8	4.0	4.2	4.8	4.9	Hi
Maribo MA717	4	46.39	45.64	93	1397	1406	103	319	318	9605	9809	30.2	30.9	17.07	17.05	1.14	1.15	76	75	0	0	5.1	4.9	4.4	5.6	3.9	4.1	4.9	5.0	Hi
Maribo MA902	2	47.16	47.42	97	1310	1369	100	321	324	8954	9381	28.0	29.0	17.17	17.32	1.11	1.12	82	83	0	0	4.9	4.8	4.6	5.8	3.6	3.7	4.3	4.4	Hi
SV 203	1	47.41	49.14	100	1296	1387	102	322	330	8835	9344	27.5	28.4	17.28	17.64	1.18	1.14	63	71	0	0	4.7	4.7	4.2	4.3	4.2	4.3	5.6	5.8	Hi
SV 265	5	46.24	46.95	96	1321	1369	100	318	323	9114	9420	28.7	29.3	17.01	17.22	1.11	1.09	75	76	1	1	4.5	4.4	4.3	4.6	4.0	4.1	6.1	5.9	Hi
SV 285	2	47.58	48.93	100	1276	1400	103	323	329	8672	9442	27.0	28.7	17.31	17.61	1.18	1.15	65	74	0	0	4.7	4.7	4.3	4.4	4.5	4.4	5.5	5.9	Hi
SX 1898	2	46.94	48.58	99	1297	1388	102	320	328	8873	9403	27.8	28.8	17.19	17.55	1.17	1.15	65	71	0	0	4.7	4.7	4.2	4.6	4.1	4.2	5.4	5.5	Hi
Newly Approved																														
BTS 8100	NC	48.43	49.86	102	1363	1453	107	325	332	9207	9731	28.4	29.4	17.44	17.77	1.17	1.16	76	79	0	0	3.9	3.9	3.8	3.8	3.7	3.4	2.3	2.6	Hi
**BTS 8133	NC	44.28	45.29	93	1392	1496	110	312	317	9787	10476	31.4	33.1	16.77	17.03	1.19	1.19	80	82	0	0	2.2	2.3	3.6	3.5	3.4	3.7	3.0	3.3	Hi
BTS 8156	NC	49.07	48.86	100	1410	1480	109	327	329	9411	9998	28.7	30.5	17.57	17.62	1.20	1.17	82	84	0	0	2.4	2.5	4.2	3.9	4.2	4.0	2.3	2.5	Hi
Crystal 130	NC	50.48	50.72	104	1436	1528	112	332	335	9469	10140	28.5	30.4	17.72	17.85	1.11	1.10	74	78	0	0	2.1	2.2	3.6	3.9	4.1	3.8	3.2	3.2	Hi
Crystal 134	NC	52.96	53.36	109	1430	1502	110	340	344	9228	9715	27.2	28.3	18.07	18.23	1.04	1.03	70	73	0	0	4.5	4.5	3.7	4.0	3.6	3.5	3.4	3.7	Hi
Crystal 137	NC	48.22	48.51	99	1390	1509	111	325	328	9381	10228	28.8	31.2	17.46	17.58	1.22	1.19	74	78	0	0	2.6	2.6	4.3	3.7	4.2	3.9	2.4	2.3	Hi
Crystal 138	NC	50.57	50.56	103	1471	1516	111	332	335	9690	10069	29.2	30.2	17.71	17.83	1.08	1.10	74	76	0	0	4.9	4.8	3.9	4.0	3.8	3.7	3.2	3.5	Hi
Hilleshög HIL2386	NC	47.52	48.38	99	1424	1461	107	322	327	9682	9905	30.1	30.3	17.25	17.52	1.13	1.15	76	80	1	1	4.5	4.4	4.3	5.1	3.5	3.9	3.7	4.0	Hi
Hilleshög HIL2389	NC	48.85	49.33	101	1407	1445	106	327	330	9431	9717	28.8	29.5	17.47	17.64	1.13	1.12	76	81	0	0	4.7	4.8	3.8	3.8	3.9	4.0	4.3	4.5	Hi
Maribo MA932	NC	47.95	48.03	98	1406	1446	106	324	326	9532	9848	29.6	30.3	17.33	17.45	1.14	1.15	76	79	0	0	4.8	4.8	4.3	4.4	3.8	3.9	4.2	4.1	Hi
SX 1815	NC	49.35	50.24	103	1403	1474	108	328	334	9366	9819	28.6	29.5	17.53	17.78	1.11	1.10	76	79	0	0	5.1	4.9	4.3	4.2	4.1	4.3	5.3	5.1	Hi
SX 1818	NC	47.24	48.28	99	1361	1458	107	321	327	9281	9904	29.0	30.4	17.21	17.47	1.15	1.13	71	75	0	0	4.7	4.8	4.8	5.2	4.2	4.3	4.5	4.9	Hi
Benchmark var. mean		48.23	48.94		1324	1363		325	329	8945	9210	27.6	28.1	17.44	17.66	1.20	1.20	74	76											

+++2021 Sites include Casselton, Glyndon, Georgetown, Hendrum, Hillsboro, Grand Forks, Scandia, Climax, Forest River, Hallock and Bathgate

Emergence is % of planted seeds producing a 4 leaf beet.

Created 11/4/2022

+++2022 Sites include Casselton, Averill, Ada, Grand Forks, Scandia, Alvarado, St. Thomas, Hallock, Bathgate

++2022 Revenue estimate based on a $46.80 beet payment (5-yr ave) at 17.5% crop with a 1.5% loss to molasses and 2021 Revenue estimate based on a $45.65 beet payment. Revenue does not consider hauling or production costs.

* Number of bolters observed across locations.

+ Aph ratings from Perley MN, Shakopee MN and Glyndon MN (res.<4.2, susc>4.8). CR from Randolph MN, Foxhome MN and Saginaw MI (res.<4.4, susc>5.0). Fusarium from Moorhead MN and Sabin 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 Rhizomania.

** Does not meet Full Market Approval. Meets Aphanomyces Specialty Approval and Rhizoctonia Approval.

Table 3. Performance Data of RR 2023 Approved Varieties Under Aphanomyces Conditions (Relative to Susceptible Checks)+++

Variety	Yrs	*Aph	Rev/Ton++				Rev/Acre++				Rec/Ton			Rec/Acre			Sugar			Yield			CR Rating +			Aph Root +			Fusarium + Rhizoctonia+			
Variety	Com	Spc	2022#	2021#	2020	%Sus	2022#	2021#	2020	%Sus	2022#	2021#	2020	2022#	2021#	2020	2022#	2021#	2020	2022#	2021#	2020	22	2Yr	3Yr	22	2 Yr	3 Yr	22	2Yr	22	2Yr
Previous Approved #	locations		0	0	2		0	0	2		0	0	2	0	0	2	0	0	2	0	0	2	3	5	8	3	4	7	2	3	3	5
BTS 8018	1	Yes	--	--	40.59	132	--	--	982	167	--	--	303.9	--	--	7256	--	--	16.22	--	--	23.62	2.03	2.17	2.25	4.00	4.26	4.13	2.98	3.10	3.93	3.88
BTS 8034	1	Yes	--	--	35.57	115	--	--	887	150	--	--	286.7	--	--	7046	--	--	15.53	--	--	24.32	2.28	2.42	2.51	3.89	3.56	3.83	2.16	2.43	4.49	4.18
BTS 8073	1	Yes	--	--	39.92	130	--	--	935	159	--	--	301.6	--	--	6983	--	--	16.16	--	--	22.91	4.55	4.55	4.59	4.01	4.15	3.92	3.06	3.35	4.21	3.94
BTS 8092	1	Yes	--	--	37.53	122	--	--	916	155	--	--	293.3	--	--	6977	--	--	15.76	--	--	23.32	4.26	4.44	4.38	3.86	3.98	3.94	3.87	3.97	3.58	3.70
BTS 8629	5	Yes	--	--	32.72	106	--	--	789	134	--	--	276.5	--	--	6493	--	--	15.03	--	--	23.05	4.52	4.65	4.62	4.50	4.37	4.22	3.95	4.08	3.72	3.97
BTS 8927	2	Yes	--	--	43.12	140	--	--	985	167	--	--	312.6	--	--	7070	--	--	16.58	--	--	22.44	4.42	4.45	4.44	4.00	4.26	4.13	3.11	3.56	4.13	3.91
BTS 8961	2	Yes	--	--	36.54	119	--	--	835	142	--	--	290.0	--	--	6478	--	--	15.64	--	--	21.96	4.54	4.53	4.58	4.47	4.64	4.44	2.89	3.11	3.75	3.75
Crystal 021	NC	Yes	--	--	38.07	124	--	--	935	159	--	--	295.3	--	--	7071	--	--	15.86	--	--	23.47	2.08	2.18	2.19	3.74	3.97	3.80	3.39	3.79	3.58	3.48
Crystal 022	1	Yes	--	--	44.07	143	--	--	1047	178	--	--	315.8	--	--	7422	--	--	16.80	--	--	23.24	4.60	4.78	4.76	4.03	4.41	4.21	3.22	3.36	4.10	3.82
Crystal 026	NC	Yes	--	--	37.63	122	--	--	913	155	--	--	293.7	--	--	7034	--	--	15.84	--	--	23.74	4.69	4.56	4.63	3.76	3.75	3.75	2.81	2.80	3.28	3.31
Crystal 572	6	Yes	--	--	38.70	126	--	--	786	133	--	--	297.5	--	--	5929	--	--	15.99	--	--	19.61	4.50	4.63	4.57	4.60	4.54	4.45	2.88	3.11	4.28	4.08
Crystal 684	4	Yes	--	--	32.62	106	--	--	799	136	--	--	276.2	--	--	6622	--	--	14.93	--	--	23.61	4.59	4.57	4.52	3.81	3.71	3.79	2.28	2.52	4.24	4.03
Crystal 793	4	Yes	--	--	37.97	123	--	--	886	150	--	--	294.9	--	--	6732	--	--	15.80	--	--	22.43	4.10	4.12	4.18	3.82	3.78	3.81	3.03	2.92	4.73	4.55
Crystal 912	1	Yes	--	--	35.21	114	--	--	886	150	--	--	285.5	--	--	7041	--	--	15.44	--	--	24.35	4.81	4.97	4.90	3.44	3.70	3.69	3.66	3.88	3.28	3.53
Crystal 913	2	Yes	--	--	39.55	128	--	--	951	161	--	--	300.2	--	--	7129	--	--	16.06	--	--	23.53	3.73	3.92	3.99	3.79	4.09	3.98	3.13	3.40	4.23	4.08
Hilleshög HIL2317	2	Yes	--	--	36.66	119	--	--	741	126	--	--	290.5	--	--	5836	--	--	15.50	--	--	20.04	5.13	4.85	4.92	3.91	4.46	4.26	5.65	5.86	4.71	4.73
Hilleshög HIL2320	1	Yes	--	--	36.99	120	--	--	735	125	--	--	291.5	--	--	5721	--	--	15.58	--	--	19.48	5.01	4.90	4.97	4.00	4.33	4.07	4.73	4.62	3.88	3.84
Hilleshög HIL2366	1	No	--	--	37.57	122	--	--	729	124	--	--	293.5	--	--	5656	--	--	15.66	--	--	19.18	5.00	5.00	4.98	4.32	5.07	4.65	4.83	4.74	3.92	3.95
Hilleshög HIL2367	NC	Yes	--	--	37.28	121	--	--	740	125	--	--	292.5	--	--	5760	--	--	15.64	--	--	19.57	4.75	4.75	4.86	4.17	4.65	4.27	4.20	4.23	3.90	4.00
Hilleshög HIL2368	NC	No	--	--	40.99	133	--	--	693	117	--	--	305.2	--	--	5136	--	--	16.25	--	--	16.78	4.56	4.61	4.64	4.63	4.94	4.53	4.33	4.39	3.46	3.19
Hilleshög HIL9708	5	No	--	--	34.56	112	--	--	644	109	--	--	283.0	--	--	5192	--	--	15.19	--	--	18.11	4.86	4.76	4.83	4.45	5.39	4.91	3.83	4.29	3.78	3.78
Hilleshög HIL9920	4	Yes	--	--	35.57	115	--	--	706	120	--	--	286.5	--	--	5606	--	--	15.37	--	--	19.33	4.92	4.84	4.83	4.33	4.49	4.21	5.66	5.56	4.58	4.64
Hilleshög HIL9528	7	Yes	--	--	36.06	117	--	--	720	122	--	--	288.2	--	--	5703	--	--	15.42	--	--	19.63	4.76	4.64	4.71	4.07	4.79	4.43	4.80	4.85	4.01	4.24
Maribo MA717	4	No	--	--	34.86	113	--	--	731	124	--	--	284.0	--	--	5834	--	--	15.24	--	--	20.22	5.05	4.86	4.95	4.39	5.57	4.97	4.87	4.99	3.92	4.12
Maribo MA902	2	No	--	--	37.28	121	--	--	652	111	--	--	292.5	--	--	5126	--	--	15.61	--	--	17.57	4.95	4.79	4.85	4.59	5.78	5.19	4.30	4.40	3.57	3.69
SV 203	1	Yes	--	--	37.75	123	--	--	829	141	--	--	294.1	--	--	6380	--	--	15.78	--	--	21.48	4.74	4.74	4.84	4.24	4.30	4.31	5.55	5.77	4.19	4.26
SV 265	5	No	--	--	37.96	123	--	--	839	142	--	--	294.9	--	--	6388	--	--	15.77	--	--	21.30	4.46	4.38	4.44	4.30	4.63	4.41	6.08	5.87	3.96	4.06
SV 285	2	Yes	--	--	38.37	125	--	--	822	139	--	--	296.3	--	--	6301	--	--	15.89	--	--	21.15	4.72	4.75	4.66	4.35	4.42	4.37	5.47	5.87	4.53	4.39
SX 1898	2	Yes	--	--	37.53	122	--	--	855	145	--	--	293.4	--	--	6643	--	--	15.74	--	--	22.57	4.72	4.74	4.74	4.25	4.61	4.33	5.38	5.53	4.12	4.23

Variety	Yrs	*Aph	Rev/Ton++				Rev/Acre++				Rec/Ton			Rec/Acre			Sugar			Yield			CR Rating +			Aph Root +			Fusarium +		Rhizoctonia +	
Variety	Com	Spc	2022#	2021#	2020	%Sus	2022#	2021#	2020	%Sus	2022#	2021#	2020	2022#	2021#	2020	2022#	2021#	2020	2022#	2021#	2020	22	2Yr	3Yr	22	2 Yr	3Yr	22	2Yr	22	2Yr
Newly Approved																																
BTS 8100	NC	NC Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.87	3.94	--	3.78	3.83	--	2.32	2.56	3.73	3.41
**BTS 8133	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.23	2.26	--	3.57	3.51	--.	3.02	3.32	3.44	3.65
BTS 8156		Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.43	2.46	--	4.21	3.93	--	2.30	2.51	4.24	4.02
Crystal 130	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.10	2.24	--	3.57	3.90	--	3.22	3.22	4.08	3.82
Crystal 134	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.47	4.53	--	3.70	4.05	--	3.37	3.74	3.63	3.53
Crystal 137	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.57	2.55	--	4.25	3.69	--	2.35	2.30	4.18	3.86
Crystal 138	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.87	4.80	--	3.87	4.03	--	3.16	3.45	3.81	3.67
Hilleshög HIL2386	NC	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.54	4.42	--	4.31	5.14	--	3.73	3.99	3.51	3.85
Hilleshög HIL2389	NC	Yes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.69	4.77	--	3.78	3.82	--	4.34	4.54	3.92	3.96
Maribo MA932	NC	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.78	4.82	--	4.28	4.44	--	4.22	4.13	3.75	3.89
SX 1815	NC	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.07	4.93	--	4.28	4.24	--	5.32	5.07	4.12	4.26
SX 1818	NC	No	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.72	4.79	--	4.82	5.19	--	4.54	4.90	4.16	4.28
Aph Susc Checks					30.80				590				269.8			4984			14.75			18.00										
Mean of Aph Specialty Varieties					37.66				856				293.8			6575			15.76			22.12										

%Sus=Percent of 15 susceptible checks. Created 11/7/2022

* 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

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

++2022 Revenue estimate based on a $46.80 beet payment (5-yr ave) at 17.5% crop with a 1.5% loss to molasses, 2021 Revenue estimate based on a $45.65 beet payment and 2020 Revenue estimate based on $45.12 beet payment. Revenue does not consider hauling or production costs.

\+ Aph ratings from Perley MN, Shakopee MN and Glyndon MN (res.<4.2, susc>4.8). CR from Randolph MN, Foxhome MN and Saginaw MI (res.<4.4, susc>5.0). Fusarium from Moorhead MN and Sabin MN (res.<3.0, susc>5.0). # Lack of uniform Aphanomyces pressure at any of the OVT sites prevented collection of Aphanomyces Yield Data for 2021 and 2022

** Does not meet Full Market Approval. Meets Aphanomyces Specialty Approval and Rhizoctonia Approval.

Table 4. Performance Data of Conventional Varieties During 2017, 2018, 2019 Growing Seasons (All Locations Combined)

Yrs		Rev/Ton ++					Rev/Acre ++					Rec/Ton		Rec/Acre		Sugar		Yield		Molasses		Emerg		Bolter / Ac		CR +		Aph Root+		Rhizoc.+		Fusarium+		Rzm+
Variety @	Com	19	2 Yr	2Y%	3Yr#	3Y%	19	2 Yr	2Y%	3Yr#	3Yr%	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	19	2 Yr	
Previous Approved # location		3	8		14		3	8		14		3	8	3	8	3	8	3	8	3	8	3	8	3	8	3	6	2	3	3	6	2	4	
Crystal 620	NC	41.74	47.24	97	49.48	99	1394	1631	118	1656	104	311	326	10403	11312	16.59	17.38	33.7	34.9	1.07	1.06	54	67	0	0	3.95	4.13	4.7	4.2	5.1	4.6	2.5	3.0	Hi
Crystal R761	10	38.62	43.53	89	46.06	92	1375	1582	115	1618	101	299	313	10742	11457	16.18	16.86	36.0	36.7	1.21	1.19	61	72	0	0	4.98	4.85	4.4	4.3	4.9	4.6	3.0	3.6	Hi
Crystal 840	NC	39.30	45.48	93	30.32	60	1288	1585	115	NA	--	302	320	9916	11173	16.23	17.10	33.1	35.1	1.15	1.10	52	65	0	0	4.18	4.25	4.0	3.9	4.7	4.4	2.7	3.1	Hi
Hilleshög HM3035Rz	13	43.77	49.17	101	50.89	101	1294	1379	100	1405	88	318	333	9439	9422	16.91	17.65	29.9	28.5	1.02	1.00	72	71	0	0	4.42	4.32	5.1	5.2	4.4	4.2	4.1	4.3	Rzm
Seedex 8869 Cnv	NC	40.88	45.47	93	48.33	96	1374	1617	117	1658	104	307	320	10388	11418	16.40	17.00	33.9	35.8	1.02	1.00	64	74	0	5	4.52	4.59	4.8	4.8	5.1	4.9	3.5	3.7	Hi
SV 48777	NC	45.18	50.25	103	52.63	105	1452	1634	118	1656	104	323	337	10342	10954	17.08	17.78	31.8	32.5	0.94	0.93	63	73	0	0	4.10	4.33	4.9	5.0	5.0	4.7	4.3	4.4	Hi
Newly Approved																																		
Crystal 950	NC	41.21	--	--	--	--	1430	--	--	--	--	309	--	10719	NA	16.49	NA	34.7	--	1.06	--	62	--	0	--	4.72	--	4.8	--	4.8	--	2.9	--	Hi
Benchmark var. mean		44.35	48.87		50.20		1427	1381		1595		320	332	10330	10887	17.07	17.68	32.4	33.0	1.08	1.09	66	75											

Emergence is % of planted seeds producing a 4 leaf beet.

++ 2019 Revenue estimate based on a $44.38beet payment (5-yr ave) at 17.5% sugar and 1.5% loss to molasses.

+ Aph ratings from Shakopee (res<4.4, susc>5.0). CR from Randolph MN, Foxhome MN & Michigan (res<4.5, susc>5.0). Fusarium from RRV (res<3.0, susc>5.0). Rhizoc. from Mhd, NWROC & Mich (res<3.8, susc>5). Hi may perform better under severe Rzm.

Bolters /Ac are based upon a planting base of 60,000.

+++ Sites include Casselton, Ada, Grand Forks, Scandia, St. Thomas in 2018

+++ Sites include Scandia, Bathgate, Grand Forks in 2019

Table 5. ACSC Official Trial Disease Nurseries 2020-2022 (Varieties tested in 2022) Cercospora, Aphanomyces, Rhizoctonia & Fusarium

Code	Description	< 4.5 Cercospora > 5.0 22 Mean	21 Mean	20 Mean	2 Yr Mean	3 Yr Mean	< 4.2 Aphanomyces > 4.8 22 Mean	21 Mean	20 Mean	2 Yr Mean	3 Yr Mean	< 3.82 Rhizoctonia > 5.0 22 Mean	21 Mean	20 Mean	2 Yr Mean	3 Yr Mean	< 3.0 Fusarium > 5.0 22 Mean	21 Mean	20 Mean	2 Yr Mean	3 Yr Mean	High Rzm
	Previously Approved																					
524	BTS 8018	2.03	2.31	2.41	2.17	2.25	4.00	4.52	3.87	4.26	4.13	3.93	3.83	4.16	3.88	3.97	2.98	3.22	2.47	3.10	2.89	Hi Rzm
567	BTS 8034	2.28	2.56	2.70	2.42	2.51	3.89	3.24	4.36	3.56	3.83	4.49	3.88	4.56	4.18	4.31	2.16	2.71	2.26	2.43	2.38	Hi Rzm
533	BTS 8073	4.55	4.56	4.68	4.55	4.59	4.01	4.30	3.45	4.15	3.92	4.21	3.67	4.11	3.94	4.00	3.06	3.63	2.58	3.35	3.09	Hi Rzm
511	BTS 8092	4.26	4.62	4.26	4.44	4.38	3.86	4.11	3.85	3.98	3.94	3.58	3.81	3.81	3.70	3.73	3.87	4.07	3.70	3.97	3.88	Hi Rzm
503	BTS 8629	4.52	4.78	4.55	4.65	4.62	4.50	4.24	3.92	4.37	4.22	3.72	4.22	4.30	3.97	4.08	3.95	4.21	3.78	4.08	3.98	Hi Rzm
510	BTS 8927	4.42	4.48	4.42	4.45	4.44	4.00	4.51	3.87	4.26	4.13	4.13	3.68	4.37	3.91	4.06	3.11	4.00	2.59	3.56	3.23	Hi Rzm
557	BTS 8961	4.54	4.53	4.69	4.53	4.58	4.47	4.80	4.04	4.64	4.44	3.75	3.75	4.11	3.75	3.87	2.89	3.33	2.19	3.11	2.80	Hi Rzm
566	Crystal 021	2.08	2.28	2.20	2.18	2.19	3.74	4.19	3.46	3.97	3.80	3.58	3.38	3.88	3.48	3.61	3.39	4.18	2.85	3.79	3.47	Hi Rzm
559	Crystal 022	4.60	4.97	4.71	4.78	4.76	4.03	4.79	3.81	4.41	4.21	4.10	3.53	3.49	3.82	3.71	3.22	3.50	2.60	3.36	3.11	Hi Rzm
563	Crystal 026	4.69	4.43	4.76	4.56	4.63	3.76	3.74	3.75	3.75	3.75	3.28	3.34	3.57	3.31	3.40	2.81	2.79	2.31	2.80	2.64	Hi Rzm
516	Crystal 572	4.50	4.75	4.46	4.63	4.57	4.60	4.47	4.28	4.54	4.45	4.28	3.88	4.21	4.08	4.13	2.88	3.34	2.36	3.11	2.86	Hi Rzm
539	Crystal 684	4.59	4.54	4.44	4.57	4.52	3.81	3.60	3.97	3.71	3.79	4.24	3.82	4.15	4.03	4.07	2.28	2.76	2.32	2.52	2.45	Hi Rzm
558	Crystal 793	4.10	4.13	4.31	4.12	4.18	3.82	3.74	3.87	3.78	3.81	4.73	4.36	4.84	4.55	4.64	3.03	2.80	2.61	2.92	2.82	Hi Rzm
530	Crystal 912	4.81	5.13	4.75	4.97	4.90	3.44	3.95	3.67	3.70	3.69	3.28	3.77	3.54	3.53	3.53	3.66	4.11	3.61	3.88	3.79	Hi Rzm
564	Crystal 913	3.73	4.10	4.13	3.92	3.99	3.79	4.39	3.75	4.09	3.98	4.23	3.94	4.58	4.08	4.25	3.13	3.68	2.59	3.40	3.13	Hi Rzm
541	Hilleshög HIL2317	5.13	4.57	5.05	4.85	4.92	3.91	5.01	3.86	4.46	4.26	4.71	4.76	4.95	4.73	4.81	5.65	6.06	5.97	5.86	5.89	Hi Rzm
517	Hilleshög HIL2320	5.01	4.78	5.11	4.90	4.97	4.00	4.66	3.55	4.33	4.07	3.88	3.80	4.64	3.84	4.11	4.73	4.50	4.56	4.62	4.60	Hi Rzm
521	Hilleshög HIL2366	5.00	5.01	4.94	5.00	4.98	4.32	5.81	3.81	5.07	4.65	3.92	3.98	4.24	3.95	4.05	4.83	4.65	4.55	4.74	4.68	Hi Rzm
545	Hilleshög HIL2367	4.75	4.75	5.08	4.75	4.86	4.17	5.13	3.51	4.65	4.27	3.90	4.10	4.26	4.00	4.09	4.20	4.27	4.44	4.23	4.30	Hi Rzm
560	Hilleshög HIL2368	4.56	4.66	4.69	4.61	4.64	4.63	5.25	3.70	4.94	4.53	3.46	2.92	3.52	3.19	3.30	4.33	4.44	3.86	4.39	4.21	Hi Rzm
504	Hilleshög HIL9708	4.86	4.65	4.97	4.76	4.83	4.45	6.34	3.96	5.39	4.91	3.78	3.78	3.83	3.78	3.80	3.83	4.76	3.64	4.29	4.08	Rzm
519	Hilleshög HIL9920	4.92	4.75	4.82	4.84	4.83	4.33	4.65	3.65	4.49	4.21	4.58	4.70	5.12	4.64	4.80	5.66	5.45	6.28	5.56	5.80	Hi Rzm
535	Hilleshög HM9528RR	4.76	4.52	4.84	4.64	4.71	4.07	5.51	3.72	4.79	4.43	4.01	4.47	4.57	4.24	4.35	4.80	4.91	4.68	4.85	4.80	Hi Rzm
536	Maribo MA717	5.05	4.68	5.11	4.86	4.95	4.39	6.75	3.77	5.57	4.97	3.92	4.31	4.61	4.12	4.28	4.87	5.11	4.62	4.99	4.87	Hi Rzm
531	Maribo MA902	4.95	4.63	4.96	4.79	4.85	4.59	6.96	4.01	5.78	5.19	3.57	3.80	3.93	3.69	3.77	4.30	4.50	4.01	4.40	4.27	Hi Rzm
554	SV 203	4.74	4.75	5.03	4.74	4.84	4.24	4.35	4.34	4.30	4.31	4.19	4.34	4.29	4.26	4.27	5.55	5.99	5.26	5.77	5.60	Hi Rzm
513	SV 265	4.46	4.30	4.55	4.38	4.44	4.30	4.95	3.98	4.63	4.41	3.96	4.17	4.21	4.06	4.11	6.08	5.65	5.70	5.87	5.81	Hi Rzm
532	SV 285	4.72	4.78	4.50	4.75	4.66	4.35	4.48	4.28	4.42	4.37	4.53	4.26	4.03	4.39	4.27	5.47	6.26	5.40	5.87	5.71	Hi Rzm
506	SX 1898	4.72	4.76	4.73	4.74	4.74	4.25	4.97	3.76	4.61	4.33	4.12	4.34	4.16	4.23	4.21	5.38	5.67	5.41	5.53	5.49	Hi Rzm
Newly Approved																						
527	BTS 8100	3.87	4.01	--	3.94	--	3.78	3.89	--	3.83	--	3.73	3.09	--	3.41	--	2.32	2.80	--	2.56	--	Hi Rzm
526	BTS 8133	2.23	2.30	--	2.26	--	3.57	3.46	--	3.51	--	3.44	3.87	--	3.65	--	3.02	3.62	--	3.32	--	Hi Rzm
555	BTS 8156	2.43	2.48	--	2.46	--	4.21	3.64	--	3.93	--	4.24	3.81	--	4.02	--	2.30	2.72	--	2.51	--	Hi Rzm
528	Crystal 130	2.10	2.38	--	2.24	--	3.57	4.23	--	3.90	--	4.08	3.57	--	3.82	--	3.22	3.22	--	3.22	--	Hi Rzm
543	Crystal 134	4.47	4.59	--	4.53	--	3.70	4.39	--	4.05	--	3.63	3.44	--	3.53	--	3.37	4.11	--	3.74	--	Hi Rzm
515	Crystal 137	2.57	2.53	--	2.55	--	4.25	3.13	--	3.69	--	4.18	3.53	--	3.86	--	2.35	2.25	--	2.30	--	Hi Rzm
565	Crystal 138	4.87	4.74	--	4.80	--	3.87	4.19	--	4.03	--	3.81	3.52	--	3.67	--	3.16	3.75	--	3.45	--	Hi Rzm
547	Hilleshög HIL2386	4.54	4.30	--	4.42	--	4.31	5.98	--	5.14	--	3.51	4.20	--	3.85	--	3.73	4.26	--	3.99	--	Hi Rzm
512	Hilleshög HIL2389	4.69	4.85	--	4.77	--	3.78	3.86	--	3.82	--	3.92	3.99	--	3.96	--	4.34	4.75	--	4.54	--	Hi Rzm
523	Maribo MA932	4.78	4.85	--	4.82	--	4.28	4.60	--	4.44	--	3.75	4.03	--	3.89	--	4.22	4.05	--	4.13	--	Hi Rzm
529	SX 1815	5.07	4.78	--	4.93	--	4.28	4.19	--	4.24	--	4.12	4.40	--	4.26	--	5.32	4.82	--	5.07	--	Hi Rzm
562	SX 1818	4.72	4.86	--	4.79	--	4.82	5.56	--	5.19	--	4.16	4.41	--	4.28	--	4.54	5.26	--	4.90	--	Hi Rzm

Created 11/08/2022

Green highlighted ratings indicate specialty or good resistance. Red highlighted ratings indicate level of concern for some fields.

-- indicates data not available

Table 6
Root Aphid Ratings
American Crystal Sugar, KWS and Magno Seed from 2020 - 2022

	Moorhead, MN[X] (1=Exc - 4=Poor)					Shakopee, MN[Y] (1=Exc - 4=Poor)					Longmont, CO[Z] (% Infested Plants)				
Variety	2020*	2021*	2022*	2 Yr Mean	3 Yr Mean	2020*	2021	2022	2 Yr Mean	3 Yr Mean	2020	2021	2022**	2 Yr Mean	3 Yr Mean
BTS 8018	--	--	--	--	--	--	1.00	1.00	1.00	--	--	67.94	--	--	--
BTS 8034	--	--	--	--	--	--	1.32	1.00	1.16	--	--	68.72	--	--	--
BTS 8073	--	--	--	--	--	--	1.19	1.00	1.10	--	--	80.81	--	--	--
BTS 8092	--	--	--	--	--	--	1.21	1.04	1.13	--	--	61.48	--	--	--
BTS 8100	--	--	--	--	--	--	--	1.08	--	--	--	--	--	--	--
BTS 8133	--	--	--	--	--	--	--	1.00	--	--	--	--	--	--	--
BTS 8156	--	--	--	--	--	--	--	1.00	--	--	--	--	--	--	--
BTS 8629	--	--	--	--	--	--	1.46	1.08	1.27	--	10.20	82.76	--	--	--
BTS 8927	--	--	--	--	--	--	1.16	1.04	1.10	--	7.90	76.97	--	--	--
BTS 8961	--	--	--	--	--	--	1.00	1.04	1.02	--	9.20	51.05	--	--	--
Crystal 021	--	--	--	--	--	--	1.22	1.04	1.13	--	--	69.71	--	--	--
Crystal 022	--	--	--	--	--	--	1.00	1.00	1.00	--	--	68.23	--	--	--
Crystal 026	--	--	--	--	--	--	1.00	1.00	1.00	--	--	62.89	--	--	--
Crystal 130	--	--	--	--	--	--	--	1.13	--	--	--	--	--	--	--
Crystal 134	--	--	--	--	--	--	--	1.00	--	--	--	--	--	--	--
Crystal 137	--	--	--	--	--	--	--	1.12	--	--	--	--	--	--	--
Crystal 138	--	--	--	--	--	--	--	1.00	--	--	--	--	--	--	--
Crystal 572	--	--	--	--	--	--	1.08	1.08	1.08	--	9.60	61.07	--	--	--
Crystal 684	--	--	--	--	--	--	1.28	1.00	1.14	--	14.40	67.74	--	--	--
Crystal 793	--	--	--	--	--	--	1.08	1.04	1.06	--	8.60	84.86	--	--	--
Crystal 912	--	--	--	--	--	--	1.24	1.00	1.12	--	3.30	64.72	--	--	--
Crystal 913	--	--	--	--	--	--	1.12	1.04	1.08	--	1.40	62.18	--	--	--
Hilleshög HIL2317	--	--	--	--	--	--	3.41	3.48	3.45	--	34.40	76.15	--	--	--
Hilleshög HIL2320	--	--	--	--	--	--	3.33	3.48	3.41	--	49.20	80.33	--	--	--
Hilleshög HIL2366	--	--	--	--	--	--	3.72	3.36	3.54	--	--	73.41	--	--	--
Hilleshög HIL2367	--	--	--	--	--	--	3.60	3.44	3.52	--	--	77.92	--	--	--
Hilleshög HIL2368	--	--	--	--	--	--	3.54	3.44	3.49	--	--	73.23	--	--	--
Hilleshög HIL2386	--	--	--	--	--	--	--	3.32	--	--	--	--	--	--	--
Hilleshög HIL2389	--	--	--	--	--	--	--	2.00	--	--	--	--	--	--	--
Hilleshög HM9528RR	--	--	--	--	--	--	3.35	3.68	3.52	--	68.20	68.62	--	--	--
Hilleshög HIL9708	--	--	--	--	--	--	3.38	3.72	3.55	--	71.10	72.26	--	--	--
Hilleshög HIL9920	--	--	--	--	--	--	3.58	3.48	3.53	--	44.40	74.56	--	--	--
Maribo MA717	--	--	--	--	--	--	3.68	3.56	3.62	--	71.60	68.33	--	--	--
Maribo MA902	--	--	--	--	--	--	3.75	3.36	3.56	--	62.50	73.70	--	--	--
Maribo MA932	--	--	--	--	--	--	--	3.52	--	--	--	--	--	--	--
SV 203	--	--	--	--	--	--	2.32	2.00	2.16	--	--	70.81	--	--	--
SV 215	--	--	--	--	--	--	--	2.76	--	--	--	--	--	--	--
SV 265	--	--	--	--	--	--	3.65	3.36	3.51	--	83.10	70.81	--	--	--
SV 285	--	--	--	--	--	--	2.28	2.24	2.26	--	28.20	66.81	--	--	--
SX 1815	--	--	--	--	--	--	--	2.40	--	--	--	--	--	--	--
SX 1816	--	--	--	--	--	--	--	2.24	--	--	--	--	--	--	--
SX 1818	--	--	--	--	--	--	--	2.00	--	--	--	--	--	--	--
SX 1898	--	--	--	--	--	--	2.21	2.32	2.27	--	43.20	54.21	--	--	--
Root Aphid Res CK#2	--	--	--	--	--	--	1.13	1.16	1.15	--	19.80	80.06	--	--	--
Root Aphid Res CK#3	--	--	--	--	--	--	1.36	1.00	1.18	--	9.60	70.65	--	--	--
Root Aphid Susc CK#4	--	--	--	--	--	--	3.48	3.48	3.48	--	64.30	71.31	--	--	--
Root Aphid Susc CK#5	--	--	--	--	--	--	3.60	3.36	3.48	--	68.20	76.10	--	--	--
Root Aphid Susc CK#6	--	--	--	--	--	--	--	3.48	--	--	--	--	--	--	--

Created 11/07/2022 X Growth chamber assay based on a 1-4 rating scale (1 = no aphids, 4 = very susceptible), Moorhead, MN, American Crystal

Sugar Company
Y Greenhouse assay based on a 1-4 rating scale (1 = no aphids, 4 = very susceptible), Shakopee, MN, KWS Z
Field trial based on incidence (% infested plants), Longmont, CO, Magno Seed, LLC
* No data available due to low levels of root aphid development and infestation
** No data due to low emergence.

Table 7. Planting & Harvest Dates, Previous Crop and Disease Levels for 2022 ACSC Official Trial Sites *

Yield Trials	**District /**		**Planting**	**Harvest**	**Preceding**		**Diseases Present @**						
Location	**Trial Type**	**Cooperator**	**Date**	**Date**	**Crop**	**Soil Type**	**Aph**	**Rhc**	**Rzm**	**Fus**	**Maggot**	**Rt Aphid**	**Comments**
Casselton ND	Mhd/Hlb	Todd Weber Farms	5/20	9/12	Wheat	Medium/Light	N	L	N	N	N	N	
Averill MN	Mhd/Hlb	Tang Farms	5/23	9/9	Wheat	Medium/Light	N	L	N	N	N	N	Moderate Cercospora leafspot at harvest
Perley MN	Mhd/Hlb	TD Hoff Partnership	6/4	9/8	Corn	Heavy	M-V	L	N	N	N	N	Yield under Aphanomyces pressure
Ada MN	Mhd/Hlb	Ruebke Bros.	5/28	10/5	Wheat	Light	N	N	N	N	L	N	Gappy stands
Buxton ND	Mhd/Hlb	Hong Farms	5/24	9/13	Wheat	Medium/Light	N	N	N	N	L	N	Moisture stress (dry)
Climax MN	EGF/Crk	Todd Evenson	5/24	10/4	Wheat	Medium/Light	N	M	N	N	N	N	Moisture stress (dry)
Grand Forks ND	EGF/Crk	Drees Farming Association	5/19	9/14	Wheat	Medium/Light	N	L	M	N	L	N	Rhizomania symptoms in indicator; some non-Cercospora leafspot/necrosis
Scandia MN	EGF/Crk	Deboer Farms	5/25	10/1	Wheat	Medium	N	L	N	N	N	N	
East Grand Forks MN	EGF/Crk	Mark Holy	5/27	Abandon	Wheat	Medium	NA	NA	NA	NA	NA	NA	Trial lost to severe wind damage
Alvarado MN	Dtn	Brent Riopelle	5/27	9/22	Wheat	Medium/Heavy	N	N	N	N	N	N	Harvested 9/22 (Comm OVT) and 9/23 (Exp OVT)
St Thomas ND	Dtn	Baldwin Farms	5/17	9/19	Wheat	Medium/Light	N	N	N	N	L-M	N	Verticillium wilt may have affected yield
Hallock MN	Dtn	Prosser/Kuznia Beets	5/26	9/29	Wheat	Heavy	N	N	N	N	N	N	
Bathgate ND	Dtn	Shady Bend Farms	5/26	9/27	Wheat	Medium	N	N	N	N	L	N	

Disease Trials	**District /**		**Planting**	**Rating**	**Preceding**		**Diseases Present @**						
Location	**Trial Type**	**Cooperator**	**Date**	**Date**	**Crop**	**Soil Type**	**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	V	N	N	Severe Fusarium pressure
Sabin Fus-S MN	Fus Nurs	Krabbenhoft & Sons Farm	6/6	Multiple	Wheat	Medium	N	N	N	M-V	L	N	Rep 5 not used due to water damage in range 14
Mhd Rhc-E MN	Rhc Nurs	Jon Hickel	7/7	10/6	Sugar Beet	Heavy	N	M	N	L	N	N	Replanted due to poor stand
Mhd Rhc-W MN	Rhc Nurs	Jon Hickel	6/3	Abandon	Sugar Beet	Heavy	NA	NA	NA	NA	NA	NA	Abandoned due to poor stand
NWROC MN	Rhc Nurs	Maureen Aubol	5/28	8/9	Wheat	Medium	N	M	N	N	N	N	Nice range of Rhizoctonia symptoms
East Lansing MI	Rhc Nurs	Linda Hanson	--	8/23-25	--	--	--	--	--	--	--	--	
Shakopee MN	Aphanomyces	Patrick O'Boyle	5/16	8/24	--	--	M-V	L	N	N	N	N	Nice range of Aphanomyces symptoms
Glyndon MN	Aphanomyces	Dennis Simmons	5/25	8/31	--	Light	L-M	N	N	NA	NA	NA	Disease pressure higher early in season
Perley MN	Aphanomyces	TD Hoff Partnership	6/4	9/7	Corn	Heavy	M-V	L	N	N	N	N	Nice range of Aphanomyces symptoms
Climax MN	Aphanomyces	Todd Evenson	5/24	Abandon	Wheat	Medium/Light	N	L-M	N	N	N	N	Very dry conditions and soil assay showed no Aphanomyces
Longmont CO	Root Aphids	Kara Guffey	--	--	--	--	--	--	--	--	--	--	Abandoned due to poor stand
Foxhome MN	Cercospora	NDSU/Kevin Etzler	6/6	Multiple	Wheat	Medium	N	L	N	N	N	N	Late developing but nice symptoms
East Lansing MI	Cercospora	Linda Hanson	--	Multiple	--	--	--	--	--	--	--	--	
Randolph MN	Cercospora	Patrick O'Boyle	6/14	Multiple	--	--	N	N	N	N	N	N	Replanted mid-June but severe disease pressure by late August
Averill MN	Cercospora	Tang Farms	5/23	Multiple	Wheat	Medium/Light	N	L	N	N	N	N	Non-inoculated trial, not used for approval numbers

Created 9/9/2022

* Fertilizer applied in accordance with cooperative recommendations.

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

Table 8. Seed Treatments Used on Varieties in Official Variety Trials in 2022

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	3	1	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8034	3	1	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8073	3	1	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8092	3	1	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8629	7	5	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8927	4	2	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8961	4	2	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
Crystal 022	3	1	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 572	8	6	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 684	7	4	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 793	6	4	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 912	4	1	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 913	4	2	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Hilleshög HIL2317	4	2	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2320	4	1	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2366	3	1	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL9708	8	5	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL9920	6	4	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HM9528RR	9	7	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Maribo MA717	6	4	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Maribo MA902	4	2	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
SV 203	3	1	Apron XL Maxim	Metlock/Rizolex/Zeltera	Int Sol	NipsIt	XBEET
SV 265	7	5	Apron XL Maxim	Metlock/Rizolex/Zeltera	Int Sol	NipsIt	XBEET
SV 285	5	2	Apron XL Maxim	Metlock/Rizolex/Zeltera	Int Sol	NipsIt	XBEET
SX 1898	4	2	Apron XL Maxim	Zeltera	Int Sol	NipsIt	XBEET
BTS 8572 (Check)	8	6	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
BTS 8337 (Check)	10	8	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 578RR (Check)	8	5	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
BTS 8815 (Check)	5	3	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 803 (Check)	5	2	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
AP CK#55 CRYS247	11	9	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
AP CK#59 BTS8606	7	5	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
ACSC Experimental							
BTS 8100	2	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8133	2	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8156	2	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8205	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8217	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8226	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8242	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8248	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8270	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
BTS 8299	1	NC	Allegiance Thiram	Kabina	Tach 35	Poncho Beta	Ultipro
Crystal 021	3	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 026	3	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 130	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 134	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 137	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 138	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 260	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 262	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 263	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 265	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 267	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 269	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Hilleshög HIL2367	3	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2368	3	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2386	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2389	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2440	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2441	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2442	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2443	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Maribo MA932	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Maribo MA942	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Maribo MA943	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Maribo MA944	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
SV 215	2	NC	Apron XL Maxim	Metlock/Rizolex/Zeltera	Int Sol	NipsIt	XBEET
SV 321	1	NC	Apron XL Maxim	Metlock/Rizolex/Zeltera	Int Sol	NipsIt	XBEET
SV 322	1	NC	Apron XL Maxim	Metlock/Rizolex/Zeltera	Int Sol	NipsIt	XBEET
SV 324	1	NC	Apron XL Maxim	Metlock/Rizolex/Zeltera	Int Sol	NipsIt	XBEET
SX 1815	2	NC	Apron XL Maxim	Zeltera	Int Sol	NipsIt	XBEET
SX 1816	2	NC	Apron XL Maxim	Zeltera	Int Sol	NipsIt	XBEET
SX 1818	2	NC	Apron XL Maxim	Zeltera	Int Sol	NipsIt	XBEET
SX 1829	1	NC	Apron XL Maxim	Zeltera	Int Sol	NipsIt	XBEET
BTS 8572 (Check)	8	6	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
BTS 8337 (Check)	10	8	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 578RR (Check)	8	5	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
BTS 8815 (Check)	5	3	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 803 (Check)	5	2	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
AP CK#55 CRYS247	11	9	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET

Created 11/7/2022

Table 9.

9 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	120	328.6	101	9656	108	49.38	102	1447	109	29.48	17.54	1.11	16.43	231	1543	368	0	76.2
BTS 8034	123	315.1	97	9469	106	45.34	94	1362	103	30.04	17.02	1.27	15.75	332	1763	391	0	76.6
BTS 8073	102	326.9	101	9787	109	48.88	101	1461	110	29.99	17.50	1.15	16.35	234	1527	400	0	72.7
BTS 8092	116	317.5	98	9722	109	46.04	95	1406	106	30.73	17.01	1.14	15.87	274	1536	371	0	73.6
BTS 8629	118	313.5	97	9687	108	44.85	93	1385	105	30.88	16.85	1.18	15.67	295	1537	398	0	77.8
BTS 8927	104	338.8	104	9399	105	52.46	109	1452	110	27.81	17.97	1.03	16.94	211	1448	339	0	78.9
BTS 8961	117	316.4	97	9478	106	45.73	95	1369	103	29.98	17.02	1.20	15.82	280	1684	377	0	76.5
Crystal 022	125	339.2	104	9376	105	52.56	109	1449	109	27.69	18.04	1.08	16.96	190	1519	365	1	73.4
Crystal 572	108	335.7	103	9292	104	51.53	107	1424	108	27.70	17.92	1.14	16.78	206	1521	401	1	77.9
Crystal 684	122	311.9	96	9945	111	44.38	92	1411	107	31.98	16.83	1.23	15.60	315	1732	377	0	75.3
Crystal 793	111	330.6	102	9773	109	49.98	104	1476	112	29.59	17.61	1.08	16.53	221	1524	351	0	76.1
Crystal 912	107	312.6	96	10047	112	44.59	92	1433	108	32.17	16.82	1.19	15.63	334	1512	399	0	76.1
Crystal 913	103	329.1	101	9702	108	49.53	103	1458	110	29.52	17.58	1.13	16.45	259	1511	379	0	75.1
Hilleshög HIL2317	112	326.8	101	9185	103	48.84	101	1371	104	28.14	17.40	1.06	16.34	247	1595	305	0	75.1
Hilleshög HIL2320	106	322.8	99	9528	107	47.65	99	1403	106	29.57	17.26	1.12	16.14	272	1532	358	0	77.4
Hilleshög HIL2366	119	319.3	98	9263	104	46.59	97	1351	102	29.04	17.08	1.12	15.96	298	1513	354	0	77.1
Hilleshög HIL9708	124	322.5	99	9127	102	47.55	99	1342	101	28.41	17.23	1.11	16.12	297	1498	354	0	80.0
Hilleshög HIL9920	115	324.5	100	9342	104	48.16	100	1383	104	28.83	17.34	1.12	16.22	276	1630	332	0	76.7
Hilleshög HM9528RR	101	319.4	98	9374	105	46.64	97	1368	103	29.39	17.07	1.10	15.97	272	1529	344	0	76.7
Maribo MA717	121	318.6	98	9605	107	46.39	96	1397	106	30.19	17.07	1.14	15.93	280	1566	363	0	76.0
Maribo MA902	110	321.2	99	8954	100	47.16	98	1310	99	27.95	17.17	1.11	16.06	303	1520	344	0	81.9
SV 203	113	322.0	99	8835	99	47.41	98	1296	98	27.53	17.28	1.18	16.10	259	1714	366	0	62.8
SV 265	109	318.1	98	9114	102	46.24	96	1321	100	28.71	17.01	1.11	15.90	250	1583	346	1	75.3
SV 285	105	322.6	99	8672	97	47.58	99	1276	96	26.95	17.31	1.18	16.13	255	1721	361	0	65.3
SX 1898	114	320.4	99	8873	99	46.94	97	1297	98	27.77	17.19	1.17	16.02	277	1714	349	0	64.9
BTS 8572 (CommBench)	126	329.3	101	9025	101	49.60	103	1355	102	27.51	17.65	1.18	16.47	234	1586	409	0	74.5
BTS 8337 (CommBench)	127	334.4	103	8696	97	51.12	106	1324	100	26.09	17.90	1.18	16.72	261	1673	375	0	74.5
Crystal 578RR (CommBench)	128	318.2	98	9272	104	46.27	96	1345	102	29.23	17.14	1.23	15.91	314	1708	383	0	78.4
BTS 8815 (CommBench)	129	317.0	98	8785	98	45.92	95	1270	96	27.75	17.07	1.22	15.85	301	1751	369	0	67.4
Crystal 803 (Check)	130	329.2	101	9483	106	49.57	103	1428	108	28.83	17.57	1.11	16.46	223	1565	359	0	80.4
AP CK#55 CRYS247	131	317.2	98	9236	103	45.96	95	1333	101	29.21	17.03	1.18	15.85	310	1707	344	0	77.2
AP CK#59 BTS8606	132	317.4	98	9310	104	46.03	95	1348	102	29.37	17.07	1.20	15.87	296	1693	373	0	76.7
Experimental Trial (Comm status)																		
BTS 8100	208	325.4	100	9207	103	48.43	100	1363	103	28.43	17.44	1.17	16.27	233	1706	367	0	75.8
BTS 8133	215	311.5	96	9787	109	44.28	92	1392	105	31.44	16.77	1.19	15.59	283	1750	355	0	80.3
BTS 8156	218	327.5	101	9411	105	49.07	102	1410	107	28.67	17.57	1.20	16.37	257	1782	360	0	81.5
BTS 8205	234	325.1	100	9607	107	48.35	100	1426	108	29.55	17.43	1.17	16.26	203	1586	411	1	76.2
BTS 8217	237	323.1	100	9268	104	47.75	99	1373	104	28.61	17.34	1.19	16.16	263	1744	363	0	73.8
BTS 8226	219	343.0	106	9723	109	53.69	111	1521	115	28.41	18.18	1.03	17.15	201	1453	339	0	75.1
BTS 8242	204	340.4	105	9321	104	52.91	110	1441	109	27.58	18.11	1.10	17.01	190	1566	364	0	76.3
BTS 8248	238	328.9	101	9354	105	49.48	103	1403	106	28.52	17.53	1.09	16.44	223	1572	347	0	68.0
BTS 8270	211	333.6	103	9683	108	50.89	106	1472	111	29.13	17.81	1.13	16.68	211	1607	376	0	74.0
BTS 8299	235	328.3	101	9114	102	49.31	102	1359	103	27.86	17.47	1.06	16.41	195	1525	343	0	74.5
Crystal 021	226	317.6	98	9577	107	46.11	96	1390	105	30.14	17.06	1.18	15.89	289	1658	369	0	71.1
Crystal 026	240	322.3	99	9691	108	47.52	99	1430	108	30.01	17.30	1.18	16.13	270	1740	357	0	77.1
Crystal 130	213	332.3	102	9469	106	50.48	105	1436	108	28.55	17.72	1.11	16.61	214	1588	358	0	74.1
Crystal 134	202	340.5	105	9228	103	52.96	110	1430	108	27.18	18.07	1.04	17.03	196	1498	338	0	70.1
Crystal 137	201	324.6	100	9381	105	48.22	100	1390	105	28.79	17.46	1.22	16.24	257	1826	367	0	73.8
Crystal 138	224	332.5	102	9690	108	50.57	105	1471	111	29.18	17.71	1.08	16.63	186	1538	361	0	73.9
Crystal 260	231	333.9	103	9757	109	50.98	106	1488	112	29.23	17.78	1.09	16.69	204	1564	352	0	77.3
Crystal 262	229	325.3	100	9850	110	48.41	100	1463	111	30.33	17.36	1.10	16.26	252	1524	354	0	74.2
Crystal 263	210	338.1	104	9221	103	52.25	108	1418	107	27.31	18.01	1.10	16.91	215	1606	348	0	72.1
Crystal 265	225	330.3	102	9062	101	49.91	103	1366	103	27.56	17.57	1.05	16.52	192	1535	337	0	74.0
Crystal 267	222	320.0	99	9494	106	46.82	97	1389	105	29.69	17.24	1.24	16.01	277	1790	382	0	74.4
Crystal 269	212	333.8	103	9648	108	50.96	106	1466	111	29.05	17.86	1.17	16.69	236	1646	382	0	69.0
Hilleshög HIL2367	242	323.0	99	9226	103	47.72	99	1356	102	28.68	17.30	1.15	16.16	289	1544	372	0	74.9
Hilleshög HIL2368	241	329.1	101	7696	86	49.55	103	1154	87	23.60	17.58	1.13	16.45	252	1573	362	0	53.7
Hilleshög HIL2386	228	322.3	99	9682	108	47.52	99	1424	108	30.07	17.25	1.13	16.13	265	1530	374	1	76.5
Hilleshög HIL2389	239	326.8	101	9431	105	48.85	101	1407	106	28.83	17.47	1.13	16.34	225	1621	359	0	75.9
Hilleshög HIL2440	232	327.7	101	9002	101	49.12	102	1343	101	27.58	17.64	1.25	16.39	285	1616	438	0	67.3
Hilleshög HIL2441	214	327.0	101	8835	99	48.92	101	1312	99	27.21	17.51	1.16	16.35	243	1591	383	1	74.2
Hilleshög HIL2442	220	331.7	102	8707	97	50.33	104	1312	99	26.41	17.76	1.18	16.58	218	1583	413	0	69.6
Hilleshög HIL2443	227	313.8	97	9512	106	44.98	93	1361	103	30.28	16.83	1.13	15.71	273	1623	348	0	68.7
Maribo MA932	230	323.8	100	9532	107	47.95	99	1406	106	29.57	17.33	1.14	16.20	256	1563	376	0	75.6
Maribo MA942	223	328.8	101	8742	98	49.45	103	1310	99	26.64	17.53	1.09	16.44	204	1526	364	0	75.7
Maribo MA943	233	326.3	100	8975	100	48.71	101	1333	101	27.60	17.47	1.15	16.32	234	1572	387	0	69.4
Maribo MA944	221	328.7	101	8908	100	49.43	102	1334	101	27.19	17.57	1.14	16.43	256	1522	384	0	72.9
SV 215	217	314.6	97	8749	98	45.21	94	1252	95	27.98	16.87	1.14	15.74	227	1765	333	0	59.7
SV 321	209	316.7	98	9165	102	45.85	95	1320	100	29.02	16.94	1.11	15.84	210	1664	339	0	65.7
SV 322	236	317.9	98	8308	93	46.18	96	1201	91	26.20	17.02	1.12	15.91	243	1671	337	0	63.2
SV 324	205	310.8	96	8695	97	44.06	91	1231	93	28.02	16.78	1.24	15.55	277	1826	375	0	67.5
SX 1815	203	328.4	101	9366	105	49.35	102	1403	106	28.58	17.53	1.11	16.42	216	1673	339	0	76.3
SX 1816	206	316.1	97	9060	101	45.66	95	1302	98	28.87	16.97	1.17	15.81	250	1678	368	0	64.6
SX 1818	216	321.4	99	9281	104	47.24	98	1361	103	28.98	17.21	1.15	16.07	239	1667	359	0	70.8
SX 1829	207	321.2	99	8317	93	47.18	98	1221	92	25.84	17.16	1.10	16.07	238	1665	322	0	64.7
BTS 8572 (Check)	243	326.1	100	8844	99	48.64	101	1314	99	27.25	17.50	1.20	16.30	229	1630	410	0	74.5
BTS 8337 (1stYrBench)	244	334.8	103	8674	97	51.24	106	1322	100	26.02	17.94	1.20	16.74	256	1683	389	0	70.4
Crystal 578RR (1stYrBench)	245	313.1	96	9364	105	44.75	93	1339	101	29.92	16.87	1.22	15.66	299	1726	379	0	77.0
BTS 8815 (1stYrBench)	246	324.9	100	8896	99	48.27	100	1320	100	27.39	17.44	1.20	16.24	276	1764	360	0	65.2
Crystal 803 (1stYrBench)	247	331.6	102	9451	106	50.31	104	1433	108	28.50	17.70	1.11	16.59	206	1588	367	0	77.2
AP CK#55 CRYS247	248	316.2	97	9292	104	45.70	95	1338	101	29.48	17.00	1.18	15.83	297	1735	349	0	75.8
Comm Benchmark Mean		324.7		8945		48.23		1324		27.65	17.44	1.20		277	1680	384		73.7
Comm Trial Mean		323.0		9344		47.71		1377		29.00	17.30	1.15		269	1599	366		75.1
Coeff. of Var. (%)		2.8		6.5		5.6		8.1		5.9	2.3	7.4		23.1	4.1	12.6		11.0
Mean LSD (0.05)		5.2		289		1.56		56		0.84	0.24	0.05		34	42	26		3.2
Mean LSD (0.01)		6.9		380		2.06		74		1.11	0.32	0.06		45	55	34		4.2
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from 9 sites

Created 11/02/2022

@ Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 22ACSExpB

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed across 9 locations.

Table 10.

2022 Performance of Varieties - ACSC RR Official Trials

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	120	343.0	99	8353	104	53.71	98	1302	103	24.47	18.43	1.29	17.14	158	1881	440	0	82.5
BTS 8034	123	338.6	98	9234	115	52.38	96	1427	113	27.29	18.24	1.31	16.93	212	2054	393	0	78.8
BTS 8073	102	350.3	101	9343	116	55.91	102	1484	117	26.80	18.72	1.21	17.51	157	1753	419	0	79.2
BTS 8092	116	341.7	99	9559	119	53.33	98	1494	118	27.92	18.29	1.20	17.09	159	1798	393	0	78.4
BTS 8629	118	321.8	93	8708	109	47.35	87	1285	102	26.94	17.38	1.29	16.09	175	1814	455	0	81.3
BTS 8927	104	356.7	103	8446	105	57.82	106	1367	108	23.70	19.02	1.19	17.83	158	1744	401	0	85.6
BTS 8961	117	336.3	97	9110	114	51.69	95	1401	111	27.10	18.09	1.28	16.81	185	1931	413	0	84.8
Crystal 022	125	359.2	104	8450	105	58.57	107	1380	109	23.50	19.25	1.29	17.96	152	1826	462	0	73.9
Crystal 572	108	347.2	100	8049	100	54.99	101	1277	101	23.17	18.72	1.35	17.37	137	1898	494	0	76.0
Crystal 684	122	331.8	96	9097	113	50.35	92	1384	109	27.35	17.98	1.39	16.59	228	2038	449	0	78.8
Crystal 793	111	343.6	99	9071	113	53.90	99	1426	113	26.36	18.42	1.24	17.18	146	1787	435	0	85.2
Crystal 912	107	333.3	96	9947	124	50.81	93	1516	120	29.84	17.91	1.24	16.67	197	1781	417	0	85.3
Crystal 913	103	348.6	101	9132	114	55.39	101	1448	114	26.25	18.67	1.24	17.43	151	1809	423	0	81.8
Hilleshög HIL2317	112	346.3	100	8568	107	54.70	100	1355	107	24.76	18.58	1.27	17.31	177	1997	387	0	78.8
Hilleshög HIL2320	106	342.4	99	9200	115	53.53	98	1435	113	26.92	18.42	1.30	17.12	172	1858	452	0	86.6
Hilleshög HIL2366	119	340.6	98	8540	106	52.99	97	1324	105	25.18	18.27	1.24	17.03	175	1863	403	0	84.3
Hilleshög HIL9708	124	344.6	100	8218	102	54.18	99	1290	102	23.91	18.47	1.24	17.23	170	1860	407	0	80.7
Hilleshög HIL9920	115	345.5	100	8178	102	54.46	100	1289	102	23.66	18.52	1.25	17.27	166	2005	372	0	85.3
Hilleshög HM9528RR	101	339.2	98	8664	108	52.58	96	1340	106	25.64	18.24	1.28	16.96	179	1886	424	0	78.3
Maribo MA717	121	332.6	96	9180	114	50.58	93	1396	110	27.61	17.90	1.27	16.63	164	1883	422	0	82.8
Maribo MA902	110	343.6	99	8139	101	53.88	99	1270	100	23.74	18.40	1.23	17.17	186	1826	399	0	86.2
SV 203	113	345.3	100	8456	105	54.39	100	1332	105	24.48	18.53	1.26	17.27	151	2032	384	0	78.0
SV 265	109	342.4	99	8384	104	53.54	98	1309	103	24.52	18.37	1.25	17.12	164	1998	378	0	87.9
SV 285	105	337.4	98	7901	98	52.03	95	1218	96	23.39	18.21	1.34	16.87	178	2044	433	0	73.4
SX 1898	114	345.0	100	8183	102	54.31	99	1287	102	23.72	18.49	1.23	17.26	156	1993	371	0	74.0
BTS 8572 (CommBench)	126	346.7	100	7756	97	54.81	100	1227	97	22.38	18.70	1.37	17.33	145	1992	478	0	77.5
BTS 8337 (CommBench)	127	352.9	102	7618	95	56.69	104	1222	97	21.59	19.00	1.35	17.65	155	2021	454	0	74.1
Crystal 578RR (CommBench)	128	345.7	100	8314	104	54.52	100	1310	104	24.07	18.59	1.30	17.29	162	1973	428	0	86.1
BTS 8815 (CommBench)	129	338.8	98	8415	105	52.45	96	1302	103	24.85	18.25	1.31	16.94	163	2041	412	0	65.5
Crystal 803 (Check)	130	345.9	100	8925	111	54.58	100	1412	112	25.73	18.55	1.26	17.29	153	1881	422	0	83.5
AP CK#55 CRYS247	131	335.0	97	8320	104	51.31	94	1278	101	24.81	18.08	1.32	16.76	176	2025	424	0	81.9
AP CK#59 BTS8606	132	335.1	97	8291	103	51.35	94	1274	101	24.72	18.11	1.34	16.77	188	2001	441	0	81.2
Experimental Trial (Comm status)																		
BTS 8100	208	345.8	100	8780	109	54.57	100	1372	108	25.67	18.66	1.35	17.31	179	2073	454	0	79.8
BTS 8133	215	332.7	96	9131	114	50.58	93	1372	108	27.77	17.95	1.30	16.65	189	2039	420	0	73.5
BTS 8156	218	342.0	99	9016	112	53.40	98	1417	112	26.16	18.47	1.37	17.09	226	2137	432	0	81.4
BTS 8205	234	345.4	100	9046	113	54.45	100	1411	111	26.48	18.73	1.44	17.29	162	1955	558	0	80.9
BTS 8217	237	348.9	101	9249	115	55.48	102	1478	117	26.37	18.68	1.23	17.44	158	2024	381	0	75.2
BTS 8226	219	371.7	107	8933	111	62.43	114	1499	118	24.06	19.77	1.18	18.59	122	1759	417	0	80.6
BTS 8242	204	366.5	106	8882	111	60.82	111	1465	116	24.42	19.56	1.23	18.32	140	1911	419	0	76.5
BTS 8248	238	350.5	101	9139	114	55.97	102	1453	115	26.21	18.77	1.23	17.53	160	1931	403	0	64.0
BTS 8270	211	356.9	103	8632	108	57.92	106	1401	111	24.19	19.12	1.27	17.85	161	1916	441	0	73.1
BTS 8299	235	358.1	103	7867	98	58.28	107	1268	100	22.22	19.08	1.17	17.92	135	1762	408	0	66.5
Crystal 021	226	334.5	97	9129	114	51.12	94	1391	110	27.39	18.08	1.34	16.74	206	2035	448	0	71.4
Crystal 026	240	340.7	98	8983	112	52.99	97	1402	111	26.29	18.33	1.30	17.03	185	2036	421	0	76.2
Crystal 130	213	352.2	102	8450	105	56.49	103	1355	107	23.98	18.86	1.24	17.62	155	1909	423	0	72.1
Crystal 134	202	369.5	107	8441	105	61.75	113	1408	111	22.89	19.68	1.21	18.47	152	1804	418	0	65.2
Crystal 137	201	345.1	100	9606	120	54.35	100	1539	122	27.30	18.60	1.36	17.24	196	2135	440	0	71.6
Crystal 138	224	350.3	101	8912	111	55.91	102	1434	113	25.21	18.76	1.24	17.51	143	1851	439	0	70.2
Crystal 260	231	356.6	103	9154	114	57.82	106	1469	116	26.00	18.99	1.15	17.84	128	1861	367	0	70.1
Crystal 262	229	348.8	101	9565	119	55.45	102	1516	120	27.53	18.65	1.21	17.43	150	1854	412	0	68.7
Crystal 263	210	362.1	105	8261	103	59.49	109	1360	107	22.75	19.35	1.25	18.10	149	1955	417	0	69.9
Crystal 265	225	355.6	103	8098	101	57.51	105	1308	103	22.82	18.93	1.16	17.77	135	1848	377	0	73.0
Crystal 267	222	347.6	100	8962	112	55.08	101	1433	113	25.54	18.74	1.37	17.37	183	2078	464	0	75.2
Crystal 269	212	352.1	102	8937	111	56.45	103	1440	114	25.25	18.88	1.27	17.61	151	1972	429	0	68.5
Hilleshög HIL2367	242	350.1	101	7896	98	55.85	102	1264	100	22.48	18.75	1.25	17.49	165	1936	419	0	74.9
Hilleshög HIL2368	241	363.6	105	7276	91	59.97	110	1184	94	20.31	19.49	1.29	18.19	174	1885	459	0	45.3
Hilleshög HIL2386	228	351.9	102	8476	106	56.41	103	1363	108	23.99	18.80	1.21	17.58	160	1929	387	0	75.6
Hilleshög HIL2389	239	344.9	100	8387	105	54.30	99	1315	104	24.41	18.56	1.30	17.25	168	1972	444	0	73.9
Hilleshög HIL2440	232	356.8	103	7983	99	57.87	106	1308	103	22.12	19.20	1.38	17.82	180	1918	514	0	67.5
Hilleshög HIL2441	214	353.3	102	7902	98	56.85	104	1272	101	22.32	18.94	1.27	17.67	172	1925	437	0	70.7
Hilleshög HIL2442	220	359.8	104	7609	95	58.81	108	1235	98	21.32	19.33	1.32	18.01	133	1928	487	0	69.4
Hilleshög HIL2443	227	337.3	97	8437	105	51.96	95	1297	103	25.08	18.18	1.31	16.87	188	1980	448	0	65.0
Maribo MA932	230	354.2	102	9076	113	57.10	105	1468	116	25.55	18.95	1.24	17.71	153	1888	430	0	72.2
Maribo MA942	223	355.3	103	8025	100	57.41	105	1303	103	22.48	18.92	1.17	17.75	130	1875	375	0	73.0
Maribo MA943	233	354.4	102	8050	100	57.19	105	1292	102	22.84	18.94	1.21	17.73	141	1865	413	0	68.6
Maribo MA944	221	357.1	103	7664	95	57.99	106	1241	98	21.52	19.13	1.28	17.85	186	1782	473	0	72.6
SV 215	217	342.6	99	8160	102	53.59	98	1276	101	23.84	18.43	1.28	17.14	144	2068	416	0	65.6
SV 321	209	337.6	98	8095	101	52.05	95	1259	100	23.74	18.14	1.27	16.87	139	1991	429	0	66.1
SV 322	236	350.6	101	8126	101	56.00	103	1300	103	23.12	18.70	1.19	17.51	144	1982	360	0	65.4
SV 324	205	340.6	98	8002	100	52.98	97	1245	98	23.50	18.39	1.35	17.03	173	2177	427	0	81.1
SX 1815	203	349.5	101	8208	102	55.67	102	1307	103	23.51	18.71	1.22	17.48	152	1976	388	0	86.1
SX 1816	206	332.1	96	8358	104	50.39	92	1274	101	25.04	17.88	1.28	16.60	190	1982	420	0	69.6
SX 1818	216	344.8	100	8736	109	54.26	99	1370	108	25.40	18.49	1.24	17.24	155	1982	401	0	73.5
SX 1829	207	341.8	99	7896	98	53.35	98	1242	98	22.90	18.30	1.21	17.09	170	2001	372	0	72.8
BTS 8572 (Check)	243	341.6	99	7694	96	53.28	98	1193	94	22.64	18.46	1.36	17.09	162	2012	487	0	69.2
BTS 8337 (1stYrBench)	244	354.8	103	8206	102	57.28	105	1319	104	23.24	19.10	1.35	17.75	171	2057	464	0	67.1
Crystal 578RR (1stYrBench)	245	340.9	99	7851	98	53.06	97	1228	97	22.91	18.33	1.30	17.03	203	2055	411	0	72.4
BTS 8815 (1stYrBench)	246	346.8	100	8352	104	54.85	100	1320	104	24.10	18.65	1.31	17.33	179	2066	421	0	54.9
Crystal 803 (1stYrBench)	247	355.4	103	8310	104	57.43	105	1359	107	23.06	19.07	1.32	17.75	151	1947	472	0	80.0
AP CK#55 CRYS247	248	337.4	97	8256	103	51.99	95	1264	100	24.64	18.20	1.32	16.88	194	2055	432	0	71.3
Comm Benchmark Mean		346.0		8026		54.62		1265		23.22	18.64	1.33		156	2007	443		75.8
Comm Trial Mean		342.4		8617		53.53		1346		25.20	18.40	1.28		169	1915	421		80.5
Coeff. of Var. (%)		2.2		9.4		4.2		10.0		9.3	1.9	5.3		14.1	2.8	9.8		10.8
Mean LSD (0.05)		6.7		708		2.01		117		2.06	0.31	0.06		21	49	38		7.7
Mean LSD (0.01)		8.8		932		2.65		154		2.71	0.41	0.08		28	64	50		10.1
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from Casselton ND

Created 10/28/2022

@ Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 228301

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed at location.

Table 11.

2022 Performance of Varieties - ACSC RR Official Trials Averill

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	120	302.1	102	8769	110	41.42	105	1197	112	29.10	16.31	1.21	15.10	255	1478	449	0	62.7
BTS 8034	123	286.7	97	8610	108	36.81	93	1107	104	29.95	15.75	1.41	14.34	358	1768	493	0	65.4
BTS 8073	102	303.2	103	8872	111	41.77	106	1218	114	29.37	16.39	1.22	15.17	244	1470	469	0	65.0
BTS 8092	116	285.1	96	8629	108	36.33	92	1095	103	30.34	15.52	1.26	14.26	311	1527	458	0	65.7
BTS 8629	118	288.5	98	8616	108	37.34	94	1116	105	29.77	15.66	1.24	14.42	291	1500	454	0	69.9
BTS 8927	104	306.6	104	8673	109	42.79	108	1211	113	28.35	16.52	1.19	15.33	254	1414	457	0	71.4
BTS 8961	117	290.5	98	8754	110	37.93	96	1145	107	30.13	15.80	1.28	14.52	300	1710	423	0	68.8
Crystal 022	125	314.0	106	8558	107	44.99	114	1225	115	27.20	16.94	1.24	15.70	214	1534	477	0	65.2
Crystal 572	108	316.7	107	8041	101	45.80	116	1163	109	25.43	17.08	1.25	15.83	211	1494	493	0	71.4
Crystal 684	122	282.9	96	9176	115	35.67	90	1158	108	32.37	15.49	1.35	14.14	325	1731	464	0	64.7
Crystal 793	111	297.4	101	8659	108	40.03	101	1161	109	29.19	16.13	1.25	14.88	279	1534	461	0	59.8
Crystal 912	107	278.1	94	8856	111	34.22	87	1091	102	31.82	15.26	1.35	13.91	369	1573	492	0	66.0
Crystal 913	103	304.5	103	8740	109	42.15	107	1206	113	28.91	16.46	1.23	15.23	273	1494	460	0	66.7
Hilleshög HIL2317	112	302.9	102	8285	104	41.67	105	1143	107	27.29	16.32	1.17	15.15	282	1547	394	0	71.4
Hilleshög HIL2320	106	293.0	99	8196	103	38.71	98	1076	101	27.99	15.89	1.23	14.66	300	1503	448	0	70.6
Hilleshög HIL2366	119	282.2	95	7853	98	35.46	90	988	93	27.89	15.37	1.26	14.11	357	1465	456	0	65.2
Hilleshög HIL9708	124	300.7	102	8028	101	41.00	104	1091	102	26.77	16.25	1.22	15.03	312	1458	440	0	76.2
Hilleshög HIL9920	115	302.0	102	8453	106	41.40	105	1159	109	28.07	16.30	1.20	15.10	294	1594	400	0	65.0
Hilleshög HM9528RR	101	294.8	100	8246	103	39.25	99	1096	103	27.97	15.95	1.20	14.75	321	1468	426	0	66.8
Maribo MA717	121	283.1	96	8249	103	35.73	90	1040	97	28.99	15.53	1.38	14.15	339	1615	512	0	64.3
Maribo MA902	110	304.4	103	7899	99	42.13	107	1088	102	25.95	16.41	1.19	15.22	298	1471	420	0	73.6
SV 203	113	290.9	98	8020	100	38.08	96	1052	99	27.60	15.85	1.31	14.54	284	1801	428	0	50.9
SV 265	109	297.6	101	8325	104	40.08	101	1121	105	27.85	16.07	1.18	14.89	258	1614	395	0	65.3
SV 285	105	291.9	99	7533	94	38.35	97	989	93	25.88	15.90	1.31	14.59	297	1764	436	0	58.8
SX 1898	114	291.8	99	7877	99	38.32	97	1031	97	26.92	15.89	1.31	14.58	282	1760	440	0	56.9
BTS 8572 (CommBench)	126	309.1	105	8309	104	43.54	110	1172	110	26.90	16.71	1.26	15.45	253	1527	475	0	66.3
BTS 8337 (CommBench)	127	304.7	103	8093	101	42.22	107	1119	105	26.67	16.55	1.31	15.24	290	1689	460	0	66.1
Crystal 578RR (CommBench)	128	288.2	97	7882	99	37.25	94	1023	96	27.42	15.75	1.35	14.40	330	1741	459	0	68.5
BTS 8815 (CommBench)	129	280.8	95	7644	96	35.05	89	957	90	27.38	15.45	1.41	14.04	390	1818	468	0	57.6
Crystal 803 (Check)	130	302.2	102	8495	106	41.46	105	1167	109	28.22	16.32	1.21	15.11	242	1538	437	0	71.9
AP CK#55 CRYS247	131	283.9	96	8252	103	35.98	91	1043	98	29.17	15.59	1.39	14.20	397	1746	467	0	68.7
AP CK#59 BTS8606	132	288.1	97	8126	102	37.24	94	1051	98	27.96	15.72	1.31	14.41	316	1698	448	0	67.0
Experimental Trial (Comm status)																		
BTS 8100	208	294.8	100	8351	105	39.26	99	1112	104	28.52	16.07	1.33	14.75	257	1696	450	0	67.2
BTS 8133	215	272.2	92	8926	112	32.70	83	1077	101	32.70	14.99	1.39	13.60	316	1681	473	0	70.4
BTS 8156	218	294.5	100	8265	104	39.18	99	1104	103	28.11	16.16	1.44	14.72	278	1790	500	0	76.5
BTS 8205	234	292.7	99	8772	110	38.64	98	1161	109	29.99	16.01	1.37	14.64	239	1602	508	0	61.6
BTS 8217	237	283.8	96	8377	105	36.05	91	1066	100	29.51	15.66	1.48	14.18	317	1787	515	0	65.3
BTS 8226	219	315.3	107	9035	113	45.22	114	1303	122	28.71	16.87	1.09	15.78	185	1414	372	0	62.9
BTS 8242	204	301.6	102	8308	104	41.23	104	1132	106	27.81	16.44	1.37	15.08	240	1590	507	0	66.0
BTS 8248	238	299.0	101	8605	108	40.46	102	1166	109	28.82	16.21	1.27	14.95	226	1533	450	0	67.2
BTS 8270	211	306.7	104	8889	111	42.70	108	1241	116	28.95	16.60	1.27	15.34	201	1581	450	0	68.9
BTS 8299	235	295.9	100	8004	100	39.57	100	1073	100	27.28	16.03	1.24	14.79	206	1531	449	0	61.0
Crystal 021	226	274.9	93	8200	103	33.46	85	997	93	30.14	15.19	1.46	13.73	378	1644	519	0	59.8
Crystal 026	240	289.6	98	8494	106	37.75	96	1111	104	29.38	15.84	1.36	14.48	276	1761	445	0	70.7
Crystal 130	213	301.4	102	8540	107	41.18	104	1165	109	28.48	16.39	1.32	15.07	190	1607	486	0	65.8
Crystal 134	202	310.3	105	8195	103	43.74	111	1161	109	26.52	16.73	1.21	15.52	200	1444	450	0	60.5
Crystal 137	201	294.3	100	8302	104	39.11	99	1105	103	28.25	16.07	1.36	14.72	247	1775	453	0	67.9
Crystal 138	224	307.0	104	8684	109	42.78	108	1214	114	28.42	16.57	1.22	15.35	171	1487	461	0	64.9
Crystal 260	231	298.9	101	8665	109	40.46	102	1173	110	29.04	16.21	1.27	14.95	235	1596	434	0	76.8
Crystal 262	229	300.0	101	8544	107	40.76	103	1161	109	28.66	16.20	1.19	15.01	239	1492	404	0	64.9
Crystal 263	210	301.6	102	8502	107	41.23	104	1164	109	28.24	16.35	1.25	15.09	208	1615	435	0	60.0
Crystal 265	225	297.2	101	8081	101	39.96	101	1090	102	27.36	16.07	1.21	14.86	173	1530	441	0	67.1
Crystal 267	222	288.4	98	8438	106	37.38	95	1092	102	29.42	15.75	1.34	14.41	252	1749	440	0	62.7
Crystal 269	212	288.8	98	8449	106	37.49	95	1100	103	29.35	15.84	1.41	14.43	287	1652	507	0	59.7
Hilleshög HIL2367	242	295.3	100	7991	100	39.39	100	1065	100	27.12	16.02	1.25	14.77	262	1495	443	0	65.8
Hilleshög HIL2368	241	295.8	100	6554	82	39.53	100	884	83	22.20	16.02	1.23	14.79	285	1506	421	0	45.0
Hilleshög HIL2386	228	288.3	97	8183	103	37.34	95	1067	100	28.44	15.74	1.34	14.40	300	1476	494	0	70.8
Hilleshög HIL2389	239	299.1	101	8409	105	40.49	102	1144	107	27.91	16.23	1.28	14.95	233	1588	446	0	67.0
Hilleshög HIL2440	232	289.1	98	8163	102	37.60	95	1064	100	28.36	15.92	1.48	14.43	341	1704	529	0	60.5
Hilleshög HIL2441	214	302.5	102	7543	95	41.49	105	1038	97	25.05	16.44	1.32	15.12	277	1534	473	0	61.0
Hilleshög HIL2442	220	298.5	101	7431	93	40.33	102	1002	94	25.22	16.27	1.35	14.92	244	1601	491	0	59.3
Hilleshög HIL2443	227	284.6	96	8163	102	36.28	92	1046	98	28.68	15.50	1.28	14.22	282	1602	426	0	59.1
Maribo MA932	230	293.4	99	8298	104	38.85	98	1103	103	28.48	15.97	1.31	14.66	285	1496	472	0	68.7
Maribo MA942	223	298.9	101	8005	100	40.43	102	1085	102	26.84	16.22	1.28	14.94	214	1469	483	0	72.7
Maribo MA943	233	300.0	101	7976	100	40.77	103	1085	102	26.71	16.34	1.35	14.99	201	1553	515	0	63.4
Maribo MA944	221	300.2	102	7766	97	40.85	103	1054	99	25.97	16.32	1.31	15.01	267	1511	473	0	61.7
SV 215	217	287.2	97	7779	97	37.04	94	1009	95	27.23	15.59	1.24	14.35	232	1691	401	0	45.8
SV 321	209	269.4	91	8144	102	31.86	81	969	91	30.16	14.79	1.34	13.45	255	1733	440	0	56.0
SV 322	236	275.2	93	7424	93	33.58	85	910	85	26.99	15.06	1.31	13.75	280	1687	423	0	49.6
SV 324	205	279.8	95	7919	99	34.90	88	987	92	28.21	15.35	1.36	13.99	272	1773	443	0	53.2
SX 1815	203	304.2	103	8660	108	41.98	106	1195	112	28.57	16.45	1.24	15.21	207	1614	422	0	73.2
SX 1816	206	276.5	94	8001	100	33.94	86	984	92	29.08	15.20	1.39	13.81	308	1702	474	0	50.7
SX 1818	216	285.2	96	8376	105	36.44	92	1077	101	29.47	15.58	1.34	14.25	263	1730	446	0	59.7
SX 1829	207	273.3	92	7404	93	32.99	83	897	84	27.22	14.96	1.31	13.65	286	1650	434	0	50.0
BTS 8572 (Check)	243	307.0	104	8058	101	42.77	108	1127	106	26.27	16.65	1.30	15.35	200	1566	483	0	71.4
BTS 8337 (1stYrBench)	244	298.9	101	7715	97	40.45	102	1045	98	25.98	16.32	1.38	14.94	332	1667	471	0	68.9
Crystal 578RR (1stYrBench)	245	288.1	97	8562	107	37.30	94	1113	104	29.66	15.70	1.31	14.40	232	1691	444	0	71.3
BTS 8815 (1stYrBench)	246	288.9	98	7593	95	37.54	95	985	92	26.46	15.79	1.35	14.44	318	1737	432	0	55.2
Crystal 803 (1stYrBench)	247	299.4	101	8585	108	40.57	103	1169	109	28.85	16.25	1.29	14.96	228	1607	455	0	69.3
AP CK#55 CRYS247	248	290.8	98	8179	102	38.11	96	1071	100	28.14	15.91	1.37	14.54	331	1771	431	0	65.7
Comm Benchmark Mean		295.7		7982		39.52		1068		27.09	16.12	1.33		316	1694	465		64.6
Comm Trial Mean		295.3		8335		39.38		1109		28.27	16.03	1.27		298	1595	452		66.1
Coeff. of Var. (%)		3.1		5.8		6.9		8.3		5.3	2.5	6.6		18.3	4.3	10.5		13.5
Mean LSD (0.05)		8.1		411		2.42		80		1.28	0.36	0.08		48	61	42		7.5
Mean LSD (0.01)		10.6		541		3.19		105		1.68	0.47	0.10		64	80	56		9.8
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from Averill MN

Created 10/28/2022

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 228302

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed at location.

Table 12.

2022 Performance of Varieties - ACSC RR Official Trials Ada

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	120	342.1	100	11787	108	53.45	101	1839	108	34.51	18.05	0.95	17.10	181	1507	267	0	62.7
BTS 8034	123	335.3	98	11517	106	51.39	97	1767	104	34.31	17.82	1.06	16.76	223	1721	282	0	68.9
BTS 8073	102	347.3	102	11905	109	55.00	103	1886	111	34.31	18.32	0.95	17.37	172	1494	277	0	61.0
BTS 8092	116	326.0	96	10912	100	48.62	91	1628	96	33.44	17.27	0.97	16.30	172	1525	283	0	59.8
BTS 8629	118	332.4	97	11538	106	50.54	95	1752	103	34.71	17.62	1.00	16.62	211	1499	296	0	65.5
BTS 8927	104	355.8	104	11746	108	57.56	108	1898	112	33.10	18.66	0.87	17.79	151	1435	236	0	67.4
BTS 8961	117	336.8	99	11545	106	51.84	98	1779	105	34.29	17.81	0.97	16.84	199	1601	251	0	59.4
Crystal 022	125	351.6	103	11103	102	56.30	106	1777	105	31.58	18.47	0.89	17.58	123	1462	255	0	62.0
Crystal 572	108	350.9	103	11143	102	56.08	105	1781	105	31.72	18.52	0.98	17.54	151	1512	300	0	63.4
Crystal 684	122	330.5	97	12332	113	49.97	94	1862	110	37.40	17.55	1.02	16.53	214	1686	268	0	58.9
Crystal 793	111	336.5	99	11274	103	51.77	97	1735	102	33.54	17.75	0.92	16.83	182	1468	254	0	61.2
Crystal 912	107	340.8	100	12407	114	53.04	100	1927	113	36.55	17.94	0.90	17.04	177	1419	253	0	62.9
Crystal 913	103	343.1	101	11564	106	53.74	101	1812	107	33.60	18.11	0.95	17.16	208	1471	273	0	57.1
Hilleshög HIL2317	112	341.6	100	11753	108	53.28	100	1831	108	34.47	17.96	0.89	17.07	187	1513	217	0	55.9
Hilleshög HIL2320	106	338.7	99	11433	105	52.43	99	1768	104	33.83	17.93	1.00	16.93	188	1563	288	0	60.0
Hilleshög HIL2366	119	337.9	99	11174	102	52.19	98	1724	101	33.10	17.86	0.97	16.89	208	1552	261	0	64.5
Hilleshög HIL9708	124	339.1	99	11447	105	52.55	99	1773	104	33.80	17.85	0.89	16.96	203	1499	221	0	71.6
Hilleshög HIL9920	115	330.9	97	11327	104	50.09	94	1717	101	34.13	17.52	0.97	16.55	217	1596	253	0	63.3
Hilleshög HM9528RR	101	326.0	96	11063	101	48.59	91	1650	97	33.94	17.25	0.95	16.30	220	1560	243	0	62.1
Maribo MA717	121	334.3	98	11614	107	51.11	96	1774	104	34.75	17.66	0.94	16.72	198	1546	246	0	62.9
Maribo MA902	110	329.5	97	11074	102	49.66	93	1669	98	33.58	17.40	0.93	16.47	214	1514	239	0	72.0
SV 203	113	336.3	99	10159	93	51.71	97	1563	92	30.17	17.77	0.96	16.81	167	1640	245	0	44.9
SV 265	109	322.3	94	11085	102	47.49	89	1634	96	34.35	17.02	0.90	16.12	171	1507	237	0	47.3
SV 285	105	338.7	99	10091	93	52.41	99	1560	92	29.83	17.91	0.98	16.93	173	1668	255	0	43.3
SX 1898	114	335.7	98	10620	97	51.52	97	1632	96	31.65	17.78	0.99	16.79	171	1685	260	0	39.6
BTS 8572 (CommBench)	126	346.2	101	10928	100	54.68	103	1725	102	31.57	18.27	0.96	17.31	164	1510	287	0	60.2
BTS 8337 (CommBench)	127	354.5	104	11153	102	57.16	108	1800	106	31.47	18.71	0.99	17.72	202	1647	254	0	57.3
Crystal 578RR (CommBench)	128	328.8	96	11223	103	49.45	93	1692	100	34.01	17.48	1.05	16.43	217	1749	267	0	61.8
BTS 8815 (CommBench)	129	335.1	98	10306	95	51.34	97	1578	93	30.74	17.75	0.99	16.76	206	1651	256	0	52.3
Crystal 803 (Check)	130	342.3	100	11204	103	53.49	101	1751	103	32.72	18.09	0.97	17.12	169	1582	274	0	65.0
AP CK#55 CRYS247	131	327.4	96	11486	105	49.04	92	1724	101	34.92	17.34	0.97	16.37	238	1638	233	0	62.5
AP CK#59 BTS8606	132	333.1	98	11366	104	50.73	95	1731	102	34.14	17.63	0.97	16.66	187	1618	255	0	59.8
Experimental Trial (Comm status)																		
BTS 8100	208	340.7	100	10514	96	53.00	100	1631	96	30.93	18.00	0.96	17.04	183	1734	252	0	58.7
BTS 8133	215	337.1	99	12186	112	51.96	98	1876	110	36.20	17.82	0.97	16.85	204	1688	255	0	66.2
BTS 8156	218	350.0	103	11166	102	55.84	105	1781	105	31.90	18.47	0.96	17.50	185	1691	258	0	63.6
BTS 8205	234	331.2	97	11110	102	50.15	94	1686	99	33.43	17.52	0.95	16.57	213	1488	296	0	58.5
BTS 8217	237	338.1	99	10261	94	52.26	98	1584	93	30.39	17.79	0.89	16.90	179	1613	220	0	53.8
BTS 8226	219	356.0	104	11687	107	57.65	108	1897	112	32.73	18.66	0.87	17.79	158	1357	277	0	55.0
BTS 8242	204	359.4	105	10811	99	58.70	110	1765	104	30.08	18.88	0.91	17.97	160	1486	278	0	55.2
BTS 8248	238	347.0	102	10310	95	54.94	103	1631	96	29.67	18.25	0.91	17.35	167	1565	258	0	49.9
BTS 8270	211	348.6	102	11206	103	55.42	104	1781	105	32.17	18.36	0.94	17.42	164	1598	271	0	60.1
BTS 8299	235	340.1	100	11503	106	52.82	99	1786	105	33.75	17.90	0.90	17.01	165	1501	267	0	50.2
Crystal 021	226	335.9	98	10277	94	51.58	97	1579	93	30.60	17.69	0.90	16.79	192	1538	246	0	46.4
Crystal 026	240	344.6	101	11617	107	54.20	102	1828	108	33.70	18.18	0.95	17.23	194	1715	240	0	53.1
Crystal 130	213	355.2	104	11387	104	57.41	108	1840	108	32.06	18.62	0.87	17.75	164	1459	248	0	62.1
Crystal 134	202	347.8	102	10713	98	55.19	104	1697	100	30.86	18.28	0.90	17.39	170	1438	274	0	54.7
Crystal 137	201	351.0	103	11311	104	56.12	106	1807	106	32.20	18.53	0.98	17.54	193	1720	264	0	51.6
Crystal 138	224	346.7	102	11594	106	54.85	103	1835	108	33.46	18.24	0.92	17.33	166	1465	285	0	55.2
Crystal 260	231	342.2	100	11076	102	53.46	101	1730	102	32.32	18.00	0.90	17.11	179	1441	271	0	60.6
Crystal 262	229	340.3	100	11422	105	52.89	100	1776	105	33.56	17.87	0.87	17.00	166	1470	244	0	57.3
Crystal 263	210	354.1	104	9559	88	57.07	107	1539	91	27.07	18.65	0.94	17.70	156	1574	285	0	50.3
Crystal 265	225	335.3	98	10270	94	51.39	97	1578	93	30.61	17.63	0.88	16.75	163	1489	249	0	51.6
Crystal 267	222	345.5	101	11240	103	54.49	103	1769	104	32.62	18.28	1.01	17.27	205	1764	261	0	53.8
Crystal 269	212	351.2	103	10097	93	56.19	106	1614	95	28.75	18.51	0.94	17.56	191	1566	279	0	48.7
Hilleshög HIL2367	242	329.7	97	11359	104	49.67	93	1711	101	34.43	17.49	1.00	16.49	267	1517	308	0	54.2
Hilleshög HIL2368	241	339.6	100	8469	78	52.67	99	1318	78	24.86	17.97	0.99	16.98	236	1604	288	0	31.8
Hilleshög HIL2386	228	327.9	96	11839	109	49.12	92	1778	105	35.95	17.37	0.96	16.40	231	1485	299	0	62.9
Hilleshög HIL2389	239	330.2	97	11682	107	49.83	94	1761	104	35.40	17.46	0.95	16.50	198	1606	267	0	55.5
Hilleshög HIL2440	232	351.6	103	11176	103	56.31	106	1787	105	31.84	18.57	0.98	17.58	214	1599	292	0	46.7
Hilleshög HIL2441	214	341.5	100	10577	97	53.26	100	1650	97	30.98	18.03	0.96	17.07	214	1632	265	0	56.1
Hilleshög HIL2442	220	334.2	98	10217	94	51.06	96	1559	92	30.67	17.78	1.08	16.70	213	1515	378	0	45.8
Hilleshög HIL2443	227	330.0	97	11452	105	49.77	94	1723	101	34.73	17.46	0.95	16.50	221	1634	256	0	47.5
Maribo MA932	230	325.4	95	10866	100	48.39	91	1620	95	33.29	17.26	0.98	16.27	232	1572	287	0	64.4
Maribo MA942	223	338.5	99	10731	98	52.34	98	1661	98	31.71	17.80	0.89	16.91	161	1440	269	0	61.6
Maribo MA943	233	342.1	100	10408	95	53.44	101	1629	96	30.34	18.09	0.98	17.11	220	1521	307	0	52.2
Maribo MA944	221	338.7	99	10792	99	52.39	99	1670	98	31.86	17.86	0.93	16.93	187	1475	291	0	55.2
SV 215	217	317.2	93	9756	89	45.88	86	1409	83	30.76	16.84	0.98	15.86	193	1706	265	0	36.3
SV 321	209	320.1	94	10016	92	46.79	88	1460	86	31.35	16.99	0.97	16.01	174	1721	260	0	39.8
SV 322	236	326.4	96	9693	89	48.70	92	1441	85	29.75	17.27	0.94	16.32	235	1605	245	0	39.7
SV 324	205	323.8	95	10873	100	47.92	90	1609	95	33.52	17.20	1.00	16.19	243	1684	269	0	48.0
SX 1815	203	333.1	98	11210	103	50.73	95	1711	101	33.54	17.73	1.07	16.66	238	1749	307	0	56.5
SX 1816	206	335.2	98	10766	99	51.36	97	1650	97	32.20	17.75	0.99	16.76	209	1652	280	0	41.6
SX 1818	216	343.2	101	11172	102	53.78	101	1750	103	32.51	18.13	0.97	17.16	203	1611	283	0	46.8
SX 1829	207	339.8	100	10633	98	52.73	99	1653	97	31.26	17.89	0.92	16.98	200	1619	231	0	44.6
BTS 8572 (Check)	243	336.2	99	10936	100	51.67	97	1683	99	32.42	17.76	0.95	16.81	199	1499	296	0	63.3
BTS 8337 (1stYrBench)	244	348.4	102	11018	101	55.36	104	1750	103	31.63	18.46	1.03	17.42	216	1631	313	0	47.1
Crystal 578RR (1stYrBench)	245	324.3	95	11029	101	48.06	90	1640	97	33.88	17.28	1.06	16.22	284	1719	290	0	55.4
BTS 8815 (1stYrBench)	246	355.6	104	10628	97	57.53	108	1722	101	29.85	18.72	0.94	17.77	192	1646	251	0	43.5
Crystal 803 (1stYrBench)	247	347.1	102	11069	102	54.96	103	1754	103	31.81	18.27	0.92	17.36	173	1520	274	0	59.7
AP CK#55 CRYS247	248	326.7	96	11254	103	48.81	92	1685	99	34.34	17.34	1.00	16.34	265	1654	268	0	52.5
Comm Benchmark Mean		341.2		10903		53.16		1699		31.95	18.05	1.00		197	1639	266		57.9
Comm Trial Mean		337.7		11290		52.13		1742		33.44	17.85	0.96		190	1564	259		59.9
Coeff. of Var. (%)		2.8		5.5		5.4		7.1		4.9	2.5	6.6		18.2	4.5	10.7		15.3
Mean LSD (0.05)		8.5		557		2.55		111		1.46	0.40	0.06		31	63	25		8.0
Mean LSD (0.01)		11.2		733		3.36		146		1.93	0.52	0.08		41	83	33		10.5
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from Ada MN

Created 10/28/2022

@ Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 228304

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed at location.

Table 13.

2022 Performance of Varieties - ACSC RR Official Trials Grand

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	120	346.2	101	9711	116	54.67	102	1531	117	28.09	18.36	1.05	17.31	254	1576	303	0	81.5
BTS 8034	123	325.7	95	9140	109	48.52	90	1358	104	28.22	17.55	1.27	16.28	426	1770	356	0	83.3
BTS 8073	102	345.0	101	9444	113	54.31	101	1488	113	27.39	18.36	1.11	17.25	264	1549	356	0	79.4
BTS 8092	116	334.7	98	9697	116	51.21	95	1480	113	29.14	17.77	1.03	16.74	275	1550	291	0	78.7
BTS 8629	118	321.2	94	9478	113	47.15	88	1398	107	29.25	17.20	1.15	16.05	329	1569	350	0	81.8
BTS 8927	104	350.9	102	8875	106	56.10	104	1420	108	25.24	18.57	1.02	17.55	264	1461	308	0	84.4
BTS 8961	117	336.9	98	9294	111	51.87	96	1427	109	27.67	17.93	1.08	16.85	261	1661	303	0	81.3
Crystal 022	125	359.8	105	9156	109	58.77	109	1493	114	25.42	18.99	1.00	17.99	224	1476	302	0	75.3
Crystal 572	108	349.5	102	8802	105	55.66	103	1403	107	25.10	18.64	1.16	17.48	334	1505	379	0	81.0
Crystal 684	122	323.4	94	9683	116	47.83	89	1427	109	30.08	17.41	1.23	16.18	394	1770	341	0	78.1
Crystal 793	111	351.7	102	9850	118	56.32	105	1578	120	28.07	18.58	0.99	17.59	232	1538	279	0	80.5
Crystal 912	107	324.1	94	9639	115	48.05	89	1429	109	29.73	17.41	1.20	16.21	430	1458	383	0	79.7
Crystal 913	103	342.5	100	9661	115	53.57	100	1508	115	28.25	18.22	1.10	17.12	321	1489	336	0	76.3
Hilleshög HIL2317	112	335.7	98	8710	104	51.52	96	1334	102	25.93	17.79	1.01	16.78	271	1569	263	0	84.1
Hilleshög HIL2320	106	341.4	99	9628	115	53.24	99	1497	114	28.34	18.10	1.03	17.07	267	1564	285	0	79.2
Hilleshög HIL2366	119	336.5	98	9040	108	51.76	96	1387	106	26.90	17.90	1.07	16.83	341	1475	313	0	85.9
Hilleshög HIL9708	124	336.7	98	8618	103	51.82	96	1324	101	25.63	18.03	1.20	16.83	445	1447	380	0	86.5
Hilleshög HIL9920	115	334.5	97	8850	106	51.15	95	1350	103	26.55	17.86	1.14	16.72	384	1604	316	0	81.5
Hilleshög HM9528RR	101	333.5	97	9136	109	50.85	95	1393	106	27.45	17.73	1.06	16.67	317	1505	304	0	83.3
Maribo MA717	121	341.5	99	9558	114	53.26	99	1488	113	28.08	18.11	1.03	17.08	273	1522	296	0	80.0
Maribo MA902	110	335.6	98	8402	100	51.48	96	1286	98	25.05	17.94	1.16	16.78	360	1552	356	0	88.0
SV 203	113	345.3	101	8735	104	54.40	101	1378	105	25.32	18.35	1.08	17.27	238	1720	296	0	73.7
SV 265	109	341.3	99	8967	107	53.21	99	1397	107	26.33	18.16	1.09	17.07	284	1568	325	0	82.8
SV 285	105	344.5	100	8689	104	54.15	101	1367	104	25.23	18.32	1.10	17.22	301	1664	300	0	75.8
SX 1898	114	337.6	98	8617	103	52.10	97	1330	101	25.55	17.95	1.07	16.88	285	1729	265	0	75.5
BTS 8572 (CommBench)	126	354.0	103	8490	101	57.02	106	1372	105	23.95	18.87	1.17	17.70	227	1568	406	0	80.0
BTS 8337 (CommBench)	127	344.4	100	7452	89	54.13	101	1166	89	21.68	18.43	1.21	17.22	339	1650	374	0	73.4
Crystal 578RR (CommBench)	128	336.7	98	8818	105	51.83	96	1356	103	26.19	18.08	1.25	16.83	397	1677	375	0	80.7
BTS 8815 (CommBench)	129	337.8	98	8732	104	52.16	97	1352	103	25.76	18.06	1.16	16.90	290	1744	333	0	76.6
Crystal 803 (Check)	130	342.8	100	9664	115	53.64	100	1515	116	28.12	18.14	1.00	17.14	267	1605	252	0	85.4
AP CK#55 CRYS247	131	338.6	99	9137	109	52.38	97	1413	108	26.95	18.00	1.07	16.93	301	1698	269	0	83.6
AP CK#59 BTS8606	132	337.9	98	9214	110	52.18	97	1423	109	27.24	17.98	1.08	16.90	295	1658	290	0	83.1
Experimental Trial (Comm status)																		
BTS 8100	208	340.2	99	8744	104	52.88	98	1358	104	25.76	18.11	1.09	17.02	262	1798	274	0	81.6
BTS 8133	215	324.2	94	9647	115	48.08	89	1449	110	29.45	17.37	1.15	16.21	307	1792	300	0	87.9
BTS 8156	218	346.1	101	9833	117	54.63	102	1554	119	28.26	18.42	1.10	17.32	263	1746	296	0	87.1
BTS 8205	234	341.2	99	8809	105	53.20	99	1372	105	25.24	18.21	1.14	17.07	247	1611	364	0	76.6
BTS 8217	237	339.5	99	9433	113	52.69	98	1493	114	27.26	18.10	1.12	16.98	273	1708	317	0	81.3
BTS 8226	219	351.5	102	8898	106	56.28	105	1444	110	25.19	18.62	1.04	17.58	244	1508	314	0	83.6
BTS 8242	204	361.7	105	8625	103	59.34	110	1414	108	23.93	19.21	1.12	18.09	229	1573	368	0	79.3
BTS 8248	238	341.5	100	9075	108	53.29	99	1419	108	27.07	18.21	1.12	17.09	300	1608	328	0	76.6
BTS 8270	211	365.2	106	9270	111	60.42	112	1546	118	25.73	19.36	1.09	18.27	230	1644	327	0	75.0
BTS 8299	235	345.6	101	8315	99	54.50	101	1309	100	24.05	18.24	0.96	17.28	202	1509	266	0	79.7
Crystal 021	226	335.7	98	9601	115	51.53	96	1483	113	27.88	17.89	1.10	16.79	337	1631	294	0	81.3
Crystal 026	240	349.9	102	9737	116	55.78	104	1561	119	27.47	18.56	1.06	17.50	253	1741	267	0	81.3
Crystal 130	213	354.3	103	9343	112	57.11	106	1516	116	26.28	18.75	1.02	17.73	213	1611	290	0	78.9
Crystal 134	202	356.2	104	9184	110	57.67	107	1479	113	25.74	18.85	1.04	17.81	251	1542	304	0	76.2
Crystal 137	201	344.4	100	9759	117	54.12	101	1533	117	28.11	18.42	1.20	17.22	298	1879	320	0	82.0
Crystal 138	224	348.8	102	9742	116	55.47	103	1560	119	27.69	18.48	1.03	17.45	228	1603	288	0	73.4
Crystal 260	231	362.4	106	9328	111	59.56	111	1541	118	25.81	19.11	0.99	18.12	203	1583	272	0	82.4
Crystal 262	229	340.7	99	9057	108	53.05	99	1410	108	27.05	18.13	1.08	17.05	299	1572	310	0	80.5
Crystal 263	210	354.5	103	9054	108	57.19	106	1462	111	25.93	18.79	1.06	17.73	282	1581	299	0	80.1
Crystal 265	225	350.2	102	8910	106	55.88	104	1420	108	25.38	18.51	1.00	17.51	227	1522	288	0	79.3
Crystal 267	222	331.4	97	9945	119	50.23	93	1515	115	30.07	17.81	1.24	16.57	349	1846	342	0	83.2
Crystal 269	212	357.2	104	9892	118	58.00	108	1599	122	27.69	18.98	1.12	17.86	286	1683	313	0	73.8
Hilleshög HIL2367	242	348.0	101	9140	109	55.23	103	1440	110	26.72	18.54	1.13	17.41	330	1559	338	0	81.6
Hilleshög HIL2368	241	353.2	103	7652	91	56.80	106	1234	94	22.03	18.71	1.05	17.66	260	1618	282	0	58.6
Hilleshög HIL2386	228	348.1	101	9863	118	55.23	103	1559	119	28.42	18.46	1.05	17.41	262	1518	316	0	82.0
Hilleshög HIL2389	239	346.4	101	9116	109	54.72	102	1449	110	25.79	18.41	1.09	17.32	250	1624	321	0	77.0
Hilleshög HIL2440	232	341.9	100	8666	104	53.40	99	1364	104	25.22	18.32	1.23	17.09	346	1613	391	0	76.6
Hilleshög HIL2441	214	346.0	101	8384	100	54.60	102	1327	101	24.31	18.41	1.11	17.30	293	1572	331	0	81.3
Hilleshög HIL2442	220	359.1	105	8535	102	58.56	109	1384	106	23.61	19.03	1.07	17.96	198	1608	335	0	74.6
Hilleshög HIL2443	227	321.6	94	9186	110	47.27	88	1347	103	28.27	17.30	1.21	16.08	410	1619	359	0	76.2
Maribo MA932	230	346.1	101	9296	111	54.63	102	1454	111	26.92	18.41	1.11	17.30	293	1558	335	0	77.3
Maribo MA942	223	351.5	102	7941	95	56.27	105	1267	97	22.53	18.61	1.03	17.58	215	1480	328	0	82.0
Maribo MA943	233	338.5	99	8913	106	52.37	97	1383	105	26.20	18.04	1.10	16.94	310	1603	317	0	71.1
Maribo MA944	221	350.6	102	8838	106	55.99	104	1419	108	25.21	18.63	1.10	17.53	278	1550	341	0	76.2
SV 215	217	343.4	100	8887	106	53.83	100	1383	105	26.45	18.28	1.10	17.18	242	1790	289	0	79.3
SV 321	209	348.1	101	9347	112	55.23	103	1473	112	26.76	18.40	1.00	17.40	222	1607	269	0	69.5
SV 322	236	338.7	99	8525	102	52.44	97	1300	99	25.23	18.03	1.09	16.94	273	1658	304	0	78.9
SV 324	205	332.0	97	8319	99	50.43	94	1269	97	25.58	17.84	1.23	16.61	353	1908	312	0	73.8
SX 1815	203	349.3	102	9020	108	55.61	103	1439	110	25.47	18.52	1.05	17.47	231	1682	283	0	77.3
SX 1816	206	327.8	96	8807	105	49.15	91	1310	100	27.88	17.54	1.14	16.40	251	1725	326	0	73.4
SX 1818	216	336.7	98	9321	111	51.84	96	1427	109	27.43	17.93	1.08	16.85	240	1667	308	0	82.8
SX 1829	207	347.9	101	8627	103	55.19	103	1367	104	24.60	18.42	1.02	17.40	252	1646	263	0	73.1
BTS 8572 (Check)	243	350.0	102	8300	99	55.83	104	1321	101	23.82	18.70	1.19	17.51	256	1712	379	0	76.2
BTS 8337 (1stYrBench)	244	345.5	101	7781	93	54.45	101	1223	93	22.60	18.53	1.26	17.27	334	1765	381	0	76.6
Crystal 578RR (1stYrBench)	245	331.4	97	8686	104	50.23	93	1322	101	26.18	17.75	1.17	16.58	362	1737	312	0	82.4
BTS 8815 (1stYrBench)	246	346.1	101	8725	104	54.64	102	1381	105	24.98	18.46	1.16	17.30	285	1776	325	0	73.8
Crystal 803 (1stYrBench)	247	350.1	102	9558	114	55.86	104	1529	117	27.66	18.53	1.02	17.51	202	1601	291	0	84.8
AP CK#55 CRYS247	248	340.9	99	8904	106	53.10	99	1388	106	26.21	18.17	1.11	17.06	315	1769	276	0	81.3
Comm Benchmark Mean		343.2		8373		53.79		1312		24.40	18.36	1.20		313	1660	372		77.7
Comm Trial Mean		339.6		9090		52.70		1408		26.81	18.09	1.11		309	1590	321		80.6
Coeff. of Var. (%)		2.7		6.9		5.2		8.0		6.8	2.3	8.5		23.6	3.9	15.5		9.3
Mean LSD (0.05)		8.4		565		2.51		101		1.62	0.38	0.09		67	56	46		6.1
Mean LSD (0.01)		11.0		744		3.31		133		2.13	0.49	0.11		88	74	60		8.0
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from Grand Forks ND

Created 10/28/2022

@ Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 228307

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed at location.

Table 14.

2022 Performance of Varieties - ACSC RR Official Trials

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	120	355.7	103	10207	109	57.52	105	1648	112	28.73	18.95	1.16	17.79	167	1489	443	0	82.2
BTS 8034	123	352.7	102	10599	114	56.62	103	1694	115	30.21	18.94	1.31	17.63	251	1642	486	0	80.8
BTS 8073	102	347.8	100	10501	113	55.16	101	1668	114	30.18	18.77	1.38	17.39	216	1560	574	0	74.2
BTS 8092	116	338.3	98	10767	115	52.30	95	1658	113	31.96	18.11	1.20	16.91	216	1488	453	0	79.6
BTS 8629	118	338.3	98	10987	118	52.31	95	1693	115	32.56	18.22	1.30	16.92	229	1504	524	0	79.8
BTS 8927	104	366.7	106	9835	105	60.83	111	1627	111	26.83	19.45	1.11	18.34	179	1421	418	0	78.8
BTS 8961	117	342.3	99	10312	111	53.52	98	1612	110	30.16	18.35	1.23	17.12	188	1566	469	0	79.8
Crystal 022	125	359.4	104	9776	105	58.64	107	1587	108	27.39	19.16	1.18	17.98	202	1457	455	0	77.6
Crystal 572	108	355.8	103	9940	107	57.56	105	1603	109	27.93	18.95	1.16	17.79	119	1414	479	0	81.7
Crystal 684	122	327.8	95	10895	117	49.14	90	1621	110	33.48	17.72	1.33	16.39	279	1634	496	0	79.7
Crystal 793	111	349.7	101	10550	113	55.73	102	1685	115	30.02	18.67	1.18	17.49	207	1448	454	0	80.5
Crystal 912	107	331.7	96	10980	118	50.33	92	1664	113	33.16	17.92	1.33	16.59	289	1530	518	0	78.9
Crystal 913	103	351.1	101	10383	111	56.15	102	1655	113	29.74	18.79	1.24	17.55	224	1470	484	0	78.6
Hilleshög HIL2317	112	350.4	101	9616	103	55.94	102	1531	104	27.49	18.67	1.15	17.52	204	1578	395	0	73.9
Hilleshög HIL2320	106	349.7	101	10029	108	55.72	102	1594	109	28.70	18.61	1.12	17.49	203	1450	411	0	79.3
Hilleshög HIL2366	119	342.3	99	10109	108	53.51	98	1576	107	29.69	18.23	1.12	17.11	210	1468	399	0	77.9
Hilleshög HIL9708	124	345.4	100	9075	97	54.42	99	1424	97	26.33	18.44	1.18	17.26	202	1437	458	0	78.3
Hilleshög HIL9920	115	338.5	98	9640	103	52.37	95	1486	101	28.60	18.07	1.14	16.93	241	1537	385	0	79.9
Hilleshög HM9528RR	101	342.2	99	9961	107	53.48	97	1554	106	29.18	18.26	1.15	17.11	239	1453	415	0	79.0
Maribo MA717	121	342.3	99	10201	109	53.50	97	1586	108	30.07	18.22	1.11	17.11	247	1525	363	0	76.2
Maribo MA902	110	334.5	96	8799	94	51.17	93	1339	91	26.47	17.88	1.16	16.72	252	1448	418	0	82.0
SV 203	113	342.1	99	9714	104	53.45	97	1508	103	28.56	18.26	1.16	17.10	162	1596	414	0	67.0
SV 265	109	340.4	98	9949	107	52.94	96	1542	105	29.33	18.20	1.17	17.03	208	1484	439	0	84.7
SV 285	105	350.0	101	9316	100	55.80	102	1483	101	26.77	18.71	1.21	17.50	212	1642	424	0	75.2
SX 1898	114	334.0	96	9798	105	51.02	93	1496	102	29.40	18.00	1.30	16.70	265	1658	473	0	70.3
BTS 8572 (CommBench)	126	348.0	100	9195	99	55.21	101	1453	99	26.47	18.65	1.25	17.40	190	1544	491	0	79.0
BTS 8337 (CommBench)	127	359.5	104	8852	95	58.67	107	1443	98	24.68	19.19	1.22	17.97	187	1546	465	0	83.0
Crystal 578RR (CommBench)	128	336.0	97	9630	103	51.62	94	1475	100	28.72	18.10	1.30	16.80	250	1608	490	0	80.7
BTS 8815 (CommBench)	129	343.9	99	9625	103	53.99	98	1505	102	28.09	18.49	1.29	17.20	223	1680	472	0	70.6
Crystal 803 (Check)	130	345.4	100	10217	110	54.44	99	1614	110	29.53	18.49	1.21	17.28	195	1480	477	0	84.2
AP CK#55 CRYS247	131	340.0	98	9512	102	52.81	96	1467	100	28.15	18.21	1.21	17.00	244	1582	427	0	79.0
AP CK#59 BTS8606	132	341.5	98	9843	106	53.26	97	1530	104	28.96	18.35	1.28	17.07	224	1616	477	0	77.5
Experimental Trial (Comm status)																		
BTS 8100	208	360.3	104	9738	104	59.00	108	1592	108	27.20	19.10	1.12	17.98	178	1517	474	0	77.1
BTS 8133	215	337.8	97	10453	112	52.11	95	1615	110	31.04	18.08	1.20	16.88	248	1638	488	0	86.6
BTS 8156	218	366.5	106	9791	105	60.89	111	1631	111	26.36	19.44	1.13	18.31	238	1596	433	0	83.9
BTS 8205	234	346.9	100	10212	110	54.86	100	1637	111	29.24	18.56	1.23	17.33	215	1399	585	0	82.3
BTS 8217	237	359.2	104	10465	112	58.67	107	1703	116	29.19	19.02	1.08	17.94	197	1565	420	0	79.6
BTS 8226	219	372.7	107	10561	113	62.81	114	1768	120	28.30	19.55	0.94	18.61	153	1318	402	0	81.7
BTS 8242	204	370.3	107	9860	106	62.10	113	1651	112	26.60	19.50	1.02	18.48	124	1446	432	0	79.4
BTS 8248	238	359.3	104	9958	107	58.69	107	1619	110	27.31	18.99	1.04	17.95	197	1518	404	0	71.8
BTS 8270	211	356.9	103	10493	113	57.97	106	1701	116	29.52	18.96	1.13	17.83	212	1460	489	0	76.9
BTS 8299	235	359.5	104	9404	101	58.76	107	1519	103	25.91	19.01	1.04	17.97	187	1462	425	0	81.4
Crystal 021	226	349.7	101	10516	113	55.77	102	1678	114	29.82	18.58	1.10	17.48	214	1562	434	0	77.7
Crystal 026	240	353.2	102	10367	111	56.83	104	1674	114	28.84	18.83	1.16	17.67	261	1598	459	0	81.2
Crystal 130	213	357.2	103	10309	111	58.07	106	1688	115	28.77	18.99	1.15	17.84	228	1530	470	0	80.8
Crystal 134	202	367.9	106	10021	107	61.35	112	1668	114	27.18	19.35	0.98	18.36	161	1445	388	0	74.2
Crystal 137	201	347.7	100	9835	105	55.14	100	1563	106	28.50	18.60	1.24	17.36	268	1766	470	0	83.7
Crystal 138	224	364.4	105	10780	116	60.27	110	1769	120	29.59	19.24	1.05	18.20	173	1437	448	0	77.3
Crystal 260	231	363.9	105	10765	115	60.11	110	1786	122	29.43	19.36	1.18	18.17	221	1534	504	0	82.7
Crystal 262	229	356.0	103	10900	117	57.68	105	1766	120	30.51	18.89	1.10	17.79	234	1437	464	0	80.8
Crystal 263	210	376.7	109	10451	112	64.07	117	1764	120	27.54	19.79	0.98	18.81	166	1498	378	0	78.5
Crystal 265	225	352.2	102	9774	105	56.50	103	1581	108	27.48	18.68	1.09	17.59	182	1454	474	0	78.9
Crystal 267	222	356.6	103	10166	109	57.87	105	1652	112	28.47	18.96	1.15	17.81	233	1640	448	0	77.0
Crystal 269	212	361.3	104	10169	109	59.32	108	1663	113	28.59	19.21	1.17	18.04	219	1498	515	0	76.2
Hilleshög HIL2367	242	343.2	99	9426	101	53.74	98	1474	100	27.73	18.26	1.12	17.14	279	1399	468	0	83.9
Hilleshög HIL2368	241	350.5	101	8107	87	56.02	102	1288	88	23.11	18.62	1.10	17.52	231	1509	449	0	67.4
Hilleshög HIL2386	228	353.0	102	10521	113	56.76	103	1696	115	29.62	18.72	1.08	17.64	223	1469	444	0	78.9
Hilleshög HIL2389	239	352.6	102	9980	107	56.63	103	1593	108	28.39	18.71	1.10	17.61	251	1437	457	0	80.4
Hilleshög HIL2440	232	347.5	100	7975	86	55.05	100	1262	86	23.07	18.70	1.33	17.38	292	1492	611	0	73.3
Hilleshög HIL2441	214	345.7	100	9226	99	54.54	99	1448	99	26.98	18.40	1.14	17.26	221	1439	495	0	80.9
Hilleshög HIL2442	220	355.5	102	8892	95	57.52	105	1422	97	25.29	18.99	1.22	17.77	228	1521	549	0	77.7
Hilleshög HIL2443	227	331.4	96	10171	109	50.11	91	1549	105	30.44	17.70	1.14	16.56	272	1534	452	0	75.3
Maribo MA932	230	342.5	99	9738	104	53.54	98	1526	104	28.39	18.26	1.15	17.11	248	1528	465	0	79.4
Maribo MA942	223	354.9	102	9100	98	57.34	105	1469	100	25.43	18.79	1.06	17.72	179	1482	436	0	78.7
Maribo MA943	233	339.5	98	9065	97	52.59	96	1405	96	26.88	18.16	1.20	16.96	261	1543	511	0	70.0
Maribo MA944	221	350.3	101	8830	95	55.93	102	1397	95	25.31	18.64	1.14	17.51	255	1453	479	0	78.2
SV 215	217	344.0	99	10935	117	53.99	98	1716	117	31.57	18.24	1.05	17.18	183	1657	388	0	68.0
SV 321	209	344.6	99	10500	113	54.17	99	1652	112	30.23	18.30	1.08	17.22	195	1592	418	0	77.3
SV 322	236	343.8	99	9399	101	53.94	98	1477	101	27.56	18.31	1.15	17.16	240	1566	455	0	75.9
SV 324	205	335.6	97	9759	105	51.39	94	1500	102	29.19	18.13	1.36	16.78	299	1745	562	0	77.8
SX 1815	203	356.3	103	9893	106	57.76	105	1594	109	27.60	18.92	1.11	17.81	227	1545	452	0	83.1
SX 1816	206	342.3	99	9975	107	53.47	97	1550	106	29.21	18.27	1.16	17.11	196	1606	480	0	73.1
SX 1818	216	335.8	97	9844	106	51.47	94	1510	103	29.51	17.91	1.15	16.76	245	1552	451	0	78.0
SX 1829	207	355.9	103	9491	102	57.64	105	1537	105	26.14	18.78	1.00	17.78	209	1614	341	0	76.3
BTS 8572 (Check)	243	347.9	100	9005	97	55.18	101	1426	97	26.00	18.63	1.25	17.39	220	1597	535	0	76.3
BTS 8337 (1stYrBench)	244	359.7	104	8186	88	58.83	107	1315	89	23.08	19.21	1.23	17.98	253	1604	523	0	78.9
Crystal 578RR (1stYrBench)	245	336.9	97	10452	112	51.81	94	1614	110	30.72	18.21	1.34	16.87	324	1644	585	0	82.4
BTS 8815 (1stYrBench)	246	343.0	99	9659	104	53.66	98	1521	104	28.16	18.38	1.25	17.13	260	1614	527	0	80.3
Crystal 803 (1stYrBench)	247	351.0	101	10140	109	56.13	102	1635	111	28.40	18.61	1.07	17.54	169	1455	457	0	80.4
AP CK#55 CRYS247	248	330.8	95	9666	104	49.96	91	1456	99	28.82	17.70	1.15	16.55	311	1570	440	0	81.4
Comm Benchmark Mean		346.9		9326		54.87		1469		26.99	18.61	1.27		212	1595	480		78.3
Comm Trial Mean		345.1		9963		54.35		1563		28.99	18.47	1.21		216	1530	455		78.4
Coeff. of Var. (%)		2.5		6.8		4.8		7.8		6.5	2.1	8.2		22.6	4.7	12.9		10.1
Mean LSD (0.05)		7.9		591		2.36		108		1.66	0.36	0.09		44	64	53		6.5
Mean LSD (0.01)		10.4		778		3.11		142		2.18	0.47	0.12		58	84	70		8.6
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from Scandia MN

Created 10/28/2022

@ Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 228308

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed at location.

Table 15.

2022 Performance of Varieties - ACSC RR Official Trials

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	120	314.1	101	9018	106	45.03	102	1290	106	28.82	16.79	1.09	15.70	279	1451	356	0	84.2
BTS 8034	123	298.4	96	8737	102	40.33	91	1181	97	29.24	16.16	1.24	14.92	392	1584	396	0	84.7
BTS 8073	102	315.3	101	9267	109	45.39	103	1328	109	29.29	16.88	1.12	15.76	248	1357	414	0	79.6
BTS 8092	116	306.7	98	9158	107	42.80	97	1274	105	29.95	16.51	1.17	15.34	382	1378	404	0	75.2
BTS 8629	118	305.4	98	9040	106	42.43	96	1253	103	29.58	16.42	1.15	15.27	318	1405	398	0	82.9
BTS 8927	104	322.0	103	8874	104	47.41	107	1306	107	27.59	17.06	0.95	16.11	229	1286	316	0	83.4
BTS 8961	117	294.5	95	8483	99	39.14	88	1127	93	28.92	15.92	1.20	14.72	369	1568	376	0	83.5
Crystal 022	125	322.3	103	8851	104	47.49	107	1309	108	27.27	17.21	1.11	16.10	176	1375	425	0	78.3
Crystal 572	108	325.5	104	8930	105	48.47	109	1326	109	27.42	17.43	1.14	16.29	266	1422	412	1	86.6
Crystal 684	122	295.1	95	8807	103	39.33	89	1178	97	29.74	15.98	1.23	14.75	366	1595	391	0	84.8
Crystal 793	111	325.8	105	9274	109	48.54	110	1378	113	28.47	17.39	1.10	16.29	218	1412	396	0	84.7
Crystal 912	107	299.2	96	9361	110	40.56	92	1265	104	31.34	16.11	1.15	14.96	380	1384	384	0	85.4
Crystal 913	103	318.0	102	9081	106	46.19	104	1320	109	28.59	17.07	1.18	15.89	324	1462	401	0	84.4
Hilleshög HIL2317	112	315.7	101	8679	102	45.50	103	1251	103	27.51	16.84	1.06	15.78	279	1514	318	0	86.4
Hilleshög HIL2320	106	305.8	98	8892	104	42.53	96	1235	102	29.09	16.36	1.07	15.29	295	1333	370	0	82.9
Hilleshög HIL2366	119	309.0	99	8818	103	43.51	98	1246	102	28.51	16.55	1.11	15.44	360	1354	365	0	86.5
Hilleshög HIL9708	124	310.2	100	8611	101	43.86	99	1205	99	27.92	16.65	1.13	15.52	352	1420	370	0	87.1
Hilleshög HIL9920	115	323.1	104	9140	107	47.73	108	1352	111	28.30	17.24	1.08	16.16	234	1490	358	0	87.8
Hilleshög HM9528RR	101	311.3	100	9073	106	44.20	100	1295	107	29.20	16.65	1.09	15.56	271	1390	372	0	84.8
Maribo MA717	121	301.1	97	8845	104	41.13	93	1204	99	29.18	16.27	1.22	15.05	303	1452	448	0	83.1
Maribo MA902	110	311.2	100	8799	103	44.15	100	1246	102	28.22	16.69	1.13	15.56	357	1428	360	0	90.1
SV 203	113	310.1	100	8070	95	43.85	99	1137	94	26.09	16.78	1.26	15.52	333	1646	420	0	59.7
SV 265	109	313.4	101	8506	100	44.82	101	1218	100	27.20	16.75	1.08	15.67	234	1414	373	1	78.0
SV 285	105	312.7	100	8373	98	44.62	101	1193	98	26.71	16.85	1.22	15.63	253	1695	402	0	62.1
SX 1898	114	311.3	100	8477	99	44.19	100	1200	99	27.44	16.76	1.19	15.57	357	1593	370	0	67.9
BTS 8572 (CommBench)	126	308.0	99	8633	101	43.21	98	1215	100	28.10	16.62	1.23	15.39	344	1478	428	0	82.7
BTS 8337 (CommBench)	127	324.2	104	8660	101	48.06	109	1288	106	26.68	17.34	1.14	16.20	252	1568	371	0	87.9
Crystal 578RR (CommBench)	128	305.6	98	8595	101	42.49	96	1202	99	28.30	16.43	1.16	15.27	327	1498	376	0	87.9
BTS 8815 (CommBench)	129	308.4	99	8249	97	43.32	98	1158	95	26.84	16.58	1.16	15.42	268	1644	365	0	72.2
Crystal 803 (Check)	130	316.4	102	8500	100	45.74	103	1230	101	26.70	16.88	1.07	15.81	239	1417	362	0	90.5
AP CK#55 CRYS247	131	306.4	98	8723	102	42.73	97	1224	101	28.26	16.45	1.14	15.31	261	1555	365	0	85.0
AP CK#59 BTS8606	132	299.6	96	8681	102	40.68	92	1181	97	28.98	16.18	1.21	14.97	356	1590	379	0	85.7
Experimental Trial (Comm status)																		
BTS 8100	208	310.7	100	9054	106	43.99	99	1287	106	29.18	16.72	1.20	15.53	274	1506	389	0	87.6
BTS 8133	215	303.1	97	9019	106	41.69	94	1247	103	29.76	16.32	1.20	15.12	367	1582	329	0	91.0
BTS 8156	218	321.6	103	8837	104	47.35	107	1306	107	27.54	17.22	1.14	16.08	205	1647	349	0	87.4
BTS 8205	234	314.8	101	9357	110	45.27	102	1355	111	29.67	16.83	1.10	15.72	188	1459	359	0	88.5
BTS 8217	237	312.6	100	8900	104	44.58	101	1278	105	28.45	16.78	1.16	15.61	280	1632	335	0	83.5
BTS 8226	219	333.9	107	9430	110	51.10	115	1451	119	28.27	17.71	1.02	16.69	204	1327	323	0	83.1
BTS 8242	204	326.1	105	9185	108	48.69	110	1378	113	28.21	17.43	1.11	16.31	220	1432	376	0	84.5
BTS 8248	238	321.3	103	8832	103	47.25	107	1306	107	27.47	17.12	1.09	16.03	201	1420	362	0	73.2
BTS 8270	211	325.5	104	8982	105	48.52	110	1346	111	27.62	17.40	1.12	16.27	191	1446	386	0	80.4
BTS 8299	235	314.1	101	8498	100	45.04	102	1225	101	27.07	16.73	1.04	15.69	185	1362	352	0	84.5
Crystal 021	226	303.0	97	9205	108	41.67	94	1273	105	30.39	16.32	1.19	15.13	301	1494	375	0	85.2
Crystal 026	240	308.5	99	8737	102	43.35	98	1232	101	28.34	16.60	1.20	15.41	331	1563	351	0	85.1
Crystal 130	213	322.2	103	9167	107	47.52	107	1359	112	28.47	17.16	1.06	16.10	271	1380	329	0	84.9
Crystal 134	202	327.9	105	8524	100	49.27	111	1288	106	26.00	17.49	1.08	16.41	237	1400	342	0	77.5
Crystal 137	201	313.4	101	8335	98	44.83	101	1196	98	26.63	16.81	1.18	15.63	256	1596	350	0	84.6
Crystal 138	224	320.9	103	8892	104	47.13	106	1311	108	27.74	17.12	1.07	16.05	202	1389	354	0	88.5
Crystal 260	231	326.3	105	9434	111	48.77	110	1417	117	28.93	17.36	1.06	16.30	185	1413	343	0	85.5
Crystal 262	229	315.8	101	8789	103	45.57	103	1276	105	27.85	16.86	1.06	15.80	264	1268	346	0	83.6
Crystal 263	210	323.8	104	8876	104	47.98	108	1318	108	27.52	17.29	1.14	16.15	261	1441	373	0	83.3
Crystal 265	225	315.9	101	8549	100	45.61	103	1237	102	27.13	16.83	1.06	15.77	270	1350	329	0	86.1
Crystal 267	222	308.3	99	9350	110	43.29	98	1319	108	30.37	16.64	1.22	15.43	270	1629	380	0	85.3
Crystal 269	212	318.6	102	9190	108	46.40	105	1343	110	28.92	17.23	1.31	15.92	298	1492	469	0	78.5
Hilleshög HIL2367	242	314.5	101	8112	95	45.17	102	1171	96	25.81	16.80	1.10	15.69	303	1355	345	0	82.2
Hilleshög HIL2368	241	318.0	102	7142	84	46.21	104	1043	86	22.48	17.02	1.14	15.88	244	1345	407	0	63.5
Hilleshög HIL2386	228	319.2	102	8973	105	46.58	105	1318	108	28.11	17.07	1.13	15.94	281	1375	378	0	86.0
Hilleshög HIL2389	239	319.2	102	8536	100	46.59	105	1253	103	26.77	17.04	1.09	15.95	184	1434	355	0	89.4
Hilleshög HIL2440	232	311.4	100	8303	97	44.22	100	1188	98	26.63	16.79	1.23	15.56	274	1443	430	0	75.1
Hilleshög HIL2441	214	310.5	100	8227	96	43.92	99	1170	96	26.54	16.60	1.08	15.52	219	1353	361	1	83.3
Hilleshög HIL2442	220	315.2	101	8498	100	45.39	103	1229	101	26.99	16.90	1.14	15.75	219	1358	414	0	81.5
Hilleshög HIL2443	227	307.1	99	9449	111	42.92	97	1327	109	30.79	16.39	1.04	15.35	229	1436	313	0	82.9
Maribo MA932	230	317.5	102	9126	107	46.07	104	1332	110	28.75	16.93	1.07	15.86	210	1322	372	0	87.0
Maribo MA942	223	322.5	104	8304	97	47.62	108	1234	102	25.72	17.19	1.08	16.11	187	1389	368	0	86.3
Maribo MA943	233	318.3	102	8566	100	46.32	105	1253	103	26.90	16.97	1.09	15.88	238	1318	375	0	80.5
Maribo MA944	221	315.7	101	8380	98	45.55	103	1215	100	26.56	16.90	1.12	15.77	294	1372	358	0	83.9
SV 215	217	303.6	97	7604	89	41.83	94	1052	86	25.09	16.26	1.07	15.19	225	1503	314	0	56.3
SV 321	209	305.1	98	8661	101	42.30	96	1207	99	28.41	16.37	1.12	15.25	205	1531	363	0	71.5
SV 322	236	311.2	100	7701	90	44.14	100	1096	90	24.80	16.62	1.09	15.53	229	1553	323	0	67.3
SV 324	205	297.7	96	7833	92	40.03	90	1059	87	26.32	16.10	1.25	14.86	264	1646	388	0	66.7
SX 1815	203	321.5	103	9047	106	47.32	107	1340	110	28.13	17.13	1.06	16.07	172	1535	329	0	81.2
SX 1816	206	307.6	99	8199	96	43.05	97	1153	95	26.68	16.58	1.20	15.39	300	1521	381	0	59.5
SX 1818	216	323.1	104	8948	105	47.81	108	1332	110	27.69	17.31	1.16	16.15	232	1534	376	0	75.5
SX 1829	207	307.4	99	7363	86	43.00	97	1036	85	23.95	16.48	1.11	15.37	241	1491	346	0	61.4
BTS 8572 (Check)	243	321.9	103	8846	104	47.43	107	1309	108	27.50	17.21	1.14	16.07	206	1485	379	0	85.0
BTS 8337 (1stYrBench)	244	320.2	103	8060	94	46.92	106	1187	98	25.21	17.20	1.19	16.02	264	1488	393	0	81.3
Crystal 578RR (1stYrBench)	245	291.9	94	8460	99	38.26	86	1115	92	29.02	15.79	1.20	14.59	326	1563	361	0	89.2
BTS 8815 (1stYrBench)	246	312.2	100	8770	103	44.47	100	1252	103	28.19	16.77	1.16	15.60	272	1573	354	0	72.5
Crystal 803 (1stYrBench)	247	314.2	101	8384	98	45.09	102	1208	99	26.72	16.86	1.16	15.69	238	1480	382	0	84.2
AP CK#55 CRYS247	248	316.9	102	9035	106	45.88	104	1314	108	28.55	16.92	1.11	15.81	218	1540	346	0	85.6
Comm Benchmark Mean		311.6		8534		44.27		1216		27.48	16.74	1.17		298	1547	385		82.7
Comm Trial Mean		310.8		8788		44.04		1244		28.30	16.68	1.14		301	1474	383		82.1
Coeff. of Var. (%)		2.5		5.8		5.3		7.8		4.9	2.1	7.6		31.8	4.7	11.7		8.6
Mean LSD (0.05)		7.0		435		2.10		84		1.21	0.32	0.08		84	62	41		6.0
Mean LSD (0.01)		9.2		573		2.77		110		1.60	0.42	0.10		110	82	53		7.9
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from Alvarado MN

Created 10/28/2022

@ Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commerci al status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 228310

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed at location.

Table 16.

2022 Performance of Varieties - ACSC RR Official Trials St.

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	120	319.0	107	9433	109	46.50	115	1374	117	29.70	16.78	0.83	15.95	145	1297	245	0	80.2
BTS 8034	123	285.6	96	7571	87	36.46	90	966	83	26.45	15.27	0.99	14.28	284	1455	280	0	76.8
BTS 8073	102	307.0	103	8840	102	42.90	106	1237	106	28.75	16.25	0.89	15.36	187	1308	278	0	77.4
BTS 8092	116	302.8	102	8961	103	41.63	103	1229	105	29.68	15.96	0.82	15.14	187	1266	228	0	78.4
BTS 8629	118	287.2	96	8883	102	36.95	92	1140	97	30.95	15.28	0.92	14.36	269	1321	262	0	85.4
BTS 8927	104	312.3	105	8859	102	44.50	110	1266	108	28.28	16.42	0.80	15.62	194	1222	227	0	80.2
BTS 8961	117	289.1	97	8206	94	37.54	93	1059	90	28.46	15.41	0.95	14.46	254	1460	258	0	80.0
Crystal 022	125	318.4	107	8832	102	46.33	115	1283	110	27.79	16.73	0.81	15.92	151	1313	227	0	76.6
Crystal 572	108	315.5	106	9242	106	45.44	113	1329	114	29.30	16.62	0.85	15.77	171	1272	257	0	78.7
Crystal 684	122	296.4	99	9479	109	39.72	99	1268	108	32.05	15.75	0.93	14.82	244	1438	253	0	76.6
Crystal 793	111	306.1	103	9156	105	42.62	106	1274	109	29.84	16.16	0.85	15.31	183	1311	244	0	78.9
Crystal 912	107	297.4	100	9268	107	40.03	99	1248	107	31.13	15.71	0.84	14.87	228	1250	233	0	78.4
Crystal 913	103	308.0	103	9246	106	43.20	107	1295	111	30.09	16.23	0.84	15.39	200	1274	237	0	76.0
Hilleshög HIL2317	112	302.2	101	7985	92	41.47	103	1094	93	26.43	15.90	0.79	15.11	237	1222	198	0	75.3
Hilleshög HIL2320	106	303.4	102	8747	101	41.81	104	1202	103	28.93	16.01	0.84	15.17	232	1282	224	0	79.2
Hilleshög HIL2366	119	301.1	101	8421	97	41.13	102	1151	98	28.01	15.87	0.81	15.06	232	1185	231	0	81.0
Hilleshög HIL9708	124	302.7	101	8490	98	41.61	103	1165	100	28.06	15.91	0.78	15.13	204	1187	212	0	82.3
Hilleshög HIL9920	115	306.1	103	8615	99	42.64	106	1197	102	28.18	16.18	0.87	15.31	245	1309	237	0	75.0
Hilleshög HM9528RR	101	298.0	100	8582	99	40.19	100	1158	99	28.72	15.74	0.84	14.90	209	1264	241	0	78.1
Maribo MA717	121	312.4	105	8871	102	44.52	110	1263	108	28.38	16.47	0.85	15.62	202	1329	235	0	78.4
Maribo MA902	110	309.1	104	8642	99	43.53	108	1218	104	27.92	16.26	0.80	15.46	220	1228	213	0	81.3
SV 203	113	302.5	101	8041	93	41.55	103	1103	94	26.68	16.07	0.95	15.12	227	1346	295	0	69.5
SV 265	109	296.9	100	8611	99	39.86	99	1157	99	29.00	15.68	0.84	14.84	207	1254	239	0	81.5
SV 285	105	300.8	101	8110	93	41.04	102	1104	94	26.94	15.99	0.95	15.04	215	1402	284	0	74.0
SX 1898	114	294.5	99	7960	92	39.15	97	1055	90	27.16	15.72	1.00	14.72	272	1406	302	0	74.0
BTS 8572 (CommBench)	126	312.9	105	9277	107	44.68	111	1322	113	29.72	16.53	0.89	15.64	193	1346	261	0	73.7
BTS 8337 (CommBench)	127	309.6	104	8577	99	43.68	108	1207	103	27.76	16.38	0.90	15.48	243	1371	243	0	82.8
Crystal 578RR (CommBench)	128	289.9	97	9023	104	37.77	94	1168	100	31.30	15.37	0.88	14.49	269	1329	229	0	79.7
BTS 8815 (CommBench)	129	280.9	94	7887	91	35.08	87	984	84	28.05	15.03	0.98	14.05	309	1447	261	0	77.6
Crystal 803 (Check)	130	308.9	104	9019	104	43.48	108	1267	108	29.29	16.31	0.87	15.44	175	1338	254	0	80.5
AP CK#55 CRYS247	131	300.3	101	9207	106	40.89	101	1245	106	30.91	15.93	0.92	15.01	274	1413	236	0	74.5
AP CK#59 BTS8606	132	296.1	99	9031	104	39.62	98	1206	103	30.60	15.72	0.92	14.80	256	1392	247	0	82.0
Experimental Trial (Comm status)																		
BTS 8100	208	296.4	99	8357	96	39.75	99	1113	95	28.25	15.76	0.95	14.81	179	1497	247	0	82.3
BTS 8133	215	270.4	91	8158	94	32.37	80	975	83	30.22	14.51	1.00	13.51	239	1557	255	0	86.6
BTS 8156	218	281.3	94	7483	86	35.46	88	940	80	26.77	15.12	1.09	14.03	273	1581	304	0	89.4
BTS 8205	234	307.1	103	9060	104	42.79	106	1259	108	29.58	16.25	0.89	15.35	147	1403	253	0	82.7
BTS 8217	237	283.4	95	7046	81	36.05	89	894	76	24.86	15.17	1.01	14.16	240	1532	263	0	74.8
BTS 8226	219	319.5	107	9340	107	46.31	115	1350	115	29.28	16.77	0.79	15.97	149	1234	211	0	83.3
BTS 8242	204	306.9	103	8855	102	42.74	106	1228	105	29.04	16.20	0.85	15.35	151	1396	222	0	81.1
BTS 8248	238	301.6	101	8710	100	41.24	102	1189	102	28.85	15.92	0.84	15.08	165	1299	227	0	73.8
BTS 8270	211	301.2	101	9299	107	41.13	102	1263	108	30.91	15.98	0.90	15.08	178	1445	233	0	83.2
BTS 8299	235	298.9	100	9015	104	40.49	100	1220	104	30.15	15.76	0.81	14.95	145	1297	218	0	85.2
Crystal 021	226	294.7	99	9083	105	39.29	97	1204	103	30.88	15.64	0.88	14.75	196	1456	209	0	76.6
Crystal 026	240	283.0	95	8441	97	35.95	89	1063	91	30.11	15.06	0.92	14.15	231	1439	228	0	88.4
Crystal 130	213	308.9	104	8985	103	43.31	107	1253	107	29.28	16.31	0.87	15.43	152	1389	231	0	75.3
Crystal 134	202	313.5	105	8517	98	44.63	111	1203	103	27.35	16.48	0.80	15.68	159	1256	212	0	76.8
Crystal 137	201	286.3	96	7479	86	36.87	91	952	81	26.45	15.34	1.04	14.30	241	1632	263	0	81.6
Crystal 138	224	303.2	102	8799	101	41.70	103	1201	103	29.11	16.03	0.86	15.17	152	1331	238	0	81.4
Crystal 260	231	303.7	102	9213	106	41.83	104	1266	108	30.38	16.05	0.87	15.17	160	1322	249	0	82.7
Crystal 262	229	297.7	100	9576	110	40.13	100	1285	110	32.26	15.69	0.80	14.89	175	1280	198	0	84.0
Crystal 263	210	321.3	108	9293	107	46.84	116	1347	115	28.94	16.95	0.87	16.07	144	1442	220	0	81.9
Crystal 265	225	308.9	104	8406	97	43.29	107	1174	100	27.30	16.27	0.83	15.44	149	1344	215	0	78.9
Crystal 267	222	273.4	92	7093	82	33.20	82	858	73	25.99	14.68	1.04	13.64	257	1495	291	0	79.6
Crystal 269	212	302.2	101	9045	104	41.40	103	1234	105	30.21	15.99	0.89	15.10	173	1448	228	0	73.7
Hilleshög HIL2367	242	309.3	104	9443	109	43.44	108	1320	113	30.66	16.30	0.82	15.47	178	1314	206	0	81.2
Hilleshög HIL2368	241	307.0	103	6675	77	42.76	106	929	79	21.89	16.22	0.88	15.34	175	1335	245	0	60.8
Hilleshög HIL2386	228	297.0	100	8952	103	39.92	99	1198	102	30.40	15.67	0.83	14.84	198	1237	230	0	81.3
Hilleshög HIL2389	239	302.3	101	8752	101	41.44	103	1200	103	28.92	15.94	0.83	15.11	167	1329	215	0	82.9
Hilleshög HIL2440	232	313.8	105	8781	101	44.72	111	1244	106	28.01	16.63	0.94	15.70	164	1431	265	0	74.7
Hilleshög HIL2441	214	310.1	104	8581	99	43.66	108	1198	102	27.91	16.38	0.87	15.51	158	1433	224	0	84.9
Hilleshög HIL2442	220	314.0	105	8208	94	44.78	111	1163	99	26.22	16.60	0.89	15.71	155	1391	250	0	73.6
Hilleshög HIL2443	227	297.3	100	9645	111	40.02	99	1296	111	32.40	15.68	0.82	14.86	179	1311	206	0	78.6
Maribo MA932	230	311.4	104	9060	104	44.02	109	1277	109	29.23	16.42	0.86	15.56	187	1292	236	0	83.3
Maribo MA942	223	299.3	100	8530	98	40.59	101	1153	98	28.55	15.83	0.86	14.96	180	1264	248	0	80.6
Maribo MA943	233	302.9	102	8563	99	41.60	103	1164	99	28.43	16.01	0.85	15.16	169	1332	228	0	77.3
Maribo MA944	221	309.0	104	8752	101	43.32	107	1221	104	28.38	16.27	0.82	15.45	177	1216	229	0	78.3
SV 215	217	286.8	96	8035	92	37.03	92	1029	88	28.23	15.26	0.94	14.33	177	1586	224	0	68.1
SV 321	209	292.5	98	8444	97	38.62	96	1113	95	28.97	15.45	0.84	14.61	137	1366	223	0	71.4
SV 322	236	288.4	97	6878	79	37.48	93	891	76	23.90	15.34	0.93	14.41	182	1490	238	0	72.2
SV 324	205	284.7	95	7528	87	36.44	90	961	82	26.49	15.18	0.95	14.23	185	1574	231	0	75.3
SX 1815	203	299.0	100	9244	106	40.50	100	1251	107	31.02	15.84	0.88	14.95	164	1418	235	0	84.8
SX 1816	206	288.9	97	8409	97	37.64	93	1086	93	29.29	15.36	0.92	14.44	189	1420	244	0	79.0
SX 1818	216	289.7	97	7930	91	37.85	94	1036	89	27.47	15.34	0.86	14.48	170	1359	232	0	79.4
SX 1829	207	279.7	94	5932	68	34.99	87	730	62	21.49	14.97	1.00	13.97	223	1475	277	0	74.8
BTS 8572 (Check)	243	302.5	101	8912	103	41.48	103	1221	104	29.59	16.03	0.92	15.11	173	1379	261	0	81.2
BTS 8337 (1stYrBench)	244	309.0	104	9155	105	43.34	108	1282	110	29.61	16.36	0.92	15.45	170	1473	236	0	74.7
Crystal 578RR (1stYrBench)	245	285.8	96	8751	101	36.73	91	1124	96	30.66	15.16	0.86	14.29	213	1381	208	0	85.6
BTS 8815 (1stYrBench)	246	296.1	99	7946	91	39.65	98	1054	90	26.97	15.76	0.96	14.80	216	1571	228	0	72.9
Crystal 803 (1stYrBench)	247	309.3	104	9167	105	43.42	108	1283	110	29.67	16.33	0.86	15.46	167	1360	229	0	81.1
AP CK#55 CRYS247	248	284.3	95	9172	106	36.32	90	1172	100	32.19	15.10	0.89	14.20	250	1440	205	0	84.0
Comm Benchmark Mean		298.3		8691		40.30		1170		29.21	15.83	0.91		254	1373	249		78.5
Comm Trial Mean		302.3		8721		41.49		1195		28.89	15.99	0.87		222	1320	246		78.2
Coeff. of Var. (%)		2.5		6.3		5.5		8.1		5.6	2.3	5.5		16.3	4.8	10.8		10.9
Mean LSD (0.05)		6.9		487		2.08		87		1.43	0.33	0.04		33	57	24		6.9
Mean LSD (0.01)		9.1		642		2.74		114		1.88	0.43	0.06		43	75	32		9.1
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from St. Thomas ND

Created 10/28/2022

@ Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commerci al status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

\+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 228311

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed at location.

Table 17.

2022 Performance of Varieties - ACSC RR Official Trials

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	120	328.3	98	9469	103	49.29	95	1418	100	28.84	17.72	1.30	16.42	354	1646	438	0	82.6
BTS 8034	123	324.4	96	9857	107	48.14	93	1467	104	30.37	17.60	1.37	16.23	432	1992	377	0	85.9
BTS 8073	102	334.4	99	9959	108	51.11	99	1514	107	29.40	17.85	1.13	16.72	256	1617	348	0	82.8
BTS 8092	116	334.5	99	9940	108	51.15	99	1516	107	29.99	17.97	1.25	16.72	369	1699	384	0	82.9
BTS 8629	118	336.7	100	10054	109	51.81	100	1550	109	30.13	18.12	1.30	16.82	400	1648	416	0	86.7
BTS 8927	104	353.3	105	9347	102	56.80	110	1502	106	26.58	18.74	1.08	17.66	217	1582	338	0	87.2
BTS 8961	117	326.3	97	9895	107	48.70	94	1476	104	30.30	17.72	1.40	16.32	379	1876	448	0	86.8
Crystal 022	125	344.5	102	9506	103	54.16	105	1491	105	27.35	18.30	1.07	17.23	239	1626	308	1	83.3
Crystal 572	108	345.5	103	9436	102	54.45	105	1491	105	27.41	18.38	1.11	17.27	211	1578	359	0	89.5
Crystal 684	122	329.9	98	9907	108	49.77	96	1491	105	30.14	17.80	1.31	16.49	390	1905	369	0	83.3
Crystal 793	111	343.8	102	9880	107	53.94	104	1546	109	28.72	18.25	1.06	17.19	275	1620	292	0	83.8
Crystal 912	107	319.4	95	9974	108	46.62	90	1456	103	31.23	17.29	1.33	15.96	481	1587	429	0	84.8
Crystal 913	103	337.1	100	9531	104	51.95	100	1466	104	28.09	18.03	1.15	16.88	289	1610	360	0	89.1
Hilleshög HIL2317	112	343.0	102	9323	101	53.72	104	1464	103	27.43	18.19	1.05	17.14	253	1703	268	0	82.6
Hilleshög HIL2320	106	323.3	96	9676	105	47.80	92	1427	101	30.03	17.42	1.26	16.16	452	1623	381	0	86.8
Hilleshög HIL2366	119	326.8	97	9704	105	48.85	94	1450	102	29.81	17.53	1.19	16.34	387	1641	348	0	82.8
Hilleshög HIL9708	124	322.2	96	9913	108	47.45	92	1463	103	30.73	17.33	1.21	16.12	430	1619	351	0	88.9
Hilleshög HIL9920	115	339.7	101	9952	108	52.74	102	1545	109	29.11	18.18	1.18	17.00	339	1803	316	0	84.1
Hilleshög HM9528RR	101	320.3	95	9710	105	46.90	91	1423	101	30.62	17.17	1.16	16.01	378	1652	325	0	87.2
Maribo MA717	121	320.8	95	10112	110	47.03	91	1481	105	31.51	17.27	1.24	16.03	424	1632	367	0	86.3
Maribo MA902	110	321.7	96	9461	103	47.31	91	1394	98	29.30	17.29	1.19	16.10	406	1623	347	0	92.2
SV 203	113	333.9	99	9183	100	50.97	99	1399	99	27.41	17.93	1.23	16.70	322	1812	357	0	71.3
SV 265	109	317.5	94	8845	96	46.04	89	1284	91	27.78	17.04	1.16	15.88	371	1660	326	0	87.0
SV 285	105	331.9	99	8885	97	50.37	97	1350	95	26.66	17.81	1.22	16.59	325	1779	353	0	70.0
SX 1898	114	343.5	102	9407	102	53.85	104	1475	104	27.51	18.30	1.14	17.16	284	1797	300	0	73.3
BTS 8572 (CommBench)	126	332.7	99	9145	99	50.63	98	1391	98	27.49	17.89	1.26	16.63	294	1646	427	0	82.9
BTS 8337 (CommBench)	127	347.7	103	8878	96	55.13	107	1402	99	25.51	18.60	1.21	17.39	303	1809	351	0	81.3
Crystal 578RR (CommBench)	128	335.2	100	9930	108	51.36	99	1529	108	29.54	18.15	1.39	16.76	441	1970	393	0	89.9
BTS 8815 (CommBench)	129	329.9	98	8872	96	49.77	96	1341	95	26.82	17.85	1.36	16.49	451	1937	373	0	74.6
Crystal 803 (Check)	130	345.7	103	9508	103	54.52	105	1498	106	27.60	18.43	1.15	17.28	267	1677	347	0	89.9
AP CK#55 CRYS247	131	328.7	98	9072	99	49.42	96	1361	96	27.65	17.76	1.32	16.44	488	1931	329	0	89.9
AP CK#59 BTS8606	132	331.7	99	9588	104	50.30	97	1458	103	28.93	17.91	1.34	16.57	395	1917	381	0	85.0
Experimental Trial (Comm status)																		
BTS 8100	208	333.1	99	9259	101	50.75	98	1412	100	27.72	17.99	1.32	16.68	317	1786	382	0	83.4
BTS 8133	215	331.1	98	10396	113	50.16	97	1579	112	31.21	17.90	1.34	16.57	399	1875	346	0	90.1
BTS 8156	218	336.9	100	9977	108	51.89	100	1540	109	29.38	18.15	1.27	16.88	345	1950	301	0	88.1
BTS 8205	234	337.0	100	10061	109	51.91	100	1553	110	29.69	18.05	1.18	16.87	232	1635	358	1	85.3
BTS 8217	237	331.4	99	9837	107	50.26	97	1497	106	29.55	17.93	1.37	16.56	368	1930	372	0	82.1
BTS 8226	219	354.4	105	9719	106	57.03	110	1571	111	27.33	18.85	1.14	17.71	246	1630	321	0	79.9
BTS 8242	204	343.6	102	9220	100	53.87	104	1446	102	26.77	18.41	1.20	17.21	255	1660	356	0	88.7
BTS 8248	238	330.1	98	9069	99	49.86	96	1377	97	27.42	17.70	1.22	16.48	310	1740	325	0	76.0
BTS 8270	211	336.7	100	10002	109	51.82	100	1541	109	29.69	18.05	1.21	16.84	283	1699	347	0	82.4
BTS 8299	235	330.2	98	9062	98	49.91	97	1371	97	27.40	17.80	1.26	16.54	308	1709	370	0	88.6
Crystal 021	226	329.1	98	9645	105	49.57	96	1459	103	29.08	17.82	1.37	16.46	373	1821	400	0	81.0
Crystal 026	240	327.3	97	10319	112	49.04	95	1551	110	31.29	17.83	1.46	16.37	401	1924	431	0	88.6
Crystal 130	213	334.7	99	9476	103	51.21	99	1447	102	28.23	17.97	1.19	16.78	276	1648	342	0	85.8
Crystal 134	202	347.8	103	9283	101	55.11	107	1470	104	26.66	18.56	1.13	17.43	221	1600	333	0	80.4
Crystal 137	201	339.1	101	9284	101	52.54	102	1439	102	27.28	18.30	1.33	16.97	303	1991	345	0	83.4
Crystal 138	224	333.1	99	9562	104	50.74	98	1459	103	28.64	17.87	1.20	16.67	266	1606	370	0	89.6
Crystal 260	231	342.0	102	9686	105	53.39	103	1515	107	28.13	18.31	1.19	17.12	256	1674	345	0	87.9
Crystal 262	229	337.9	100	10091	110	52.18	101	1558	110	29.83	18.22	1.31	16.91	370	1676	389	0	80.5
Crystal 263	210	338.0	100	9302	101	52.23	101	1441	102	27.36	18.16	1.24	16.92	276	1708	365	0	87.5
Crystal 265	225	342.6	102	9774	106	53.59	104	1531	108	28.40	18.28	1.14	17.14	238	1642	321	0	85.5
Crystal 267	222	332.3	99	9976	108	50.51	98	1520	107	29.90	18.01	1.40	16.61	372	1959	389	0	81.8
Crystal 269	212	354.0	105	10605	115	56.93	110	1707	121	29.90	18.98	1.26	17.72	284	1804	358	0	83.8
Hilleshög HIL2367	242	314.6	94	9741	106	45.27	88	1402	99	30.92	17.16	1.45	15.71	488	1704	440	0	83.6
Hilleshög HIL2368	241	316.3	94	8871	96	45.80	89	1293	91	27.87	17.09	1.28	15.81	385	1684	367	0	72.7
Hilleshög HIL2386	228	308.4	92	9710	105	43.46	84	1372	97	31.30	16.77	1.33	15.45	379	1637	415	0	84.4
Hilleshög HIL2389	239	344.3	102	9783	106	54.07	105	1537	109	28.36	18.42	1.19	17.23	246	1751	324	0	84.8
Hilleshög HIL2440	232	332.4	99	9714	106	50.53	98	1478	104	29.18	18.02	1.40	16.62	406	1713	438	0	78.1
Hilleshög HIL2441	214	328.6	98	9572	104	49.43	96	1440	102	29.13	17.82	1.38	16.45	358	1719	439	0	86.8
Hilleshög HIL2442	220	332.1	99	9213	100	50.47	98	1403	99	27.63	17.87	1.25	16.62	251	1690	391	0	82.8
Hilleshög HIL2443	227	322.6	96	9869	107	47.65	92	1459	103	30.50	17.38	1.22	16.16	346	1685	338	0	74.7
Maribo MA932	230	319.9	95	9936	108	46.82	91	1454	103	31.05	17.34	1.35	15.99	377	1710	406	0	82.6
Maribo MA942	223	335.0	100	8641	94	51.33	99	1328	94	25.69	17.98	1.22	16.76	270	1639	371	0	81.0
Maribo MA943	233	341.7	102	9546	104	53.31	103	1489	105	27.94	18.38	1.28	17.09	286	1688	395	0	81.3
Maribo MA944	221	332.8	99	9808	107	50.65	98	1496	106	29.43	17.89	1.26	16.63	319	1592	400	0	83.8
SV 215	217	315.1	94	8698	94	45.44	88	1259	89	27.53	17.04	1.29	15.75	335	1961	321	0	64.3
SV 321	209	330.9	98	9207	100	50.12	97	1398	99	27.80	17.67	1.12	16.56	262	1735	281	0	79.4
SV 322	236	328.1	98	8210	89	49.29	95	1229	87	25.01	17.73	1.28	16.45	337	1742	365	0	68.7
SV 324	205	315.8	94	8623	94	45.66	88	1246	88	27.22	17.07	1.26	15.81	318	1912	313	0	73.7
SX 1815	203	331.5	99	9161	100	50.29	97	1393	98	27.51	17.86	1.28	16.58	339	1749	358	0	83.8
SX 1816	206	331.8	99	9152	99	50.38	97	1392	98	27.50	17.87	1.26	16.61	325	1759	356	0	73.2
SX 1818	216	334.7	99	9630	105	51.21	99	1478	104	28.69	17.97	1.22	16.75	335	1783	313	0	82.5
SX 1829	207	331.1	98	8109	88	50.17	97	1230	87	24.42	17.86	1.31	16.56	368	1790	355	0	72.6
BTS 8572 (Check)	243	332.8	99	8608	93	50.66	98	1314	93	25.80	17.84	1.20	16.64	251	1713	348	0	80.7
BTS 8337 (1stYrBench)	244	356.7	106	8794	96	57.73	112	1428	101	24.59	19.06	1.23	17.83	288	1754	338	0	78.3
Crystal 578RR (1stYrBench)	245	327.3	97	10457	114	49.04	95	1571	111	31.79	17.78	1.43	16.35	397	1902	412	0	84.7
BTS 8815 (1stYrBench)	246	328.7	98	8967	97	49.46	96	1349	95	27.18	17.80	1.36	16.45	414	1936	338	0	76.1
Crystal 803 (1stYrBench)	247	349.7	104	9633	105	55.68	108	1538	109	27.43	18.69	1.20	17.49	262	1718	341	0	91.3
AP CK#55 CRYS247	248	328.8	98	9120	99	49.50	96	1375	97	27.71	17.77	1.34	16.44	385	1911	341	0	87.7
Comm Benchmark Mean		336.4		9206		51.72		1416		27.34	18.12	1.31		372	1841	386		82.2
Comm Trial Mean		332.9		9560		50.69		1454		28.75	17.87	1.22		353	1726	360		84.2
Coeff. of Var. (%)		3.3		5.7		6.4		7.9		4.7	2.7	8.5		23.8	3.7	14.9		8.2
Mean LSD (0.05)		9.8		460		2.94		101		1.16	0.44	0.09		74	57	46		5.7
Mean LSD (0.01)		12.9		605		3.87		133		1.53	0.58	0.12		97	75	61		7.5
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from Hallock MN

Created 10/28/2022

@ Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 228312

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed at location.

Table 18.

2022 Performance of Varieties - ACSC RR Official Trials

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	120	306.0	101	10143	108	42.60	102	1413	109	33.13	16.45	1.15	15.30	295	1568	363	0	65.3
BTS 8034	123	289.3	96	9952	106	37.59	90	1294	100	34.31	15.89	1.42	14.47	412	1880	452	0	65.4
BTS 8073	102	291.9	96	10112	107	38.36	92	1331	103	34.56	15.92	1.32	14.60	354	1631	463	0	54.7
BTS 8092	116	288.9	95	9883	105	37.47	90	1281	99	34.24	15.77	1.32	14.45	399	1589	450	0	62.6
BTS 8629	118	288.5	95	9802	104	37.36	90	1268	98	34.04	15.74	1.32	14.42	449	1559	441	0	68.4
BTS 8927	104	325.2	107	9958	106	48.38	116	1484	115	30.63	17.35	1.08	16.27	258	1467	351	0	72.4
BTS 8961	117	295.6	98	9668	103	39.49	95	1290	100	32.75	16.15	1.38	14.77	382	1781	454	0	64.4
Crystal 022	125	322.3	107	10215	108	47.50	114	1508	117	31.67	17.24	1.13	16.11	215	1601	368	0	66.2
Crystal 572	108	314.6	104	10022	106	45.18	109	1440	111	31.76	16.96	1.23	15.73	264	1594	429	0	72.0
Crystal 684	122	290.7	96	10209	108	38.00	91	1333	103	35.25	15.81	1.27	14.54	387	1805	362	0	73.2
Crystal 793	111	319.9	106	10261	109	46.78	113	1498	116	32.15	17.12	1.12	16.00	258	1597	349	0	71.3
Crystal 912	107	289.8	96	10100	107	37.73	91	1318	102	34.74	15.89	1.40	14.49	455	1626	482	0	65.9
Crystal 913	103	308.6	102	9952	106	43.38	104	1400	108	32.16	16.66	1.23	15.43	339	1521	423	0	63.9
Hilleshög HIL2317	112	302.7	100	9619	102	41.61	100	1322	102	31.90	16.28	1.15	15.13	344	1704	313	0	67.6
Hilleshög HIL2320	106	308.0	102	9928	105	43.20	104	1395	108	32.19	16.59	1.18	15.41	339	1612	366	0	71.2
Hilleshög HIL2366	119	296.7	98	9579	102	39.82	96	1290	100	32.07	16.12	1.29	14.83	423	1615	414	0	67.9
Hilleshög HIL9708	124	301.3	100	9775	104	41.19	99	1338	104	32.43	16.20	1.14	15.06	354	1560	341	0	69.7
Hilleshög HIL9920	115	300.2	99	9823	104	40.85	98	1338	104	32.73	16.23	1.22	15.01	364	1731	354	0	68.8
Hilleshög HM9528RR	101	309.7	102	9822	104	43.70	105	1382	107	31.81	16.62	1.15	15.47	326	1585	348	0	71.0
Maribo MA717	121	300.6	99	10007	106	40.98	99	1367	106	33.16	16.23	1.21	15.02	369	1591	375	0	69.7
Maribo MA902	110	299.8	99	9412	100	40.75	98	1276	99	31.50	16.19	1.20	14.99	433	1591	350	0	72.0
SV 203	113	292.2	97	9166	97	38.46	93	1204	93	31.37	16.03	1.42	14.61	434	1839	451	0	50.4
SV 265	109	292.1	97	9338	99	38.43	92	1227	95	31.98	15.89	1.28	14.61	358	1740	399	0	64.7
SV 285	105	295.1	98	9191	98	39.34	95	1225	95	31.21	16.02	1.26	14.76	350	1841	362	0	54.4
SX 1898	114	291.1	96	8950	95	38.14	92	1172	91	30.72	15.86	1.30	14.56	421	1815	370	0	51.2
BTS 8572 (CommBench)	126	305.9	101	9535	101	42.58	102	1328	103	31.18	16.56	1.26	15.30	290	1665	427	0	67.0
BTS 8337 (CommBench)	127	310.2	103	8930	95	43.87	106	1258	97	28.91	16.82	1.31	15.51	380	1750	408	0	65.3
Crystal 578RR (CommBench)	128	297.4	98	9947	106	40.03	96	1338	104	33.36	16.25	1.38	14.87	427	1814	427	0	71.8
BTS 8815 (CommBench)	129	296.8	98	9258	98	39.83	96	1243	96	31.13	16.14	1.31	14.83	416	1791	385	0	59.8
Crystal 803 (Check)	130	313.1	103	9932	105	44.73	108	1421	110	31.67	16.86	1.20	15.66	284	1570	411	0	70.5
AP CK#55 CRYS247	131	294.4	97	9368	99	39.12	94	1242	96	31.94	15.95	1.23	14.72	383	1778	341	0	68.7
AP CK#59 BTS8606	132	294.9	97	9629	102	39.27	94	1279	99	32.77	16.12	1.38	14.74	441	1738	444	0	68.9
Experimental Trial (Comm status)																		
BTS 8100	208	303.2	100	9776	104	41.76	100	1353	105	32.08	16.42	1.26	15.16	300	1735	405	0	66.9
BTS 8133	215	295.9	98	10161	108	39.57	95	1364	106	34.45	16.01	1.22	14.79	281	1906	335	0	73.1
BTS 8156	218	309.3	102	10202	108	43.60	105	1438	111	33.14	16.73	1.26	15.47	290	1905	360	0	75.3
BTS 8205	234	307.9	102	10050	107	43.18	104	1409	109	32.72	16.64	1.23	15.41	198	1737	422	0	68.5
BTS 8217	237	308.1	102	9609	102	43.24	104	1349	104	31.18	16.78	1.38	15.40	333	1915	439	0	67.5
BTS 8226	219	309.8	102	9848	105	43.74	105	1394	108	31.62	16.69	1.19	15.50	327	1508	400	0	64.3
BTS 8242	204	320.9	106	10014	106	47.04	113	1470	114	31.21	17.16	1.12	16.04	210	1653	348	0	75.5
BTS 8248	238	310.5	103	10317	110	43.96	106	1459	113	33.34	16.64	1.11	15.53	274	1525	351	0	58.3
BTS 8270	211	309.7	102	10218	109	43.70	105	1440	111	33.15	16.71	1.24	15.47	273	1681	415	0	65.5
BTS 8299	235	315.1	104	10307	109	45.31	109	1478	114	32.90	16.80	1.07	15.73	214	1586	327	0	71.5
Crystal 021	226	295.8	98	10307	109	39.56	95	1388	107	34.59	16.13	1.30	14.83	390	1747	401	0	60.9
Crystal 026	240	302.4	100	10512	112	41.51	100	1450	112	34.59	16.40	1.27	15.13	318	1842	381	0	70.5
Crystal 130	213	303.3	100	9405	100	41.77	100	1305	101	30.94	16.44	1.24	15.20	286	1749	390	0	60.5
Crystal 134	202	323.3	107	10029	106	47.73	115	1483	115	30.93	17.23	1.09	16.14	238	1569	338	0	63.0
Crystal 137	201	309.7	102	10219	109	43.71	105	1435	111	33.28	16.75	1.29	15.46	285	1925	385	0	58.7
Crystal 138	224	315.6	104	10219	109	45.47	109	1474	114	32.44	16.96	1.16	15.80	205	1686	375	0	63.2
Crystal 260	231	317.2	105	10406	111	45.93	110	1512	117	32.83	17.00	1.11	15.89	245	1611	345	0	66.3
Crystal 262	229	293.3	97	10445	111	38.80	93	1383	107	35.50	15.92	1.28	14.64	349	1699	412	0	68.9
Crystal 263	210	318.3	105	9515	101	46.27	111	1379	107	30.14	17.06	1.13	15.93	258	1644	346	0	58.2
Crystal 265	225	307.6	102	9723	103	43.09	104	1369	106	31.63	16.55	1.14	15.41	229	1667	355	0	68.5
Crystal 267	222	296.8	98	10111	107	39.85	96	1360	105	34.07	16.23	1.40	14.83	370	1957	428	0	70.2
Crystal 269	212	317.6	105	10123	107	46.06	111	1473	114	32.03	17.05	1.15	15.90	254	1707	346	0	58.4
Hilleshög HIL2367	242	304.3	101	9714	103	42.08	101	1343	104	32.09	16.42	1.21	15.21	321	1621	387	0	68.2
Hilleshög HIL2368	241	312.4	103	8511	90	44.50	107	1211	94	27.49	16.82	1.22	15.60	300	1726	375	0	37.3
Hilleshög HIL2386	228	309.0	102	10524	112	43.50	105	1483	115	34.24	16.68	1.22	15.46	334	1646	388	1	65.9
Hilleshög HIL2389	239	301.6	100	10142	108	41.29	99	1386	107	33.80	16.37	1.30	15.07	321	1828	402	0	71.7
Hilleshög HIL2440	232	303.9	100	10210	108	41.97	101	1417	110	33.46	16.53	1.32	15.21	346	1620	466	0	54.2
Hilleshög HIL2441	214	302.6	100	9432	100	41.57	100	1294	100	31.34	16.38	1.27	15.11	271	1707	429	0	63.4
Hilleshög HIL2442	220	317.7	105	9679	103	46.08	111	1408	109	30.49	17.17	1.24	15.93	303	1632	419	0	61.1
Hilleshög HIL2443	227	291.4	96	9141	97	38.23	92	1202	93	31.40	15.77	1.20	14.56	316	1805	330	0	59.5
Maribo MA932	230	298.4	99	10010	106	40.32	97	1357	105	33.66	16.17	1.23	14.94	326	1710	380	0	67.1
Maribo MA942	223	303.5	100	9332	99	41.83	101	1296	100	30.53	16.40	1.21	15.19	294	1658	387	0	64.3
Maribo MA943	233	299.3	99	9564	102	40.60	98	1301	101	32.01	16.25	1.28	14.97	298	1725	422	0	62.1
Maribo MA944	221	303.2	100	9226	98	41.76	100	1278	99	30.21	16.46	1.27	15.19	339	1698	408	0	64.4
SV 215	217	289.7	96	8640	92	37.74	91	1129	87	29.94	15.83	1.30	14.52	317	1926	383	0	52.6
SV 321	209	298.6	99	9886	105	40.38	97	1339	104	33.11	16.13	1.19	14.94	281	1711	366	0	60.2
SV 322	236	298.1	99	8582	91	40.23	97	1161	90	28.93	16.10	1.19	14.91	293	1760	345	0	50.3
SV 324	205	289.8	96	9170	97	37.77	91	1200	93	31.59	15.89	1.40	14.49	374	1993	417	0	59.7
SX 1815	203	305.6	101	9766	104	42.47	102	1359	105	31.89	16.40	1.09	15.31	228	1793	290	0	62.5
SX 1816	206	305.6	101	9628	102	42.45	102	1332	103	31.77	16.47	1.22	15.25	290	1774	365	0	61.7
SX 1818	216	293.4	97	9527	101	38.83	93	1265	98	32.35	15.96	1.28	14.68	302	1776	412	0	58.2
SX 1829	207	313.3	104	9122	97	44.78	108	1304	101	29.26	16.70	1.04	15.66	187	1679	288	0	54.2
BTS 8572 (Check)	243	296.2	98	9264	98	39.67	95	1243	96	31.08	16.21	1.41	14.80	393	1678	499	0	67.5
BTS 8337 (1stYrBench)	244	319.7	106	9086	96	46.70	112	1328	103	28.41	17.19	1.20	15.99	272	1707	381	0	61.5
Crystal 578RR (1stYrBench)	245	287.9	95	9946	106	37.22	90	1288	100	34.51	15.75	1.34	14.40	367	1860	405	0	69.1
BTS 8815 (1stYrBench)	246	306.5	101	9374	100	42.72	103	1307	101	30.57	16.62	1.30	15.32	349	1954	365	0	57.3
Crystal 803 (1stYrBench)	247	314.8	104	10165	108	45.23	109	1462	113	32.36	16.92	1.15	15.77	230	1570	391	0	62.7
AP CK#55 CRYS247	248	288.2	95	10155	108	37.31	90	1320	102	35.23	15.82	1.39	14.42	412	1927	412	0	73.0
Comm Benchmark Mean		302.6		9418		41.58		1292		31.15	16.44	1.32		378	1755	412		66.0
Comm Trial Mean		301.1		9734		41.12		1328		32.36	16.31	1.26		363	1673	396		66.1
Coeff. of Var. (%)		3.0		5.4		6.6		7.7		5.0	2.4	7.5		18.5	4.1	13.3		13.8
Mean LSD (0.05)		8.2		473		2.45		92		1.38	0.36	0.09		61	62	48		7.6
Mean LSD (0.01)		10.8		623		3.23		121		1.82	0.47	0.11		81	82	63		10.0
Sig Lvl		**		**		**		**		**	**	**		**	**	**		**

2022 Data from Bathgate ND

Created 10/28/2022

@ Statistics and trial mean are from Commercial trial including benchmark means. Experimental trial data adjusted to commercial status.

%Bnch = percentage of four commercial benchmark (CommBench) varieties used for approval of second year entries.

+ Revenue estimates are based on a $46.80 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Trial # = 228313

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

++ Number of bolters observed at location.

Table 19

Description	Approval Status	Rec/Ton 2021	2022	2 Yr	% Bench	Rev/Acre++ 2021	2022	2 Yr	% Bench	R/T + $/A Bench	Cercospora Rating + 2020	2021	2022	2 Yr Mean	3 Yr Mean
Previously Approved (3 Yr)															**<=5.30**
BTS 8018	Approved	338.0	328.6	333.3	101.2	1622	1447	1535	112.6	213.8	2.41	2.31	2.03	2.17	2.25
BTS 8034	Approved	323.2	315.1	319.2	97.0	1587	1362	1475	108.2	205.1	2.70	2.56	2.28	2.42	2.51
BTS 8073	Approved	332.4	326.9	329.7	100.1	1533	1461	1497	109.8	210.0	4.68	4.56	4.55	4.55	4.59
BTS 8092	Approved	332.2	317.5	324.9	98.7	1611	1406	1509	110.7	209.3	4.26	4.62	4.26	4.44	4.38
BTS 8629	Approved	322.9	313.5	318.2	96.7	1590	1385	1488	109.1	205.8	4.55	4.78	4.52	4.65	4.62
BTS 8927	Approved	343.3	338.8	341.1	103.6	1572	1452	1512	110.9	214.5	4.42	4.48	4.42	4.45	4.44
BTS 8961	Approved	328.5	316.4	322.5	98.0	1556	1369	1463	107.3	205.2	4.69	4.53	4.54	4.53	4.58
Crystal 021	Approved	330.0	317.6	323.8	98.4	1620	1390	1505	110.4	208.8	2.20	2.28	2.08	2.18	2.19
Crystal 022	Approved	340.7	339.2	340.0	103.3	1543	1449	1496	109.7	213.0	4.71	4.97	4.60	4.78	4.76
Crystal 026	Approved	327.9	322.3	325.1	98.8	1602	1430	1516	111.2	210.0	4.76	4.43	4.69	4.56	4.63
Crystal 572	Approved	337.9	335.7	336.8	102.3	1530	1424	1477	108.4	210.7	4.46	4.75	4.50	4.63	4.57
Crystal 684	Approved	320.8	311.9	316.4	96.1	1533	1411	1472	108.0	204.1	4.44	4.54	4.59	4.57	4.52
Crystal 793	Approved	339.3	330.6	335.0	101.8	1625	1476	1551	113.7	215.5	4.31	4.13	4.10	4.12	4.18
Crystal 912	Approved	328.2	312.6	320.4	97.3	1665	1433	1549	113.6	211.0	4.75	5.13	4.81	4.97	4.90
Crystal 913	Approved	339.5	329.1	334.3	101.6	1579	1458	1519	111.4	213.0	4.13	4.10	3.73	3.92	3.99
Hilleshög HIL2317	Approved	334.5	326.8	330.7	100.4	1451	1371	1411	103.5	204.0	5.05	4.57	5.13	4.85	4.92
Hilleshög HIL2320	Approved	324.3	322.8	323.6	98.3	1411	1403	1407	103.2	201.5	5.11	4.78	5.01	4.90	4.97
Hilleshög HIL2366	Approved	331.3	319.3	325.3	98.8	1481	1351	1416	103.9	202.7	4.94	5.01	5.00	5.00	4.98
Hilleshög HIL2367	Approved	327.3	323.0	325.2	98.8	1443	1356	1400	102.7	201.4	5.08	4.75	4.75	4.75	4.86
Hilleshög HIL2368	Approved	337.7	329.1	333.4	101.3	1339	1154	1247	91.4	192.7	4.69	4.66	4.56	4.61	4.64
Hilleshög HIL9708	Approved	326.9	322.5	324.7	98.6	1402	1342	1372	100.7	199.3	4.97	4.65	4.86	4.76	4.83
Hilleshög HIL9920	Approved	335.4	324.5	330.0	100.2	1497	1383	1440	105.6	205.9	4.82	4.75	4.92	4.84	4.83
Hilleshög HM9528RR	Approved	320.3	319.4	319.9	97.2	1392	1368	1380	101.2	198.4	4.84	4.52	4.76	4.64	4.71
Maribo MA717	Approved	317.4	318.6	318.0	96.6	1414	1397	1406	103.1	199.7	5.11	4.68	5.05	4.86	4.95
Maribo MA902	Approved	326.9	321.2	324.1	98.4	1427	1310	1369	100.4	198.8	4.96	4.63	4.95	4.79	4.85
SV 203	Approved	337.8	322.0	329.9	100.2	1478	1296	1387	101.8	202.0	5.03	4.75	4.74	4.74	4.84
SV 265	Approved	326.9	318.1	322.5	98.0	1416	1321	1369	100.4	198.4	4.55	4.30	4.46	4.38	4.44
SV 285	Approved	335.8	322.6	329.2	100.0	1524	1276	1400	102.7	202.7	4.50	4.78	4.72	4.75	4.66
SX 1898	Approved	335.6	320.4	328.0	99.6	1479	1297	1388	101.8	201.5	4.73	4.76	4.72	4.74	4.74
Candidates for Approval (2 Yr)														**<=5.00**	
BTS 8100	Approved	339.2	325.4	332.3	100.9	1544	1363	1454	106.6	207.6	--	4.01	3.87	3.94	--
BTS 8133	Not Approved	322.1	311.5	316.8	96.2	1601	1392	1497	109.8	206.0	--	2.30	2.23	2.26	--
BTS 8156	Approved	330.2	327.5	328.9	99.9	1551	1410	1481	108.6	208.5	--	2.48	2.43	2.46	--
Crystal 130	Approved	338.1	332.3	335.2	101.8	1620	1436	1528	112.1	213.9	--	2.38	2.10	2.24	--
Crystal 134	Approved	347.6	340.5	344.1	104.5	1574	1430	1502	110.2	214.7	--	4.59	4.47	4.53	--
Crystal 137	Approved	330.7	324.6	327.7	99.5	1628	1390	1509	110.7	210.2	--	2.53	2.57	2.55	--
Crystal 138	Approved	336.6	332.5	334.6	101.6	1561	1471	1516	111.2	212.8	--	4.74	4.87	4.80	--
Hilleshög HIL2386	Approved	332.3	322.3	327.3	99.4	1499	1424	1462	107.2	206.6	--	4.30	4.54	4.42	--
Hilleshög HIL2389	Approved	334.1	326.8	330.5	100.4	1483	1407	1445	106.0	206.4	--	4.85	4.69	4.77	--
Maribo MA932	Approved	328.4	323.8	326.1	99.1	1486	1406	1446	106.1	205.1	--	4.85	4.78	4.82	--
SV 215	Not Approved	331.3	314.6	323.0	98.1	1427	1252	1340	98.3	196.4	--	5.11	4.66	4.88	--
SX 1815	Approved	338.7	328.4	333.6	101.3	1545	1403	1474	108.1	209.5	--	4.78	5.07	4.93	--
SX 1816	Not Approved	328.3	316.1	322.2	97.9	1518	1302	1410	103.4	201.3	--	4.63	4.51	4.57	--
SX 1818	Approved	332.5	321.4	327.0	99.3	1555	1361	1458	107.0	206.3	--	4.86	4.72	4.79	--

Benchmark Varieties		Rec/Ton 2020	2021	2022	2yr	3yr	Rev/Acre 2020	2021	2022	2yr	3yr
Crystal 355RR(Check)	Benchmark	333.8	330.5				1200	1292			
BTS 8572 (Check)	Benchmark	335.2	333.2	329.3			1292	1412	1355		
BTS 8337 (Check)	Benchmark	342.6	340.4	334.4			1262	1447	1324		
Crystal 578RR (Check)	Benchmark	323.5	330.5	318.2			1296	1460	1345		
BTS 8815 (Check)	Benchmark			317.0					1270		
Benchmark mean		333.8	333.7	324.7	329.2	330.7	1263	1403	1324	1363	1330

++2022 Revenue estimate based on a $46.80 beet payment (5-yr ave) at 17.5% crop with a 1.5% loss to molasses and 2021 Revenue estimate based on a $45.65 beet payment. Revenue does not consider hauling or production costs.

+ All Cercospora ratings 2020-2022 were adjusted to 1982 basis.

Created 11/04/2022

Variety approval criteria include: 1) 2 years of official trial data, 2) Cercospora rating must not exceed 5.00 (1982 adjusted data), 3a) R/T >= 100% of Bench or 3b) R/T >= 97% and R/T + $/A >= 202% of Bench. 3 yrs of data may be considered for initial approval.

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

Table 20

2022 First Year Experimental Varieties New Benchmark Comparison

Projected Calculation for Approval of Sugarbeet Varieties for ACSC Market

Description	Approval ^ Likely	Rec/Ton % 2022	Rec/Ton Bench	Rev/Acre % 2022	Rev/Acre Bench	R/T + $/A Bench	CR Rating ^^ 2022
Candidates for Retesting (1 Yr)							
BTS 8205	On Track	325.1	99.7	1426	105.4	205.1	4.27
BTS 8217	Not On Track	323.1	99.1	1373	101.5	200.5	2.25
BTS 8226	On Track	343.0	105.2	1521	112.4	217.6	2.00
BTS 8242	On Track	340.4	104.4	1441	106.5	210.9	4.35
BTS 8248	On Track	328.9	100.9	1403	103.7	204.5	1.96
BTS 8270	On Track	333.6	102.3	1472	108.8	211.1	1.97
BTS 8299	On Track	328.3	100.7	1359	100.4	201.1	2.02
Crystal 260	On Track	333.9	102.4	1488	110.0	212.4	2.05
Crystal 262	On Track	325.3	99.8	1463	108.1	207.9	4.43
Crystal 263	On Track	338.1	103.7	1418	104.8	208.5	3.80
Crystal 265	On Track	330.3	101.3	1366	100.9	202.2	2.06
Crystal 267	Not On Track	320.0	98.1	1389	102.6	200.8	2.25
Crystal 269	On Track	333.8	102.4	1466	108.3	210.7	4.60
Hilleshög HIL2440	On Track	327.7	100.5	1343	99.2	199.7	4.98
Hilleshög HIL2441	On Track	327.0	100.3	1312	97.0	197.2	4.01
Hilleshög HIL2442	On Track	331.7	101.7	1312	97.0	198.7	4.39
Hilleshög HIL2443	Not On Track	313.8	96.2	1361	100.6	196.8	5.16
Maribo MA942	On Track	328.8	100.8	1310	96.8	197.6	4.57
Maribo MA943	On Track	326.3	100.1	1333	98.5	198.6	4.28
Maribo MA944	On Track	328.7	100.8	1334	98.6	199.4	4.29
SV 321	Not On Track	316.7	97.1	1320	97.5	194.7	4.52
SV 322	Not On Track	317.9	97.5	1201	88.8	186.2	3.80
SV 324	Not On Track	310.8	95.3	1231	91.0	186.3	5.22
SX 1829	Not On Track	321.2	98.5	1221	90.2	188.7	3.51
Benchmarks							
BTS 8337 (Check)		334.8	102.7	1322	97.7		
Crystal 578RR (Check)		313.1	96.0	1339	98.9		
BTS 8815 (Check)		324.9	99.6	1320	97.5		
Crystal 803 (Check)		331.6	101.7	1433	105.9		
Benchmark Mean		326.1		1353			

^ Not on Track = not on track for approval. On Track = data is tracking for potential approval. Created 11/04/2022

^^ All Cercospora ratings 2022 were adjusted to 1982 basis.

Full market approval criteria include: 1) 2 years of official trial data, 2) Cercospora rating must not exceed 5.00 (1982 adjusted data), 3a) R/T >= 100% of Bench or 3b) R/T >= 97% and R/T + $/A equal to 202% of Bench.

Bench for 2022 first year entries added Crystal 803 and dropped BTS 8572

Table 227

Calculation for Approval of Sugarbeet Varieties for ACSC Aphanomyces Specialty Market for 2023

Approval Description	Status	Aph. Root Rating 2020	2021	2022	2 Yr	3 Yr	Cercospora Rating* 2020	2021	2022	2 Yr	3 Yr
Previously Approved (3 Yrs)						**<=4.50**					**<=5.30**
BTS 8018	Approved	3.87	4.52	4.00	4.26	4.13	2.41	2.31	2.03	2.17	2.25
BTS 8034	Approved	4.36	3.24	3.89	3.57	3.83	2.70	2.56	2.28	2.42	2.51
BTS 8073	Approved	3.45	4.30	4.01	4.16	3.92	4.68	4.56	4.55	4.56	4.60
BTS 8092	Approved	3.85	4.11	3.86	3.99	3.94	4.26	4.62	4.26	4.44	4.38
BTS 8629	Approved	3.92	4.24	4.50	4.37	4.22	4.55	4.78	4.52	4.65	4.62
BTS 8927	Approved	3.87	4.51	4.00	4.26	4.13	4.42	4.48	4.42	4.45	4.44
BTS 8961	Approved	4.04	4.80	4.47	4.64	4.44	4.69	4.53	4.54	4.54	4.59
Crystal 021	Approved	3.46	4.19	3.74	3.97	3.80	2.20	2.28	2.08	2.18	2.19
Crystal 022	Approved	3.81	4.79	4.03	4.41	4.21	4.71	4.97	4.60	4.79	4.76
Crystal 026	Approved	3.75	3.74	3.76	3.75	3.75	4.76	4.43	4.69	4.56	4.63
Crystal 572	Approved	4.28	4.47	4.60	4.54	4.45	4.46	4.75	4.50	4.63	4.57
Crystal 684	Approved	3.97	3.60	3.81	3.71	3.79	4.44	4.54	4.59	4.57	4.52
Crystal 793	Approved	3.87	3.74	3.82	3.78	3.81	4.31	4.13	4.10	4.12	4.18
Crystal 912	Approved	3.67	3.95	3.44	3.70	3.69	4.75	5.13	4.81	4.97	4.90
Crystal 913	Approved	3.75	4.39	3.79	4.09	3.98	4.13	4.10	3.73	3.92	3.99
Hilleshög HIL2317	Approved	3.86	5.01	3.91	4.46	4.26	5.05	4.57	5.13	4.85	4.92
Hilleshög HIL2320	Approved	3.55	4.66	4.00	4.33	4.07	5.11	4.78	5.01	4.90	4.97
Hilleshög HIL2367	Approved	3.51	5.13	4.17	4.65	4.27	5.08	4.75	4.75	4.75	4.86
Hilleshög HIL9708	Not Approved	3.96	6.34	4.45	5.40	4.92	4.97	4.65	4.86	4.76	4.83
Hilleshög HIL9920	Approved	3.65	4.65	4.33	4.49	4.21	4.82	4.75	4.92	4.84	4.83
Hilleshög HM9528RR	Approved	3.72	5.51	4.07	4.79	4.43	4.84	4.52	4.76	4.64	4.71
Maribo MA717	Not Approved	3.77	6.75	4.39	5.57	4.97	5.11	4.68	5.05	4.87	4.95
SV 203	Approved	4.34	4.35	4.24	4.30	4.31	5.03	4.75	4.74	4.75	4.84
SV 285	Approved	4.28	4.48	4.35	4.42	4.37	4.50	4.78	4.72	4.75	4.67
SX 1898	Approved	3.76	4.97	4.25	4.61	4.33	4.73	4.76	4.72	4.74	4.74
Candidates for Approval (2 Yrs)					**<=4.20**					**<=5.00**	
BTS 8100	Approved	--	3.89	3.78	3.84	--	--	4.01	3.87	3.94	--
BTS 8133	Approved	--	3.46	3.57	3.52	--	--	2.30	2.23	2.27	--
BTS 8156	Approved	--	3.64	4.21	3.93	--	--	2.48	2.43	2.46	--
Crystal 130	Approved	--	4.23	3.57	3.90	--	--	2.38	2.10	2.24	--
Crystal 134	Approved	--	4.39	3.70	4.05	--	--	4.59	4.47	4.53	--
Crystal 137	Approved	--	3.13	4.25	3.69	--	--	2.53	2.57	2.55	--
Crystal 138	Approved	--	4.19	3.87	4.03	--	--	4.74	4.87	4.81	--
Hilleshög HIL2366	Not Approved	3.81	5.81	4.32	5.07	4.65	4.94	5.01	5.00	5.01	4.98
Hilleshög HIL2368	Not Approved	3.70	5.25	4.63	4.94	4.53	4.69	4.66	4.56	4.61	4.64
Hilleshög HIL2386	Not Approved	--	5.98	4.31	5.15	--	--	4.30	4.54	4.42	--
Hilleshög HIL2389	Approved	--	3.86	3.78	3.82	--	--	4.85	4.69	4.77	--
Maribo MA902	Not Approved	4.01	6.96	4.59	5.78	5.19	4.96	4.63	4.95	4.79	4.85
Maribo MA932	Not Approved	--	4.60	4.28	4.44	--	--	4.85	4.78	4.82	--
SV 215	Not Approved	--	5.03	5.07	5.05	--	--	5.11	4.66	4.89	--
SV 265	Not Approved	3.98	4.95	4.30	4.63	4.41	4.55	4.30	4.46	4.38	4.44
SX 1815	Not Approved	--	4.19	4.28	4.24	--	--	4.78	5.07	4.93	--
SX 1816	Not Approved	--	5.21	4.97	5.09	--	--	4.63	4.51	4.57	--
SX 1818	Not Approved	--	5.56	4.82	5.19	--	--	4.86	4.72	4.79	--
Approval Criteria new varieties					4.20					5.00	
Criteria to Maintain Approval						4.50					5.30

* All Cercospora ratings 2020-2022 were adjusted to 1982 basis. Created 11/09/2022

Aphanomyces approval criteria include: 1) Cercospora rating 2 year mean must not exceed 5.00 (1982 adjusted data), 2) Aph root rating 2 year mean <= 4.20. Three years of data may be considered for initial approval.

To maintain Aphanomyces approval, criteria include: 1) Cercospora 3 year mean must not exceed 5.30, 2) Aph root rating 3 year mean <= 4.50. Previously approved varieties not meeting current approval standards may be sold in 2023.

Table 228

Calculation for Approval of Sugarbeet Varieties for ACSC Rhizoctonia Specialty Market for 2023

Approval		Rhizoctonia Root Rating					Cercospora Rating				
Description	Status	2020	2021	2022	2 Yr Mn	3 Yr Mn	2020	2021	2022	2 Yr Mn	3 Yr Mn
Previously Approved (3 Yr)						**<=4.12**					**<=5.30**
BTS 8092	Approved	3.81	3.81	3.58	3.70	3.73	4.26	4.62	4.26	4.44	4.38
Crystal 912	Approved	3.54	3.77	3.28	3.53	3.53	4.75	5.13	4.81	4.97	4.90
Crystal 021	Approved	3.88	3.38	3.58	3.48	3.61	2.20	2.28	2.08	2.18	2.19
Crystal 022	Approved	3.49	3.53	4.10	3.82	3.71	4.71	4.97	4.60	4.79	4.76
Crystal 026	Approved	3.57	3.34	3.28	3.31	3.40	4.76	4.43	4.69	4.56	4.63
Hilleshög HIL9708	Approved	3.83	3.78	3.78	3.78	3.80	4.97	4.65	4.86	4.76	4.83
Hilleshög HIL2368	Approved	3.52	2.92	3.46	3.19	3.30	4.69	4.66	4.56	4.61	4.64
Candidates for Approval (2 Yr)					**<=3.82**					**<=5.00**	
BTS 8018	Not Approved	4.16	3.83	3.93	3.88	3.97	2.41	2.31	2.03	2.17	2.25
BTS 8034	Not Approved	4.56	3.88	4.49	4.19	4.31	2.70	2.56	2.28	2.42	2.51
BTS 8073	Not Approved	4.11	3.67	4.21	3.94	4.00	4.68	4.56	4.55	4.56	4.60
BTS 8100	Approved	--	3.09	3.73	3.41	--	--	4.01	3.87	3.94	--
BTS 8133	Approved	--	3.87	3.44	3.66	--	--	2.30	2.23	2.27	--
BTS 8156	Not Approved	--	3.81	4.24	4.03	--	--	2.48	2.43	2.46	--
BTS 8629	Not Approved	4.30	4.22	3.72	3.97	4.08	4.55	4.78	4.52	4.65	4.62
BTS 8927	Not Approved	4.37	3.68	4.13	3.91	4.06	4.42	4.48	4.42	4.45	4.44
BTS 8961	Approved	4.11	3.75	3.75	3.75	3.87	4.69	4.53	4.54	4.54	4.59
Crystal 130	Not Approved	--	3.57	4.08	3.83	--	--	2.38	2.10	2.24	--
Crystal 134	Approved	--	3.44	3.63	3.54	--	--	4.59	4.47	4.53	--
Crystal 137	Not Approved	--	3.53	4.18	3.86	--	--	2.53	2.57	2.55	--
Crystal 138	Approved	--	3.52	3.81	3.67	--	--	4.74	4.87	4.81	--
Crystal 572	Not Approved	4.21	3.88	4.28	4.08	4.12	4.46	4.75	4.50	4.63	4.57
Crystal 684	Not Approved	4.15	3.82	4.24	4.03	4.07	4.44	4.54	4.59	4.57	4.52
Crystal 793	Not Approved	4.84	4.36	4.73	4.55	4.64	4.31	4.13	4.10	4.12	4.18
Crystal 913	Not Approved	4.58	3.94	4.23	4.09	4.25	4.13	4.10	3.73	3.92	3.99
Hilleshög HIL2317	Not Approved	4.95	4.76	4.71	4.74	4.81	5.05	4.57	5.13	4.85	4.92
Hilleshög HIL2320	Not Approved	4.64	3.80	3.88	3.84	4.11	5.11	4.78	5.01	4.90	4.97
Hilleshög HIL2366	Not Approved	4.24	3.98	3.92	3.95	4.05	4.94	5.01	5.00	5.01	4.98
Hilleshög HIL2367	Not Approved	4.26	4.10	3.90	4.00	4.09	5.08	4.75	4.75	4.75	4.86
Hilleshög HIL2386	Not Approved	--	4.20	3.51	3.86	--	--	4.30	4.54	4.42	--
Hilleshög HIL2389	Not Approved	--	3.99	3.92	3.96	--	--	4.85	4.69	4.77	--
Hilleshög HIL9920	Not Approved	5.12	4.70	4.58	4.64	4.80	4.82	4.75	4.92	4.84	4.83
Hilleshög HM9528RR	Not Approved	4.57	4.47	4.01	4.24	4.35	4.84	4.52	4.76	4.64	4.71
Maribo MA717	Not Approved	4.61	4.31	3.92	4.12	4.28	5.11	4.68	5.05	4.87	4.95
Maribo MA902	Approved	3.93	3.80	3.57	3.69	3.77	4.96	4.63	4.95	4.79	4.85
Maribo MA932	Not Approved	--	4.03	3.75	3.89	--	--	4.85	4.78	4.82	--
SV 203	Not Approved	4.29	4.34	4.19	4.27	4.27	5.03	4.75	4.74	4.75	4.84
SV 215	Not Approved	--	3.79	4.20	4.00	--	--	5.11	4.66	4.89	--
SV 265	Not Approved	4.21	4.17	3.96	4.07	4.11	4.55	4.30	4.46	4.38	4.44
SV 285	Not Approved	4.03	4.26	4.53	4.40	4.27	4.50	4.78	4.72	4.75	4.67
SX 1815	Not Approved	--	4.40	4.12	4.26	--	--	4.78	5.07	4.93	--
SX 1816	Not Approved	--	4.09	4.24	4.17	--	--	4.63	4.51	4.57	--
SX 1818	Not Approved	--	4.41	4.16	4.29	--	--	4.86	4.72	4.79	--
SX 1898	Not Approved	4.16	4.34	4.12	4.23	4.21	4.73	4.76	4.72	4.74	4.74
Approval Criteria new varieties					3.82					5.00	
Criteria to Maintain Approval						4.12					5.30

Rhc and CR ratings were adjusted based upon check performance. Created 10/08/2022

+ Root Rating based on a scale of 0 (healthy) to 7 (dead).

++ Candidates must have 2yr Rhizoctonia rating less than or equal to 3.82. To maintain approval, 3 yr Rhizoctonia rating must be less than or equal to 4.12.

Previously approved varieties not meeting current approval standards may be sold in 2023.

Table 23.

2022 Aphanomyces Ratings for Official Trial Entries

		Unadjusted ^^				Adjusted ++									
Chk++	Code Description	Perl 9/8	Clim NA	Shak 8/24	Glyn 9/1	Perl 9/8	Clim NA	Shak 8/24	Glyn 9/1	2022	2 Yr	3 Yr	2021 ++	2020 ++	Trial Yrs $$
	524 BTS 8018	5.18		3.53	4.14	4.14		3.65	4.21	4.00	4.26	4.13	4.52	3.87	3
	567 BTS 8034	5.21		3.06	4.26	4.16		3.17	4.33	3.89	3.56	3.83	3.24	4.36	3
	533 BTS 8073	5.32		3.77	3.81	4.25		3.90	3.87	4.01	4.15	3.92	4.30	3.45	3
	511 BTS 8092	5.20		3.12	4.11	4.16		3.23	4.18	3.86	3.98	3.94	4.11	3.85	3
	527 BTS 8100	5.09		3.49	3.59	4.07		3.61	3.65	3.78	3.83	--	3.89	--	2
	526 BTS 8133	4.59		2.99	3.89	3.67		3.10	3.96	3.57	3.51	--	3.46	--	2
	555 BTS 8156	5.18		3.92	4.37	4.14		4.06	4.44	4.21	3.93	--	3.64	--	2
	501 BTS 8205	4.80		2.95	4.12	3.84		3.05	4.19	3.69	--	--	--	--	1
	508 BTS 8217	5.49		3.21	4.43	4.39		3.32	4.50	4.07	--	--	--	--	1
	542 BTS 8226	5.03		3.30	3.87	4.02		3.42	3.94	3.79	--	--	--	--	1
	537 BTS 8242	5.72		4.27	4.35	4.57		4.42	4.42	4.47	--	--	--	--	1
	509 BTS 8248	5.64		3.21	3.89	4.51		3.32	3.96	3.93	--	--	--	--	1
	540 BTS 8270	5.04		3.42	3.97	4.03		3.54	4.04	3.87	--	--	--	--	1
	551 BTS 8299	5.03		3.27	3.80	4.02		3.39	3.86	3.76	--	--	--	--	1
	503 BTS 8629	5.79		4.10	4.55	4.63		4.24	4.63	4.50	4.37	4.22	4.24	3.92	7
	510 BTS 8927	5.45		3.32	4.13	4.36		3.44	4.20	4.00	4.26	4.13	4.51	3.87	4
	557 BTS 8961	5.21		4.02	4.99	4.16		4.16	5.07	4.47	4.64	4.44	4.80	4.04	4
	566 Crystal 021	4.97		3.21	3.86	3.97		3.32	3.93	3.74	3.97	3.80	4.19	3.46	3
	559 Crystal 022	4.70		3.81	4.31	3.76		3.94	4.38	4.03	4.41	4.21	4.79	3.81	3
	563 Crystal 026	4.13		3.44	4.34	3.30		3.56	4.41	3.76	3.75	3.75	3.74	3.75	3
	528 Crystal 130	4.79		2.98	3.73	3.83		3.09	3.79	3.57	3.90	--	4.23	--	2
	543 Crystal 134	4.68		3.30	3.89	3.74		3.42	3.96	3.70	4.05	--	4.39	--	2
	515 Crystal 137	5.04		3.31	5.21	4.03		3.43	5.30	4.25	3.69	--	3.13	--	2
	565 Crystal 138	4.75		3.46	4.16	3.80		3.58	4.23	3.87	4.03	--	4.19	--	2
	553 Crystal 260	5.22		3.74	3.57	4.17		3.87	3.63	3.89	--	--	--	--	1
	505 Crystal 262	4.35		3.37	3.23	3.48		3.49	3.28	3.42	--	--	--	--	1
	552 Crystal 263	4.27		3.65	4.04	3.41		3.78	4.11	3.77	--	--	--	--	1
	544 Crystal 265	4.49		3.61	3.87	3.59		3.74	3.94	3.75	--	--	--	--	1
	520 Crystal 267	4.55		3.06	4.06	3.64		3.17	4.13	3.64	--	--	--	--	1
	548 Crystal 269	4.64		3.20	3.37	3.71		3.31	3.43	3.48	--	--	--	--	1
	516 Crystal 572	6.05		4.70	4.03	4.84		4.87	4.10	4.60	4.54	4.45	4.47	4.28	8
	539 Crystal 684	5.28		3.45	3.58	4.22		3.57	3.64	3.81	3.71	3.79	3.60	3.97	7
	558 Crystal 793	4.97		3.67	3.63	3.97		3.80	3.69	3.82	3.78	3.81	3.74	3.87	6
	530 Crystal 912	4.86		2.87	3.42	3.89		2.97	3.48	3.44	3.70	3.69	3.95	3.67	4
	564 Crystal 913	5.06		3.31	3.83	4.04		3.43	3.89	3.79	4.09	3.98	4.39	3.75	4
	541 Hilleshög HIL2317	4.78		3.26	4.46	3.82		3.38	4.54	3.91	4.46	4.26	5.01	3.86	4
	517 Hilleshög HIL2320	5.31		4.01	3.55	4.24		4.15	3.61	4.00	4.33	4.07	4.66	3.55	4
	521 Hilleshög HIL2366	5.64		4.47	3.77	4.51		4.63	3.83	4.32	5.07	4.65	5.81	3.81	3
	545 Hilleshög HIL2367	5.27		4.67	3.41	4.21		4.83	3.47	4.17	4.65	4.27	5.13	3.51	3
	560 Hilleshög HIL2368	5.82		4.28	4.73	4.65		4.43	4.81	4.63	4.94	4.53	5.25	3.70	3
	547 Hilleshög HIL2386	5.72		4.37	3.77	4.57		4.52	3.83	4.31	5.14	--	5.98	--	2
	512 Hilleshög HIL2389	5.02		3.75	3.38	4.01		3.88	3.44	3.78	3.82	--	3.86	--	2
	514 Hilleshög HIL2440	5.70		4.45	3.80	4.56		4.61	3.86	4.34	--	--	--	--	1
	538 Hilleshög HIL2441	4.84		4.00	3.66	3.87		4.14	3.72	3.91	--	--	--	--	1
	507 Hilleshög HIL2442	6.06		4.65	4.74	4.84		4.81	4.82	4.83	--	--	--	--	1
	518 Hilleshög HIL2443	4.81		4.55	3.68	3.85		4.71	3.74	4.10	--	--	--	--	1
	504 Hilleshög HIL9708	5.29		4.14	4.74	4.23		4.29	4.82	4.45	5.39	4.91	6.34	3.96	8
	519 Hilleshög HIL9920	5.03		4.73	4.01	4.02		4.90	4.08	4.33	4.49	4.21	4.65	3.65	6
	535 Hilleshög HM9528RR	5.51		4.01	3.58	4.40		4.15	3.64	4.07	4.79	4.43	5.51	3.72	9
	536 Maribo MA717	4.77		4.50	4.63	3.81		4.66	4.71	4.39	5.57	4.97	6.75	3.77	6
	531 Maribo MA902	5.93		4.71	4.08	4.74		4.88	4.15	4.59	5.78	5.19	6.96	4.01	4
	523 Maribo MA932	5.40		4.28	4.02	4.32		4.43	4.09	4.28	4.44	--	4.60	--	2
	550 Maribo MA942	5.51		4.11	3.86	4.40		4.26	3.93	4.20	--	--	--	--	1
	556 Maribo MA943	4.87		4.08	4.43	3.89		4.22	4.50	4.21	--	--	--	--	1
	502 Maribo MA944	5.60		4.35	4.07	4.48		4.50	4.14	4.37	--	--	--	--	1

Table 23.

2022 Aphanomyces Ratings for Official Trial Entries

		Unadjusted ^^				Adjusted ++									
		Perl	Clim	Shak	Glyn	Perl	Clim	Shak	Glyn						Trial
Chk++	Code Description	9/8	NA	8/24	9/1	9/8	NA	8/24	9/1	2022	2 Yr	3 Yr	2021 ++	2020 ++	Yrs $$
	554 SV 203	5.06		4.47	3.99	4.04		4.63	4.06	4.24	4.30	4.31	4.35	4.34	3
	522 SV 215	6.02		5.05	5.08	4.81		5.23	5.17	5.07	5.05	--	5.03	--	2
	513 SV 265	5.57		4.45	3.79	4.45		4.61	3.85	4.30	4.63	4.41	4.95	3.98	7
	532 SV 285	5.25		4.64	3.98	4.20		4.80	4.05	4.35	4.42	4.37	4.48	4.28	5
	546 SV 321	6.36		5.43	4.63	5.08		5.62	4.71	5.14	--	--	--	--	1
	549 SV 322	5.98		4.88	4.57	4.78		5.05	4.65	4.83	--	--	--	--	1
	534 SV 324	5.90		5.28	3.96	4.72		5.47	4.03	4.74	--	--	--	--	1
	529 SX 1815	5.28		4.80	3.60	4.22		4.97	3.66	4.28	4.24	--	4.19	--	2
	525 SX 1816	5.79		5.36	4.65	4.63		5.55	4.73	4.97	5.09	--	5.21	--	2
	562 SX 1818	5.68		5.24	4.41	4.54		5.42	4.48	4.82	5.19	--	5.56	--	2
	561 SX 1829	5.79		4.28	4.12	4.63		4.43	4.19	4.42	--	--	--	--	1
	506 SX 1898	5.09		4.49	3.96	4.07		4.65	4.03	4.25	4.61	4.33	4.97	3.76	4
1	1001 AP CK#32 CRYS981	4.95		3.07	4.29	3.96		3.18	4.36	3.83	3.96	3.97	4.09	3.99	14
1	1002 AP CK#33 CRYS768	6.32		3.98	4.56	5.05		4.12	4.64	4.60	4.21	4.43	3.82	4.87	16
1	1003 AP CK#35 BETA87RR5	6.68		4.80	5.85	5.34		4.97	5.95	5.42	5.11	4.96	4.79	4.68	16
1	1004 AP CK#41 CRYS765	7.02		5.51	5.61	5.61		5.70	5.70	5.67	5.28	5.45	4.89	5.78	12
1	1005 AP CK#43 BTS80RR32	5.72		4.87	4.69	4.57		5.04	4.77	4.79	4.87	4.88	4.94	4.92	13
1	1006 AP CK#44 SEEDVISIO	6.50		5.53	5.58	5.20		5.73	5.67	5.53	4.84	4.94	4.14	5.15	14
1	1007 AP CK#45 CRYS986	5.38		4.29	3.94	4.30		4.44	4.01	4.25	4.91	4.84	5.57	4.71	14
1	1008 AP CK#47 CRYS101	4.78		3.50	4.59	3.82		3.62	4.67	4.04	4.24	4.11	4.45	3.86	12
1	1009 AP CK#59 BTS8606	5.67		3.97	4.17	4.53		4.11	4.24	4.29	4.68	4.64	5.06	4.56	7
1	1010 AP CK#51 CRYS246	6.08		4.77	4.54	4.86		4.94	4.62	4.81	4.65	4.71	4.50	4.82	11
1	1011 AP CK#52 HILL4094RR	5.75		5.37	4.71	4.60		5.56	4.79	4.98	4.96	4.72	4.94	4.23	15
1	1012 AP CK#55 CRYS247	6.32		4.79	4.65	5.05		4.96	4.73	4.91	4.82	4.96	4.73	5.22	11
1	1013 AP CK#56 BTS8363	6.16		5.10	4.65	4.92		5.28	4.73	4.98	5.23	5.15	5.49	4.99	10
1	1014 AP CK#57 CRYS578	5.66		4.66	4.26	4.52		4.82	4.33	4.56	4.76	4.72	4.95	4.66	8
1	1015 AP CK#58 CRYS572	6.03		4.53	3.89	4.82		4.69	3.96	4.49	4.64	4.61	4.79	4.56	8
	1016 AP CK MOD RES RR	6.28		4.47	4.70	5.02		4.63	4.78	4.81	4.23	4.36	3.65	4.61	16
	1017 Crystal 684 (Filler)	5.38		3.35	3.44	4.30		3.47	3.50	3.76	3.68	3.77	3.60	3.97	7
15	Check Mean	5.93		4.58	4.67	4.74		4.74	4.74	4.74					
	Trial Mean	5.37		4.06	4.16	4.29		4.20	4.23	4.24					
	Coeff. of Var. (%)	9.5		13.3	12.6										
	Mean LSD (0.05)	0.59		0.68	0.77										
	Mean LSD (0.01)	0.78		0.89	1.01										
	Sig Lvl	**		**	**										
	Adjustment Factor					0.799		1.035	1.017						

^^ 2022 Root Rating was taken in early fall (1=healthy, 9+=severe damage).
++ Ratings adjusted to 2003 basis. (2000-2002 Aph nurseries). Ratings adjusted on the basis of checks. Climax(Clim)-
Abandoned due to lack of Aph pressure
Ratings in green font indicate good resistance. Ratings in red font indicate
a level of concern.

Table 24.

2022 Cercospora Ratings for Official Trial Entries

Chk	Code	Description	Unadjusted Randolph Avg 8 Dates+	Unadjusted BSDF Avg 5 Dates+	Unadjusted Foxhome Avg 4 Dates+	Adjusted to 1982 Basis++ Randolph Avg 8 Dates+	Adjusted to 1982 Basis++ BSDF Avg 5 Dates+	Adjusted to 1982 Basis++ Foxhome Avg 4 Dates+	Adjusted to 1982 Basis++ 2022 3 loc	Adjusted to 1982 Basis++ 2 Yr	Adjusted to 1982 Basis++ 3 Yr	Adjusted to 1982 Basis++ 2021	Adjusted to 1982 Basis++ 2020	Trial Yrs $$
	524	BTS 8018	1.56	2.54	1.78	1.73	2.34	2.03	2.03	2.17	2.25	2.31	2.41	3
	567	BTS 8034	1.75	2.81	2.04	1.94	2.59	2.33	2.28	2.42	2.51	2.56	2.70	3
	533	BTS 8073	3.64	5.30	4.16	4.03	4.88	4.75	4.55	4.55	4.59	4.56	4.68	3
	511	BTS 8092	3.85	5.03	3.40	4.26	4.63	3.88	4.26	4.44	4.38	4.62	4.26	3
	527	BTS 8100	3.59	4.05	3.42	3.97	3.73	3.90	3.87	3.94	--	4.01	--	2
	526	BTS 8133	1.87	2.62	1.94	2.07	2.41	2.21	2.23	2.26	--	2.30	--	2
	555	BTS 8156	1.83	3.17	2.05	2.02	2.92	2.34	2.43	2.46	--	2.48	--	2
	501	BTS 8205	3.55	4.85	3.88	3.93	4.47	4.43	4.27	--	--	--	--	1
	508	BTS 8217	1.75	2.94	1.84	1.94	2.71	2.10	2.25	--	--	--	--	1
	542	BTS 8226	1.39	2.88	1.60	1.54	2.65	1.83	2.00	--	--	--	--	1
	537	BTS 8242	3.50	5.40	3.69	3.87	4.97	4.21	4.35	--	--	--	--	1
	509	BTS 8248	1.34	2.91	1.51	1.48	2.68	1.72	1.96	--	--	--	--	1
	540	BTS 8270	1.44	2.47	1.79	1.59	2.27	2.04	1.97	--	--	--	--	1
	551	BTS 8299	1.68	2.30	1.84	1.86	2.12	2.10	2.02	--	--	--	--	1
	503	BTS 8629	4.39	4.71	3.83	4.85	4.34	4.37	4.52	4.65	4.62	4.78	4.55	7
	510	BTS 8927	3.72	5.02	3.96	4.11	4.62	4.52	4.42	4.45	4.44	4.48	4.42	4
	557	BTS 8961	3.58	5.50	4.02	3.96	5.06	4.59	4.54	4.53	4.58	4.53	4.69	4
	566	Crystal 021	1.93	2.66	1.46	2.13	2.45	1.67	2.08	2.18	2.19	2.28	2.20	3
	559	Crystal 022	3.37	5.41	4.46	3.73	4.98	5.09	4.60	4.78	4.76	4.97	4.71	3
	563	Crystal 026	3.75	5.84	3.99	4.15	5.38	4.55	4.69	4.56	4.63	4.43	4.76	3
	528	Crystal 130	1.46	2.84	1.82	1.61	2.61	2.08	2.10	2.24	--	2.38	--	2
	543	Crystal 134	3.65	5.34	3.90	4.04	4.92	4.45	4.47	4.53	--	4.59	--	2
	515	Crystal 137	1.91	3.29	2.25	2.11	3.03	2.57	2.57	2.55	--	2.53	--	2
	565	Crystal 138	4.05	5.89	4.13	4.48	5.42	4.71	4.87	4.80	--	4.74	--	2
	553	Crystal 260	1.44	2.72	1.80	1.59	2.50	2.05	2.05	--	--	--	--	1
	505	Crystal 262	4.03	5.00	3.70	4.46	4.60	4.22	4.43	--	--	--	--	1
	552	Crystal 263	3.26	4.39	3.28	3.60	4.04	3.74	3.80	--	--	--	--	1
	544	Crystal 265	1.76	2.55	1.65	1.95	2.35	1.88	2.06	--	--	--	--	1
	520	Crystal 267	1.75	2.81	1.95	1.94	2.59	2.23	2.25	--	--	--	--	1
	548	Crystal 269	4.43	4.92	3.83	4.90	4.53	4.37	4.60	--	--	--	--	1
	516	Crystal 572	3.78	5.40	3.81	4.18	4.97	4.35	4.50	4.63	4.57	4.75	4.46	8
	539	Crystal 684	4.66	4.31	4.07	5.15	3.97	4.64	4.59	4.57	4.52	4.54	4.44	7
	558	Crystal 793	3.90	4.44	3.43	4.31	4.09	3.91	4.10	4.12	4.18	4.13	4.31	6
	530	Crystal 912	4.26	5.48	4.10	4.71	5.05	4.68	4.81	4.97	4.90	5.13	4.75	4
	564	Crystal 913	3.18	4.16	3.38	3.52	3.83	3.86	3.73	3.92	3.99	4.10	4.13	4
	541	Hilleshög HIL2317	4.88	5.12	4.63	5.40	4.71	5.28	5.13	4.85	4.92	4.57	5.05	4
	517	Hilleshög HIL2320	4.63	5.19	4.51	5.12	4.78	5.15	5.01	4.90	4.97	4.78	5.11	4
	521	Hilleshög HIL2366	4.76	5.31	4.25	5.26	4.89	4.85	5.00	5.00	4.98	5.01	4.94	3
	545	Hilleshög HIL2367	4.40	5.27	3.98	4.87	4.85	4.54	4.75	4.75	4.86	4.75	5.08	3
	560	Hilleshög HIL2368	4.25	5.04	3.80	4.70	4.64	4.34	4.56	4.61	4.64	4.66	4.69	3
	547	Hilleshög HIL2386	4.17	5.46	3.50	4.61	5.03	3.99	4.54	4.42	--	4.30	--	2
	512	Hilleshög HIL2389	4.59	4.65	4.12	5.08	4.28	4.70	4.69	4.77	--	4.85	--	2
	514	Hilleshög HIL2440	4.41	5.91	4.06	4.88	5.44	4.63	4.98	--	--	--	--	1
	538	Hilleshög HIL2441	3.80	4.64	3.11	4.20	4.27	3.55	4.01	--	--	--	--	1
	507	Hilleshög HIL2442	3.79	5.30	3.58	4.19	4.88	4.08	4.39	--	--	--	--	1
	518	Hilleshög HIL2443	4.83	5.61	4.35	5.34	5.16	4.96	5.16	--	--	--	--	1
	504	Hilleshög HIL9708	4.58	5.32	4.06	5.06	4.90	4.63	4.86	4.76	4.83	4.65	4.97	8
	519	Hilleshög HIL9920	4.63	5.07	4.37	5.12	4.67	4.99	4.92	4.84	4.83	4.75	4.82	6
	535	Hilleshög HM9528RR	4.56	5.26	3.86	5.04	4.84	4.40	4.76	4.64	4.71	4.52	4.84	9
	536	Maribo MA717	4.90	5.46	4.13	5.42	5.03	4.71	5.05	4.86	4.95	4.68	5.11	6
	531	Maribo MA902	4.49	5.58	4.15	4.96	5.14	4.74	4.95	4.79	4.85	4.63	4.96	4
	523	Maribo MA932	4.48	5.30	3.95	4.95	4.88	4.51	4.78	4.82	--	4.85	--	2
	550	Maribo MA942	4.20	4.88	4.01	4.64	4.49	4.58	4.57	--	--	--	--	1
	556	Maribo MA943	3.59	5.20	3.58	3.97	4.79	4.08	4.28	--	--	--	--	1
	502	Maribo MA944	3.82	5.23	3.36	4.22	4.81	3.83	4.29	--	--	--	--	1
	554	SV 203	4.72	4.53	4.23	5.22	4.17	4.83	4.74	4.74	4.84	4.75	5.03	3
	522	SV 215	4.37	4.84	4.10	4.83	4.46	4.68	4.66	4.88	--	5.11	--	2
	513	SV 265	4.05	4.49	4.19	4.48	4.13	4.78	4.46	4.38	4.44	4.30	4.55	7
	532	SV 285	4.62	4.74	4.10	5.11	4.36	4.68	4.72	4.75	4.66	4.78	4.50	5
	546	SV 321	4.18	4.96	3.84	4.62	4.57	4.38	4.52	--	--	--	--	1
	549	SV 322	3.37	4.46	3.12	3.73	4.11	3.56	3.80	--	--	--	--	1
	534	SV 324	5.22	5.16	4.49	5.77	4.75	5.12	5.22	--	--	--	--	1

Table 24.

2022 Cercospora Ratings for Official Trial Entries

Chk	Code	Description	Unadjusted Randolph Avg 8 Dates+	Unadjusted BSDF Avg 5 Dates+	Unadjusted Foxhome Avg 4 Dates+	Adjusted to 1982 Basis++ Randolph Avg 8 Dates+	Adjusted BSDF Avg 5 Dates+	Adjusted Foxhome Avg 4 Dates+	2022 3 loc	2 Yr	3 Yr	2021	2020	Trial Yrs $$
	529	SX 1815	4.87	5.07	4.53	5.39	4.67	5.17	5.07	4.93	--	4.78	--	2
	525	SX 1816	4.20	4.73	3.97	4.64	4.35	4.53	4.51	4.57	--	4.63	--	2
	562	SX 1818	4.28	4.75	4.44	4.73	4.37	5.07	4.72	4.79	--	4.86	--	2
	561	SX 1829	3.06	3.92	3.10	3.38	3.61	3.54	3.51	--	--	--	--	1
	506	SX 1898	4.74	4.83	3.92	5.24	4.45	4.47	4.72	4.74	4.74	4.76	4.73	4
1	1101	CR CK#19 CRYS808	4.58	5.81	4.96	5.06	5.35	5.66	5.36	5.25	5.22	5.14	5.17	5
1	1102	CR CK#24 HILL4012RR	4.42	5.41	4.56	4.89	4.98	5.20	5.02	5.07	5.15	5.12	5.30	17
1	1103	CR CK#52 MARI717	4.42	5.00	4.10	4.89	4.60	4.68	4.72	4.75	4.87	4.79	5.11	6
1	1104	CR CK#41 CRYS981RR	5.04	5.97	4.17	5.57	5.50	4.76	5.28	5.11	5.09	4.95	5.04	14
1	1105	CR CK#43 CRYS246RR	4.78	4.68	4.26	5.29	4.31	4.86	4.82	4.90	4.85	4.98	4.74	11
1	1106	CR CK#44 BETA80RR32	5.12	5.64	4.37	5.66	5.19	4.99	5.28	5.17	5.04	5.06	4.80	13
1	1107	CR CK#45 HILL4448RR	4.66	6.14	4.48	5.15	5.65	5.11	5.31	5.28	5.38	5.25	5.59	11
1	1108	CR CK#47 HILL4094RR	3.18	4.85	3.71	3.52	4.47	4.23	4.07	4.19	4.20	4.31	4.22	15
1	1109	CR CK#48 MARI504	4.59	5.08	4.43	5.08	4.68	5.05	4.94	5.02	5.16	5.11	5.43	8
1	1110	CR CK#49 CRYS578RR	4.60	5.33	4.37	5.09	4.91	4.99	4.99	5.03	4.95	5.07	4.78	8
1	1111	CR CK#50 CRYS101RR	4.34	5.40	3.97	4.80	4.97	4.53	4.77	4.57	4.61	4.38	4.68	12
1	1112	CR CK#51 CRYS355RR	3.63	4.78	4.33	4.01	4.40	4.94	4.45	4.66	4.67	4.86	4.71	10
	1113	CR CK MOD SUS #6	4.80	5.68	4.73	5.31	5.23	5.40	5.31	5.29	5.22	5.28	5.07	5
	1114	CR CK MOD RES #4	3.43	4.98	3.89	3.79	4.58	4.44	4.27	4.43	4.51	4.58	4.69	15
	1115	CR CK MOD SUS #7	3.96	4.75	4.07	4.38	4.37	4.64	4.47	4.61	4.56	4.75	4.46	8
	1116	CR CK MOD SUS #8	4.40	5.20	3.93	4.87	4.79	4.48	4.71	4.92	4.86	5.13	4.75	4
	1117	Crystal 684 (Filler)	4.54	4.63	3.68	5.02	4.26	4.20	4.49	4.52	4.49	4.54	4.44	7

		Randolph	BSDF	Foxhome	Randolph Adj	BSDF Adj	Foxhome Adj	2022
12	Check Mean	4.45	5.34	4.31	4.92	4.92	4.92	4.92
	Trial Mean	3.75	4.67	3.61	4.15	4.30	4.12	4.19
	Coeff. of Var. (%)	7.3	6.50	9.0				
	Mean LSD (0.05)	0.36	0.49	0.42				
	Mean LSD (0.01)	0.47	0.65	0.55				
	Sig Mrk	**	**	**				
	Adj Factor				1.10577	0.92064	1.14105	

* Lower numbers indicate better Cercospora resistance (1-Ex,9=Poor).
++ Ratings adjusted to 1982 basis (5.5 equivalent in 1978-81 CR nurseries). Ratings adjusted on the basis of checks. Chk = varieties used to adjust CR readings to 1982 basis. Ratings * (Adj. factor) = Adj Rating.
$$ Trial years indicates how many years the entry has been in the official trials.
+ Average rating based upon multiple rating dates. Ratings in green font indicate good resistance.
Ratings in red font indicate a level of concern.

Created 11/02/2022

Table 25

2022 Rhizoctonia Ratings for OVT Entries

BSDF (Saginaw, MI) - ACSC (Moorhead, MN) - ACSC (NWROC)

Chk			Unadjusted				Adjusted @									
@	Code	Description	BSDF 8/11	TSC-E 10/6	TSC-W NA	NWROC 8/9	BSDF 8/11	TSC-E 10/6	TSC-W NA	NWROC 8/9	2022	2 Yr	3 Yr	2021	2020	Years
	524	BTS 8018	4.40	3.50		3.42	3.76	4.05		3.98	3.93	3.88	3.97	3.83	4.16	3
	567	BTS 8034	5.13	4.18		3.64	4.39	4.84		4.24	4.49	4.18	4.31	3.88	4.56	3
	533	BTS 8073	4.78	3.89		3.47	4.09	4.50		4.04	4.21	3.94	4.00	3.67	4.11	3
	511	BTS 8092	4.56	2.97		2.92	3.90	3.44		3.40	3.58	3.70	3.73	3.81	3.81	3
	527	BTS 8100	4.82	2.79		3.29	4.12	3.23		3.83	3.73	3.41	--	3.09	--	2
	526	BTS 8133	4.36	2.56		3.11	3.73	2.96		3.62	3.44	3.65	--	3.87	--	2
	555	BTS 8156	4.91	3.64		3.69	4.20	4.21		4.30	4.24	4.02	--	3.81	--	2
	501	BTS 8205	4.90	3.03		3.23	4.19	3.51		3.76	3.82	--	--	--	--	1
	508	BTS 8217	4.51	3.87		3.51	3.86	4.48		4.09	4.14	--	--	--	--	1
	542	BTS 8226	4.46	3.30		3.08	3.81	3.82		3.59	3.74	--	--	--	--	1
	537	BTS 8242	4.64	3.46		3.46	3.97	4.01		4.03	4.00	--	--	--	--	1
	509	BTS 8248	5.05	3.35		3.39	4.32	3.88		3.95	4.05	--	--	--	--	1
	540	BTS 8270	4.94	3.96		3.59	4.22	4.59		4.18	4.33	--	--	--	--	1
	551	BTS 8299	4.47	3.68		2.85	3.82	4.26		3.32	3.80	--	--	--	--	1
	503	BTS 8629	4.53	2.89		3.38	3.87	3.35		3.94	3.72	3.97	4.08	4.22	4.30	7
	510	BTS 8927	5.14	3.61		3.28	4.40	4.18		3.82	4.13	3.91	4.06	3.68	4.37	4
	557	BTS 8961	4.61	3.01		3.28	3.94	3.49		3.82	3.75	3.75	3.87	3.75	4.11	4
	566	Crystal 021	4.09	3.04		3.19	3.50	3.52		3.71	3.58	3.48	3.61	3.38	3.88	3
	559	Crystal 022	5.10	3.38		3.47	4.36	3.91		4.04	4.10	3.82	3.71	3.53	3.49	3
	563	Crystal 026	4.15	2.78		2.65	3.55	3.22		3.09	3.28	3.31	3.40	3.34	3.57	3
	528	Crystal 130	4.86	3.67		3.29	4.16	4.25		3.83	4.08	3.82	--	3.57	--	2
	543	Crystal 134	4.34	2.86		3.32	3.71	3.31		3.87	3.63	3.53	--	3.44	--	2
	515	Crystal 137	4.58	3.89		3.55	3.92	4.50		4.13	4.18	3.86	--	3.53	--	2
	565	Crystal 138	4.53	3.29		3.23	3.87	3.81		3.76	3.81	3.67	--	3.52	--	2
	553	Crystal 260	4.85	3.08		2.92	4.15	3.57		3.40	3.70	--	--	--	--	1
	505	Crystal 262	3.83	2.82		3.10	3.28	3.27		3.61	3.38	--	--	--	--	1
	552	Crystal 263	5.14	3.95		3.68	4.40	4.57		4.28	4.42	--	--	--	--	1
	544	Crystal 265	4.35	3.09		2.62	3.72	3.58		3.05	3.45	--	--	--	--	1
	520	Crystal 267	4.73	3.44		3.60	4.04	3.98		4.19	4.07	--	--	--	--	1
	548	Crystal 269	4.66	3.75		3.66	3.98	4.34		4.26	4.20	--	--	--	--	1
	516	Crystal 572	5.31	3.60		3.56	4.54	4.17		4.14	4.28	4.08	4.13	3.88	4.21	8
	539	Crystal 684	4.98	3.76		3.54	4.26	4.35		4.12	4.24	4.03	4.07	3.82	4.15	7
	558	Crystal 793	4.84	4.43		4.22	4.14	5.13		4.91	4.73	4.55	4.64	4.36	4.84	6
	530	Crystal 912	4.13	2.66		2.78	3.53	3.08		3.24	3.28	3.53	3.53	3.77	3.54	4
	564	Crystal 913	4.50	4.06		3.56	3.85	4.70		4.14	4.23	4.08	4.25	3.94	4.58	4
	541	Hilleshög HIL2317	4.94	4.58		3.95	4.22	5.30		4.60	4.71	4.73	4.81	4.76	4.95	4
	517	Hilleshög HIL2320	4.64	3.56		3.06	3.97	4.12		3.56	3.88	3.84	4.11	3.80	4.64	4
	521	Hilleshög HIL2366	4.76	3.43		3.19	4.07	3.97		3.71	3.92	3.95	4.05	3.98	4.24	3
	545	Hilleshög HIL2367	4.87	3.18		3.31	4.16	3.68		3.85	3.90	4.00	4.09	4.10	4.26	3
	560	Hilleshög HIL2368	4.95	2.80		2.50	4.23	3.24		2.91	3.46	3.19	3.30	2.92	3.52	3
	547	Hilleshög HIL2386	4.20	3.06		2.92	3.59	3.54		3.40	3.51	3.85	--	4.20	--	2
	512	Hilleshög HIL2389	4.87	3.33		3.22	4.16	3.86		3.75	3.92	3.96	--	3.99	--	2
	514	Hilleshög HIL2440	5.24	3.26		3.41	4.48	3.77		3.97	4.08	--	--	--	--	1
	538	Hilleshög HIL2441	4.19	3.18		3.08	3.58	3.68		3.59	3.62	--	--	--	--	1
	507	Hilleshög HIL2442	4.82	3.08		2.92	4.12	3.57		3.40	3.70	--	--	--	--	1
	518	Hilleshög HIL2443	4.57	4.02		3.60	3.91	4.65		4.19	4.25	--	--	--	--	1
	504	Hilleshög HIL9708	4.72	3.52		2.76	4.04	4.08		3.21	3.78	3.78	3.80	3.78	3.83	8
	519	Hilleshög HIL9920	4.83	4.26		4.02	4.13	4.93		4.68	4.58	4.64	4.80	4.70	5.12	6
	535	Hilleshög HM9528RR	4.59	3.64		3.34	3.92	4.21		3.89	4.01	4.24	4.35	4.47	4.57	9
	536	Maribo MA717	4.47	3.57		3.28	3.82	4.13		3.82	3.92	4.12	4.28	4.31	4.61	6
	531	Maribo MA902	4.72	2.84		2.92	4.04	3.29		3.40	3.57	3.69	3.77	3.80	3.93	4
	523	Maribo MA932	3.90	3.58		3.24	3.33	4.15		3.77	3.75	3.89	--	4.03	--	2
	550	Maribo MA942	4.85	3.57		3.67	4.15	4.13		4.27	4.18	--	--	--	--	1
	556	Maribo MA943	5.00	3.36		3.40	4.28	3.89		3.96	4.04	--	--	--	--	1
	502	Maribo MA944	4.47	3.41		3.45	3.82	3.95		4.02	3.93	--	--	--	--	1
	554	SV 203	4.63	3.87		3.54	3.96	4.48		4.12	4.19	4.26	4.27	4.34	4.29	3
	522	SV 215	4.79	3.85		3.47	4.10	4.46		4.04	4.20	3.99	--	3.79	--	2
	513	SV 265	4.85	3.18		3.47	4.15	3.68		4.04	3.96	4.06	4.11	4.17	4.21	7
	532	SV 285	5.23	4.41		3.45	4.47	5.11		4.02	4.53	4.39	4.27	4.26	4.03	5
	546	SV 321	5.49	3.78		3.77	4.69	4.38		4.39	4.49	--	--	--	--	1
	549	SV 322	5.15	4.27		4.03	4.40	4.94		4.69	4.68	--	--	--	--	1
	534	SV 324	5.10	4.48		3.67	4.36	5.19		4.27	4.61	--	--	--	--	1
	529	SX 1815	4.80	3.69		3.42	4.10	4.27		3.98	4.12	4.26	--	4.40	--	2
	525	SX 1816	5.07	3.82		3.41	4.34	4.42		3.97	4.24	4.17	--	4.09	--	2
	562	SX 1818	4.71	3.79		3.49	4.03	4.39		4.06	4.16	4.28	--	4.41	--	2
	561	SX 1829	4.91	4.14		3.69	4.20	4.79		4.30	4.43	--	--	--	--	1
	506	SX 1898	4.67	3.73		3.47	3.99	4.32		4.04	4.12	4.23	4.21	4.34	4.16	4

2022 Rhizoctonia Ratings for OVT Entries

BSDF (Saginaw, MI) - ACSC (Moorhead, MN) - ACSC (NWROC)

Chk		Unadjusted				Adjusted @									
		BSDF	TSC-E	TSC-W	NWROC	BSDF	TSC-E	TSC-W	NWROC						
@	Code Description	8/11	10/6	NA	8/9	8/11	10/6	NA	8/9	2022	2 Yr	3 Yr	2021	2020	Years
1	1301 RH CK#55 CRYS803	4.76	4.42	4.12		4.07	5.12	4.80		4.66	4.81	4.87	4.96	5.00	5
1	1302 RH CK#21 CRYS768	5.02	3.54	3.96		4.29	4.10	4.61		4.33	4.33	4.39	4.32	4.50	14
1	1303 RH CK#25 HILL4043RR	5.59	4.15	3.89		4.78	4.81	4.53		4.70	4.59	4.69	4.47	4.89	14
1	1304 RH CK#35 SES36812RR	5.08	3.49	3.75		4.34	4.04	4.37		4.25	4.18	4.27	4.11	4.46	15
1	1305 RH CK#58 CRYS793	4.77	4.12	3.96		4.08	4.77	4.61		4.49	4.43	4.56	4.36	4.84	6
1	1306 RH CK#57 BTS8606	5.50	3.62	3.62		4.70	4.19	4.21		4.37	4.43	4.53	4.48	4.75	7
1	1307 RH CK#40 CRYS101	5.43	3.83	4.01		4.64	4.43	4.67		4.58	4.81	4.71	5.04	4.52	12
1	1308 RH CK#56 MARI504	5.00	3.77	3.34		4.28	4.37	3.89		4.18	4.38	4.53	4.58	4.83	8
1	1309 RH CK#47 SES36272RR	5.51	4.45	3.46		4.71	5.15	4.03		4.63	4.36	4.36	4.09	4.36	11
1	1310 RH CK#48 HILL4094RR	4.92	2.71	3.00		4.21	3.14	3.49		3.61	3.42	3.48	3.22	3.61	15
1	1311 RH CK#49 CRYS247	5.01	3.64	3.80		4.28	4.21	4.42		4.31	4.50	4.47	4.70	4.41	11
1	1312 RH CK#51 SXWinchester	5.27	3.99	3.89		4.51	4.62	4.53		4.55	4.46	4.39	4.37	4.25	10
1	1313 RH CK#52 CRYS573	5.03	3.96	4.01		4.30	4.59	4.67		4.52	4.40	4.70	4.29	5.31	8
1	1314 RH CK#53 BTS8500	4.83	3.91	3.88		4.13	4.53	4.52		4.39	4.29	4.32	4.18	4.39	8
1	1315 RH CK#54 CRYS574	5.30	3.28	3.88		4.53	3.80	4.52		4.28	4.18	4.09	4.08	3.92	8
	1316 MOD RHC #10	4.85	4.49	4.07		4.15	5.20	4.74		4.69	4.80	4.86	4.90	5.00	5
	1317 Crystal 684 (Filler)	5.34	3.20	3.48		4.57	3.71	4.05		4.11	3.97	4.03	3.82	4.15	7
15	Mean of Check Varieties	5.13	3.79	3.77		4.39	4.39	4.39							
	Trial Mean	4.80	3.57	3.44		4.10	4.13	4.01							
	Coeff. of Var. (%)	11.7	11.8	10.4											
	Mean LSD (0.05)	0.76	0.62	0.46											
	Mean LSD (0.01)	1.00	0.82	0.60											
	Sig Lvl	**	**	**											
	Adjustment Factor					0.8551	1.1579	1.1643							

@ Ratings adjusted to 2009 basis (2007-2009) RH nurseries. Ratings adjusted on the basis of checks Lower numbers indicate better tolerance (0=Ex, 7=Poor).

Rhizoctonia Specialty Approval criteria is based upon a 3.82 as of 2022. TSC-W- Ratings not used due to poor stand.

Ratings in green font indicate good resistance. Ratings in red font indicate a level of concern.

Table 26.
2022 Fusarium Ratings for Official Trial Entries ACSC (North Moorhead, MN) - ACSC (Sabin, MN)

Chk @	Code	Description	Unadjusted N Mhd 4Dates+	Unadjusted Sab 4Dates+	Adjusted N Mhd 4Dates+	Adjusted Sab 4Dates+	2022	2 Yr	3 Yr	2021	2020	Years
	524	BTS 8018	2.99	3.38	2.79	3.16	2.98	3.10	2.89	3.22	2.47	3
	567	BTS 8034	2.16	2.46	2.02	2.30	2.16	2.43	2.38	2.71	2.26	3
	533	BTS 8073	3.09	3.46	2.89	3.24	3.06	3.35	3.09	3.63	2.58	3
	511	BTS 8092	3.90	4.38	3.64	4.10	3.87	3.97	3.88	4.07	3.70	3
	527	BTS 8100	2.30	2.66	2.15	2.49	2.32	2.56	--	2.80	--	2
	526	BTS 8133	2.97	3.50	2.77	3.27	3.02	3.32	--	3.62	--	2
	555	BTS 8156	2.30	2.62	2.15	2.45	2.30	2.51	--	2.72	--	2
	501	BTS 8205	2.74	3.35	2.56	3.13	2.85	--	--	--	--	1
	508	BTS 8217	2.54	2.90	2.37	2.71	2.54	--	--	--	--	1
	542	BTS 8226	3.57	3.86	3.33	3.61	3.47	--	--	--	--	1
	537	BTS 8242	3.40	3.92	3.18	3.67	3.42	--	--	--	--	1
	509	BTS 8248	3.42	4.18	3.19	3.91	3.55	--	--	--	--	1
	540	BTS 8270	2.98	3.56	2.78	3.33	3.06	--	--	--	--	1
	551	BTS 8299	3.56	4.21	3.32	3.94	3.63	--	--	--	--	1
	503	BTS 8629	3.96	4.50	3.70	4.21	3.95	4.08	3.98	4.21	3.78	7
	510	BTS 8927	3.04	3.62	2.84	3.39	3.11	3.56	3.23	4.00	2.59	4
	557	BTS 8961	2.92	3.27	2.73	3.06	2.89	3.11	2.80	3.33	2.19	4
	566	Crystal 021	3.09	4.16	2.89	3.89	3.39	3.79	3.47	4.18	2.85	3
	559	Crystal 022	3.02	3.86	2.82	3.61	3.22	3.36	3.11	3.50	2.60	3
	563	Crystal 026	3.03	2.99	2.83	2.80	2.81	2.80	2.64	2.79	2.31	3
	528	Crystal 130	3.07	3.81	2.87	3.57	3.22	3.22	--	3.22	--	2
	543	Crystal 134	3.22	4.00	3.01	3.74	3.37	3.74	--	4.11	--	2
	515	Crystal 137	2.43	2.60	2.27	2.43	2.35	2.30	--	2.25	--	2
	565	Crystal 138	3.13	3.62	2.92	3.39	3.16	3.45	--	3.75	--	2
	553	Crystal 260	3.15	3.39	2.94	3.17	3.06	--	--	--	--	1
	505	Crystal 262	3.25	3.74	3.04	3.50	3.27	--	--	--	--	1
	552	Crystal 263	3.35	4.58	3.13	4.29	3.71	--	--	--	--	1
	544	Crystal 265	4.05	3.64	3.78	3.41	3.59	--	--	--	--	1
	520	Crystal 267	2.31	2.48	2.16	2.32	2.24	--	--	--	--	1
	548	Crystal 269	2.87	4.32	2.68	4.04	3.36	--	--	--	--	1
	516	Crystal 572	2.48	3.69	2.32	3.45	2.88	3.11	2.86	3.34	2.36	8
	539	Crystal 684	2.14	2.74	2.00	2.56	2.28	2.52	2.45	2.76	2.32	7
	558	Crystal 793	2.84	3.65	2.65	3.42	3.03	2.92	2.82	2.80	2.61	6
	530	Crystal 912	3.43	4.39	3.20	4.11	3.66	3.88	3.79	4.11	3.61	4
	564	Crystal 913	2.87	3.83	2.68	3.58	3.13	3.40	3.13	3.68	2.59	4
	541	Hilleshög HIL2317	6.10	5.99	5.70	5.60	5.65	5.86	5.89	6.06	5.97	4
	517	Hilleshög HIL2320	4.96	5.17	4.63	4.84	4.73	4.62	4.60	4.50	4.56	4
	521	Hilleshög HIL2366	5.04	5.29	4.71	4.95	4.83	4.74	4.68	4.65	4.55	3
	545	Hilleshög HIL2367	3.95	5.03	3.69	4.71	4.20	4.23	4.30	4.27	4.44	3
	560	Hilleshög HIL2368	4.47	4.80	4.17	4.49	4.33	4.39	4.21	4.44	3.86	3
	547	Hilleshög HIL2386	3.45	4.53	3.22	4.24	3.73	3.99	--	4.26	--	2
	512	Hilleshög HIL2389	4.47	4.81	4.17	4.50	4.34	4.54	--	4.75	--	2
	514	Hilleshög HIL2440	3.78	4.26	3.53	3.99	3.76	--	--	--	--	1
	538	Hilleshög HIL2441	3.97	4.59	3.71	4.29	4.00	--	--	--	--	1
	507	Hilleshög HIL2442	4.92	5.09	4.59	4.76	4.68	--	--	--	--	1
	518	Hilleshög HIL2443	3.17	3.49	2.96	3.27	3.11	--	--	--	--	1
	504	Hilleshög HIL9708	3.75	4.44	3.50	4.15	3.83	4.29	4.08	4.76	3.64	8
	519	Hilleshög HIL9920	6.00	6.11	5.60	5.72	5.66	5.56	5.80	5.45	6.28	6
	535	Hilleshög HM9528RR	4.55	5.71	4.25	5.34	4.80	4.85	4.80	4.91	4.68	9
	536	Maribo MA717	5.40	5.03	5.04	4.71	4.87	4.99	4.87	5.11	4.62	6
	531	Maribo MA902	4.54	4.67	4.24	4.37	4.30	4.40	4.27	4.50	4.01	4
	523	Maribo MA932	3.99	5.04	3.73	4.72	4.22	4.13	--	4.05	--	2
	550	Maribo MA942	4.95	5.77	4.62	5.40	5.01	--	--	--	--	1
	556	Maribo MA943	4.59	4.36	4.29	4.08	4.18	--	--	--	--	1
	502	Maribo MA944	5.26	5.39	4.91	5.04	4.98	--	--	--	--	1

2022 Fusarium Ratings for Official Trial Entries ACSC (North Moorhead, MN) - ACSC (Sabin, MN)

			Unadjusted		Adjusted							
Chk @	Code	Description	N Mhd 4Dates+	Sab 4Dates+	N Mhd 4Dates+	Sab 4Dates+	2022	2 Yr	3 Yr	2021	2020	Years
	554	SV 203	5.89	5.99	5.50	5.60	5.55	5.77	5.60	5.99	5.26	3
	522	SV 215	5.29	5.05	4.94	4.73	4.83	4.81	--	4.79	--	2
	513	SV 265	6.11	6.90	5.71	6.46	6.08	5.87	5.81	5.65	5.70	7
	532	SV 285	5.73	5.98	5.35	5.60	5.47	5.87	5.71	6.26	5.40	5
	546	SV 321	4.19	4.82	3.91	4.51	4.21	--	--	--	--	1
	549	SV 322	4.37	4.46	4.08	4.17	4.13	--	--	--	--	1
	534	SV 324	4.41	5.32	4.12	4.98	4.55	--	--	--	--	1
	529	SX 1815	5.61	5.78	5.24	5.41	5.32	5.07	--	4.82	--	2
	525	SX 1816	3.91	4.39	3.65	4.11	3.88	4.13	--	4.37	--	2
	562	SX 1818	4.61	5.10	4.31	4.77	4.54	4.90	--	5.26	--	2
	561	SX 1829	3.81	4.10	3.56	3.84	3.70	--	--	--	--	1
	506	SX 1898	5.86	5.65	5.47	5.29	5.38	5.53	5.49	5.67	5.41	4
1	1201	FS CK #8 HILL4000RR	7.04	6.43	6.57	6.02	6.30	6.10	6.22	5.90	6.48	15
1	1202	FS CK #34 SES265	6.00	5.96	5.60	5.58	5.59	5.80	5.77	6.02	5.70	7
1	1203	FS CK #12 HILL4012RR	7.14	6.50	6.67	6.08	6.38	6.30	6.35	6.23	6.45	17
1	1204	FS CK #13 HILL4043RR	6.20	6.13	5.79	5.74	5.76	5.67	5.50	5.58	5.16	16
1	1205	FS CK #18 CRYS768RR	4.55	5.00	4.25	4.68	4.46	4.17	4.18	3.87	4.21	14
1	1206	FS CK #33 SES375	5.59	6.02	5.22	5.63	5.43	5.74	5.58	6.05	5.25	6
1	1207	FS CK #29 CRYS875RR	5.30	4.95	4.95	4.63	4.79	4.63	4.70	4.48	4.84	15
1	1208	FS CK #30 BTS8337	4.03	4.37	3.76	4.09	3.93	3.73	3.69	3.53	3.60	10
1	1209	FS CK #31 SXMarathon	5.43	5.29	5.07	4.95	5.01	5.37	5.34	5.72	5.30	8
1	1210	FS CK #32 CRYS574	2.31	2.84	2.16	2.66	2.41	2.54	2.52	2.67	2.48	8
	1211	FS CK SUS RR #11	5.83	5.67	5.44	5.31	5.38	5.41	5.42	5.45	5.45	10
	1212	FS CK MOD RR SUS #2	5.77	5.61	5.39	5.25	5.32	5.58	5.31	5.83	4.77	10
	1213	Crystal 684 (Filler)	2.21	2.81	2.06	2.63	2.35	2.55	2.47	2.76	2.32	7
10		Check Mean	5.36	5.35	5.00	5.01	5.00					
		Trial Mean	4.05	4.45	3.78	4.16	3.97					
		Coeff. of Var. (%)	10.9	9.2								
		Mean LSD (0.05)	0.54	0.56								
		Mean LSD (0.01)	0.71	0.74								
		Sig Mrk	**	**								
		Adj Factor			0.9339	0.9357						

@ Ratings adjusted to 2007 basis. (2005-2006 FS Nurseries). Ratings adjusted on the basis of checks.

+ Average rating based upon multiple rating dates. Lower numbers indicate better tolerance (1=Ex, 9=Poor). Ratings in green font indicate good resistance.

Ratings in red font indicate a level of concern.

Table 27. Pesticides Applied to ACSC Official Trials

	Herbicide			Fungicide		
Location	**Herbicide & Rate**	**Spray Dates**	**Method**	**Fungicide Used**	**Spray Dates**	**Method**
Casselton	RU1, RU1	6/17, 7/13	Ground	CR1, CR2, CR3, CR4	7/21, 8/3, 8/17, 8/30	Ground
Averill	RU1, RU1	6/15, 7/13	Ground	CR1, CR2, CR3, CR4	7/21, 8/3, 8/17, 8/30	Ground
Ada	RU1, RU1	6/17, 7/13	Ground	See below*	5-spray program	Air
Grand Forks	RU1, RU1	6/17, 7/13	Ground	CR1, CR2, CR3, CR4	7/22, 8/4, 8/17, 8/31	Ground
Scandia	RU1, RU1	6/22, 7/13	Ground	CR1, CR2, CR3, CR4	7/22, 8/4, 8/17, 9/7	Ground
Alvarado	RU1, RU1	6/22, 7/18	Ground	CR1, CR2, CR3, CR4	7/29, 8/11, 8/23, 8/31	Ground
St Thomas	RU1, RU1	6/22, 7/18	Ground	CR1, CR2, CR3, CR4	7/28, 8/11, 8/23, 9/2	Ground
Hallock	RU1, RU1	6/22, 7/18	Ground	CR1, CR2, CR3, CR4	7/29, 8/11, 8/23, 8/31	Ground
Bathgate	RU1, RU1	6/22, 7/18	Ground	CR1, CR2, CR3, CR4	7/29, 8/11, 8/23, 8/31	Ground

Ground applications made by beet seed personnel from Crystal Technical Services Center.

Created 12/15/2022

RU1 = Roundup Powermax 3(26 oz./A), Event (1 gal./100 gal water).

CR1=Insir

e XT + Manzate Max Counter 20G applied at 8.9 lbs./A at all locations.

CR2=Agrit

in + Incognito AZteroid in-furrow (5.7 fl oz/A) was used at all locations.

CR3=Proli

ne+Manzate Max Quadris (14 fl oz/A) was applied to 4-8 leaf beets at all locations

CR4=Pria

xor + Agritin

* Ada site Cercospora fungicides applied by air with grower's field:

Inspire XT + Penncozeb, Super Tin + Talaris, Proline + Penncozeb, Penncozeb, Headline + Super Tin