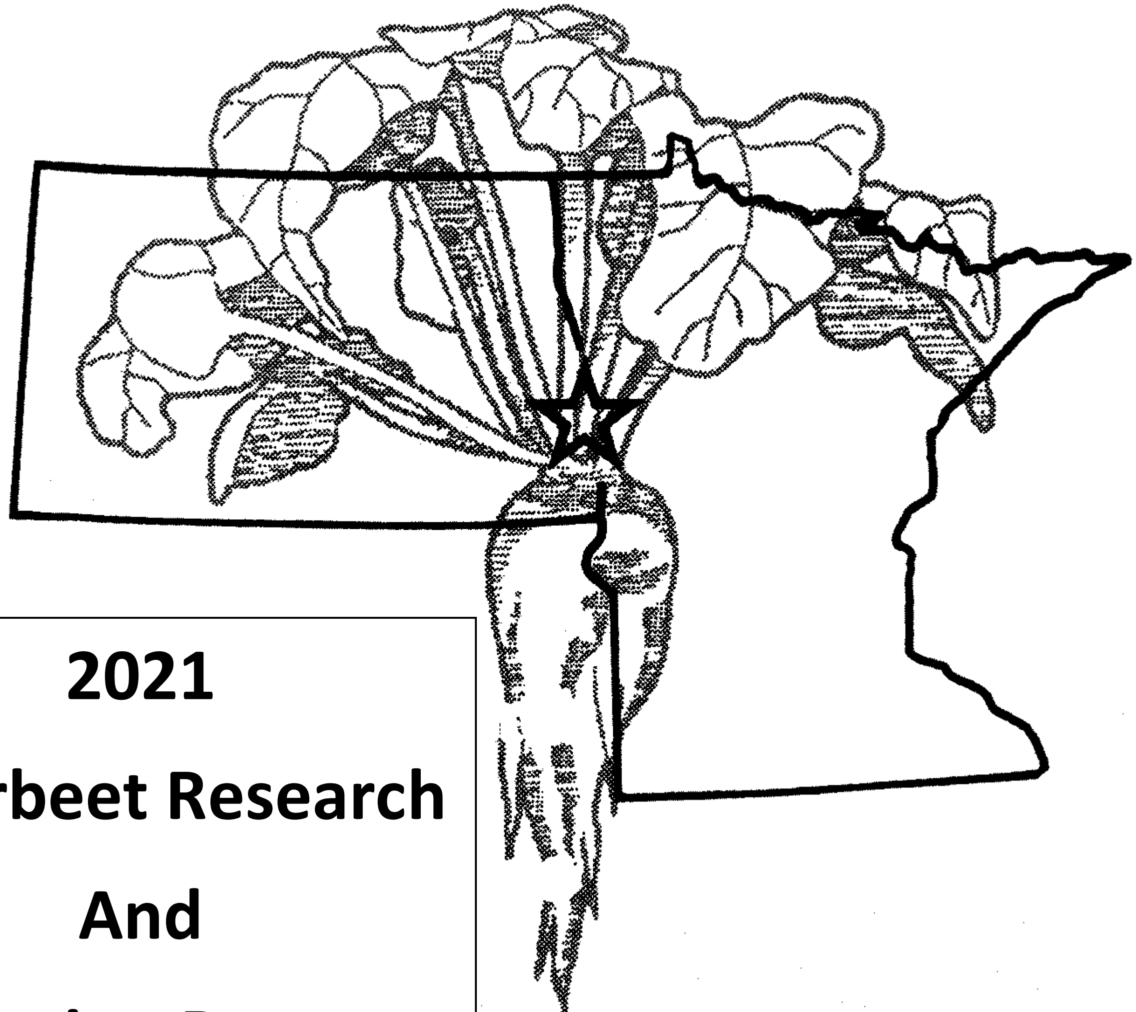
Volume 52 August 2022



2021 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 The contents of this booklet are not for publication or reprint without permission of the individual author.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

ENTOMOLOGY

PLANT PATHOLOGY

SUGARBEET VARIETIES/QUALITY TESTING

WEED CONTROL

NOTES

OUR EXPERIENCES WITH COVER CROPS

Thomas J. Peters[1]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist
North Dakota State University and the University of Minnesota, Fargo, ND

Cover crops protect soils and plants against wind erosion. Producers using spring seeded cover crops are considering fall seeded cover crops to extend the window of protection against wind erosion in winter and early spring. Is it too dry to seed cover crops in fall 2021? Why consider fall seeded vs. spring seeded cover crops?

Key Points
Fall seeded cover crops protect against soil erosion caused by high winds in winter and early spring.
Cover crops may not germinate until rainfall when seeded into dry soil conditions and may not become established in the fall.
At this time, seeding rate should target protection from wind and water erosion and not waterhemp suppression.

Introduction
Producers in American Crystal Sugar Coop, Minn-Dak Farmers Coop and Southern Minnesota Beet Sugar Coop used spring seeded cover crops as a companion crop with sugarbeet on 49% of the sugarbeet acreage in 2015, according to results from the annual growers' survey of weed control and production practices (2016 Sugarbeet Research and Extension Reports, 47:7-17). Producers seed cover crops to protect sugarbeet from high winds or blowing soil. Cover crops, especially fall seeded cover crops, may also suppress waterhemp. Researchers at the University of Missouri reported fall seeded cereal rye suppresses waterhemp germination and emergence by 97% when cereal rye was terminated before stem elongation compared with no cover crop.

Our Current Knowledge of Spring and Fall Seeded Cover Crops
Much of our experience is with spring seeded cover crops. Barley, oat, and spring wheat were broadcast at 36, 32, and 45 lb/A and incorporated into the soil before sugarbeet planting in 2015 and 2016. However, cover crops need to be carefully managed after emergence at these seeding rates. Sugarbeet cooperative agriculturalists recommend terminating cover crops when sugarbeet are at the 2 to 4-leaf stage. Extension sugarbeet research supports their recommendation, especially considering time allotment for postemergence herbicide to kill cover crop (Table 1). Additionally, cover crop species are actively growing during spring weather conditions and create a mat of high albedo reflection that rob heat units from slower growing sugarbeet seedlings. Cover crops also create a very heavy below ground root mass, analogous to an 'iceberg' in ocean waters, that is competing with the sugarbeet plant for moisture and nutrients. Finally, cover crops will continue to protect sugarbeet seedlings from wind or blowing soil even after they have been terminated with herbicide. That is, the carcasses from dead cereal grasses will protect the sugarbeet seedling several weeks or until the sugarbeet plant is able to withstand wind and blowing soil.

Table 1. Sugarbeet yield, percent sucrose, and extractable sucrose in response to spring wheat timing of removal, Prosper, ND, 2015[a].

Sugarbeet stage at wheat termination	Wheat Height at Termination	Wheat Growth Stage	Yield	Sugar	Extractable Sucrose
no. of leaves	inches	NA	ton/A	%	lb/A
No Cover Crop	n/a		35.3 ab	17.0	11,051 ab
2	2	3	36.0 a	16.9	11,253 a
3	4	3	36.6 a	16.5	11,173 ab
4	6	4-5 (tillering)	35.5 ab	16.8	10,929 abc
5	8	Jointing	33.8 b	16.7	10,373 c
6	10-12	Jointing	34.0 b	16.9	10,644 bc
LSD (0.10)			1.6	NS	542
CV			5	3	6

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.

Spring environmental conditions often dictate timing for cover crop establishment. Unfortunately, there are seasons when wind events occur before cover crop establishment. Thus, spring seeded cover crops is often a compromise between seeding rates, to rapidly establish ground cover, and termination date, to prevent interference and sugarbeet yield loss.

Stordahl and Dexter evaluated fall seeded cereal rye to reduce soil movement and to protect sugarbeet from wind from 1990 to 1992 at NDSU. Sugarbeet yield and quality was greatest when glyphosate was banded over the row at sugarbeet planting and when cereal rye seeded at 7.5 to 22.5 lb/A was terminated within three weeks of sugarbeet planting. More recently, fall seeded cover crops have been considered for weed suppression. Cereal rye at 50 lb/A suppressed hairy nightshade, common lambsquarters, and redroot pigweed better than winter wheat at 60 lb/A but weed suppression was confounded by incomplete cover crop burndown control in some treatments (Table 2).

Table 2. Visual weed suppression in response to cereal rye or winter wheat stubble, by cover crop termination date, Prosper, ND, 2017[a].

Termination date	Cereal rye	Winter wheat
	%	%
April 17	91 a	39 c
April 21	96 a	51 c
April 25	93 a	71 b
Mean	93 a	54 b
No Cover Crop	55 b	54 b
LSD (0.05)	**18**	**18**

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.

However, seeding rates were too great. Cereal rye and winter wheat at 20, 40, and 80 lb/A, terminated at flag leaf emergence, reduced sugarbeet stand and biomass compared to sugarbeet planted without cover crop at Hickson and Moorhead in 2021 (data not presented).

Field Selection, Operations and Cover Crop Designs

I can think of at least three different scenarios where fall cover crops might shelter soils against losses caused by wind. I categorize them as follows:

- Cover crop after small grains and before sugarbeet.
- Cover crop after corn or soybean and before sugarbeet.
- Cover crop seeded between preharvest sugarbeet cut-outs and headlands and following sugarbeet.

At this point, we have the most knowledge and experience when cover crops follow small grains and proceed sugarbeet, mostly due to timing of small grains harvest, although we encourage producers to seed sugarbeet cut-outs and headlands to prevent blowing in sugarbeet stubble. Field preparation is conducted at the discretion of the producer. Most producers use two or three tillage operations. Fertilizer (NPK) is applied according to soil test, usually before the final tillage pass. A word of caution, tillage to level fields and prepare the seedbed is conducted with fall tillage. Spring tillage, after fall seeded cover crops, loosens soil for plant but usually is not designed to level fields or prepare the seedbed.

What type cover crop should I seed and how confident are you cover crop will germinate and emerge in these dry 2021 fall conditions? Cereal rye is seeded between 3 and 15 pound per acre. Cereal rye is a drought-tolerant small grain species so it should establish under dry soil conditions. If dry conditions prevent germination after seeding, cereal rye seed will remain viable and germinate later once there is adequate moisture. Seeding in late August to mid-September is preferred for cereal rye, although cereal rye should have enough fall growth to survive the winter and continue to grow next spring, if seeded before October 1. Winter wheat is rarely used for fall seeding by growers although we have had good success with winter wheat as a fall seeded cover crop in my research.

Consider herbicide rotation restrictions since our dry weather conditions likely reduced microbial degradation of soil residual herbicides. Iowa State University and the University of Wisconsin (www.ipcm.wisc.edu/download/pubsPM/2019_RotationalRestrictions_final.pdf) publish guidelines for herbicide rotational restrictions for cover crops under their environmental conditions but local conditions will influence microbial breakdown of soil residual herbicides and supersede recommendations in these regional publications.

I am aware of at least three techniques producers have used to apply cover crops in small grains stubble. They are:
Broadcast cover crop seed uniformly across fields
Broadcast cover crops in strips at intervals across fields
Seed cover crops in rows between sugarbeet

Many producers broadcast cover crop with fall fertilizers or drill cover crop with an air seeder or planter. Cover crop usually is seeded less than 15 lb/A depending on broadcast technique. Probably the easiest way to seed cover crops is to add with fall fertilizer and have your ag-retailer broadcast with a floater (Figure 1). However, be certain your ag-retailer adequately mixes the seed and fertilizer before field application.

Figure 1. Cereal rye broadcast at 15 lb/A with fertilizer

Use a harrow packer to lightly till the field in spring before sugarbeet planting. A producer applied ethofumesate (Nortron, Ethotron, Willowood 4SC) over cover cereal rye in spring 2021 and used the harrow packer to lightly incorporate ethofumesate into the soil to finalize the seed bed for sugarbeet planting. Ethofumesate will not injure emerged cover crops.

Fall seeded cover crop broadcast across the field can create clumps that may affect sugarbeet seeding depth and uniformity of stands, especially when high speed planters are used to seed sugarbeet. An adaptation to reduce exposure is to broadcast cover crops in strips at intervals in fields (Figure 2). The distance between intervals is at the discretion of the producer. Those using this technique suggest strips should be seeded from 60 to 100 feet apart.


Figure 2. Cover crop broadcast in strips at 80ft intervals across the field in 2020.

In spring, a supercoulter was used to loosen soil before planting sugarbeet diagonally across the field. Planting configuration was designed to protect against wind exposure and to reduce planter ‘bounce’ during sugarbeet plant (Figure 3).


Figure 3. Sugarbeet planted diagonally across fall seeded cover crop.

Fall seeded cover crop was planted with the sugarbeet planter at approximately 3 lb/A (60,000 seeds per acre) using the sugarbeet plates and planter after fall tillage and fertilizer application. In the spring, field was prepared for sugarbeet planting using a super coulter after ethofumesate application. Finally, sugarbeet were seeded between cover crop rows (Figure 4).

Cover Crop Termination
Actively manage fall seeded cover crops, especially cereal rye, since they grow very quickly during our spring conditions. Cover crops extract excess moisture from the soils in a wet year but also extract much needed moisture from soils in a dry year, which affected sugarbeet germination and emergence in 2021 (Figure 5). Producers need to carefully manage cover crop growth and terminate cover crops in a timely manner. In 2021, most cover crops were terminated before they were 12-inch tall.

Actively managing the cover crops is especially important for producers that broadcast cover crop seed since some seed will be near sugarbeet. We suggest banding glyphosate or perhaps glyphosate plus ethofumesate over the sugarbeet row to ensure cover crop does not interfere with sugarbeet growth and development.

Cover crops were terminated with glyphosate at 28 to 32 fl oz/A alone or in tank-mixures in May, 2021 (Figure 6). Glyphosate provided slow and less than effective control of cover crop in research conducted in 2017 near Amenia, ND. However, the objective of the 2017 experiment was to terminate cover crops before planting resulting in air temperature ranging from 48 to 62F when the glyphosate application was made.

Figure 4. Sugarbeet seeded between cover crop rows in spring 2021.

Figure 5. Cover crops extract moisture from the soil, opening the seed furrow after plant, Hickson, ND 2021.


Figure 6. Sugarbeet after cover crop termination.

A snowfall event occurred after application with one application timing. Glyphosate efficacy is best when daytime air temperatures are in the 60s or greater and night time temperatures are above freezing. That stated, using full glyphosate rates for control of cover crop is critical.

Conclusions and Recommendations
Fall seeded cover crops are an excellent technique to reduce winter erosion, especially in fields with fall tillage in preparation for 2022 sugarbeet planting. Fall seeded cover crops have been successfully established using several different techniques by producers. We recommend either winter wheat or cereal rye planted in late August to mid-September at less than 15 lb/A seeding rate. I realize many producers might consider cover crops seeded after corn or soybean harvest in late September in west central and possibly, southern Minnesota? I think in many years we would be okay with plantings at these calendar dates.

At this point, we do not recommend planting cover crops at greater seeding rates to suppress spring emerging waterhemp since the system has not been optimized. Cover crop must be actively managed in the spring as they will extract moisture from the soil, especially in dry environments. We recommend terminating cover crops in the spring using glyphosate at full rates before they reach 12-inch height. However, spring conditions will dictate actual termination date.

SUGARBEET TOLERANCE FOLLOWING HERBICES FOR WATERHEMP CONTROL IN SMALL GRAIN STUBBLE

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

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

Summary

Introduction
Small grains are effective crops to control waterhemp since they become established before waterhemp germination and emergence. However, waterhemp may begin to grow and produce seed following small grain harvest in late July and August.

Postemergence herbicides were applied alone or in mixtures for waterhemp control in wheat stubble in 2020. Sharpen and Valor (PPO inhibitors, group 14) require 4-month rotation restriction to sugarbeet (4-month unfrozen ground) and 4-month rotation restriction and tillage, respectively, to sugarbeet. Valor can carry over to sugarbeet planted in sequence with soybean, especially when soybean is planted in late May or June or in course textured soils or soils with low organic matter. A rotational crop experiment was seeded in 2021 to determine if fall-applied Valor or Sharpen injured sugarbeet planted the following May.

Objective
The objective of this experiment was to evaluate sugarbeet tolerance following fall-applied herbicides to control waterhemp in small grain stubble.

Material and Methods
2020
An experiment was conducted in wheat stubble on natural waterhemp populations near Moorhead, MN in 2020. Experimental area consisted of a uniform infestation of waterhemp ranging from newly emerged to 12 inches tall.

Herbicide treatments were applied on August 20 and September 2, 2020 with a bicycle wheel sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 43 psi. The treatment list can be found in Table 1.

Table 1. Herbicide treatments and rates in trial near Moorhead, MN in fall of 2020.

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

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

Fall chisel plow tillage was done parallel with fall applied treatments so that herbicide would not be carried across plots. The corners of the experimental area were marked so that plots could be located again in 2021.

2021
The experimental area was prepared for planting by applying the appropriate fertilizer. Spring tillage was with a Kongskilde s-tine field cultivator with rolling baskets and was done parallel to 2021 treatments so that soil would not be carried between plots. Sugarbeet was seeded on May 12, 2021 in 22-inch rows at about 62,000 seeds per acre

with 4.6 inch spacing between seeds. Inadequate spring rainfall lead to poor sugarbeet stands. We opted to replant on June 16, 2021 and had excellent stands since planting was timed to moisture both before and after replant.

Sugarbeet stands were counted and sugarbeet visible injury was evaluated 7, 14, and 21 days after planting (DAP). Evaluations were a visual estimate of injury in the four treated rows compared to the adjacent, two-row, untreated strip. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Results
Sugarbeet stand (number of sugarbeet per 100 ft row) were similar across treatments and sugarbeet injury was negligible across treatments and evaluation (Table 2). Sugarbeet stand and injury differences did not relate to fall applied treatments.

Table 2. Percent visual sugarbeet injury by treatment and evaluation date near Moorhead, MN in 2021.

Treatment	Rate	Sugarbeet Stand	Sugarbeet Injury 16 DAP[3]	24 DAP	30 DAP
	--fl oz/A--	Num/100 ft	-------------------%-------------------		
Roundup PowerMax[1]	32	135	0	0	5
Roundup PowerMax + Weedar 64[1]	32 + 64	123	0	0	0
Roundup PowerMax + Sharpen[2]	32 + 1	126	8	8	10
Roundup PowerMax + Sharpen[2]	32 + 2	144	6	5	0
Roundup PowerMax + Sharpen + Valor SX[2]	32 + 1 + 1	134	8	13	10
Roundup PowerMax + Sharpen + Valor SX[2]	32 + 1 + 2	124	5	15	5
Roundup PowerMax / Roundup PowerMax[1]	32 / 32	110	10	10	5
Roundup PowerMax + Weedar 64 / Roundup PowerMax + Weedar 64[1]	32 + 64 / 32 + 64	131	3	0	5
LSD (0.05)			**NS**	**NS**	**NS**

[1]Treatment applied with Prefer 90 NIS at 0.25 % v/v + N-Pak Liquid AMS at 2.5% v/v.
[2]Sharpen and Valor SX applied with methylated seed oil at 1.5 pt/A + N-Pak Liquid AMS at 2.5% v/v.
[3]DAP=Days after planting.

Conclusion
The experiment did not detect carryover from Sharpen or Valor. However, Valor and Sharpen carryover is an interaction depending on soil type and organic matter, herbicide rate, timing between application and sugarbeet plant, and rainfall and temperature conditions. Because of this, occasionally, we observe significant sugarbeet injury, even though none was observed in this study.

SPRING WHEAT TOLERANCE TO ETHOFUMESATE APPLIED THE PREVIOUS YEAR IN SUGARBEET

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

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

Summary

This experiment was a continuation from Experiment 1 described in "Waterhemp Control in 2020" in the 2020 Sugarbeet Research and Extension Reports.

Ethofumesate rate did not influence spring wheat emergence. Spring wheat growth reduction injury was negligible from ethofumesate PRE at 1.5 pt/A to 7.5 pt/A applied the previous season.

Introduction

Ethofumesate is one of our most flexible herbicides in sugarbeet and is used at rates ranging from 0.25 to 7.5 pint per acre for control of pigweed species including waterhemp. A common question from sugarbeet producers relates to the number of weeks of weed control provided by ethofumesate at various rates. For others, questions about ethofumesate safety to spring wheat or barley as a nurse crop are concerns.

Ethofumesate (a group 16 herbicide) binds stronger to soil colloids, is less water soluble, and has a half-life greater than group 15 herbicides used in sugarbeet. Thus, sugarbeet producers have concerns about ethofumesate carryover from sugarbeet to crops in sequence with sugarbeet including spring wheat and corn. Lystad, Peters, and Sprague reported ethofumesate does not injure corn, dry bean, soybean, and wheat when applied at labeled rates 9-, 10- or 11-months before rotation crop planting (Journal of Sugarbeet Research, 2020). Schroeder and Dexter (1978) and Schweizer (1977) reported ethofumesate carryover is greatest under dry environmental conditions or when little or no tillage follows sugarbeet in preparation for wheat.

Objective

Our objectives spanned over two growing seasons. The first objective was to determine how many weeks of waterhemp control can be expected from ethofumesate preemergence (PRE). The second objective determined spring wheat injury from ethofumesate PRE at 1.5 to 7.5 pt/A in 2020.

Material and Methods

2020 Experiment

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

Herbicide treatments were applied PRE after planting with a bicycle wheel sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center 6.67 feet of the 11 by 40 feet long plots. Treatments consisted of one application of ethofumesate at 0, 1.5, 3.0, 4.5, 6.0 and 7.5 pt/A.

Wheat injury and waterhemp control were evaluated visually, beginning approximately twenty-three days after ethofumesate application (DAA). Additional waterhemp control was evaluated 43, 56, and 62 days after planting (DAP) at Moorhead and 36, 44, 58, and 77 DAP at Blomkest. All evaluations were a visual estimate of control in the treated area compared to the adjacent untreated strip. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2020.2 software package.

2021 Experiment
The 2020 experiment was continued near Moorhead, MN in 2021 to determine spring wheat tolerance in the year following PRE ethofumesate application. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage. Spring wheat at 0.75 bu/A was evenly spread throughout the plot area and incorporated with shallow tillage. Tillage was applied in the same direction as the previous herbicide treatments. Experimental area was maintained weed-free to evaluate spring wheat growth.

Evaluations considering the number of days for spring wheat to emerge and visible assessment of wheat safety in the treated area (0% to 100% injury, 0% indicating no wheat injury and 100% indicating complete loss of wheat stand) compared with the adjacent untreated strip were collected 7, 14, and 21 days after wheat emergence. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Results
For results regarding the 2020 experiment, please reference "Waterhemp control in 2020" in the 2020 Sugarbeet Research and Extension Reports. Spring wheat did not immediately germinate and emerge following May planting due to extremely dry conditions. We did not observe spring wheat emergence until mid-June or after June 7 and June 10 when the site received 0.7- and 1.4-inch rainfall, respectively. Ethofumesate rate did not delay emergence and spring wheat injury was negligible (Table 1). A trend of increased ethofumesate rate translated to increased growth reduction; however, the greatest growth reduction measured was 15%.

Table 1. Spring wheat growth reduction in response to ethofumesate rate applied PRE in 2020 at Moorhead, MN in 2021.

Ethofumesate Rate	17 DAE[1]	22 DAE	30 DAE
--pt/A--	-----------------------------% growth reduction--------------------------		
0	0 a	0	0
1.5	0 a	5	0
3	11 ab	10	8
4.5	5 ab	5	0
6	6 ab	8	0
7.5	15 b	13	0
LSD (0.20)	12	NS	NS

[1]DAE=Days after emergence.

Conclusion
Carryover to spring wheat was negligible from ethofumesate application from 1.5 pt/A to 7.5 pt/A to sugarbeet the previous season. There were no differences observed in spring wheat growth by 22 days after emergence.

References

Lystad AL, Peters TJ, Sprague C (2020) Sugarbeet and rotational crop tolerance from Ethofumesate 4SC applied postemergence. Journal of Sugarbeet Research. 57:1-20

Peters TJ, Lystad AL, Mettler D (2020) Waterhemp control in sugarbeet in 2020. 2020 Sugarbeet Research and Extension Reports. 30-37

Schroeder GL and Dexter AG (1978) Weed control and residual effects on wheat and barley with Nortron. Publication of the Department of Agronomy

Schweizer EE (1977) Response of spring cereal crops to soil residues of ethofumesate. Weed Res 17:339-345

WATERHEMP CONTROL FROM SOIL RESIDUAL HERBICIDES IN A DRY SEASON

Thomas J. Peters[1], Alexa L. Lystad[2], and David Mettler[3]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, [2]Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND, and [3]Research Agronomist, Southern Minnesota Beet Sugar Cooperative, Renville, MN

Summary
Shallow incorporation of ethofumesate reduces degradation losses.
Soil residual herbicides control weeds when they are incorporated into the soil solution.
Time application of soil residual herbicides to sugarbeet growth stage rather than rainfall events.
Preemergence (PRE) application followed by a split layby application of soil residual herbicides is our best waterhemp control strategy.
A third postemergence (POST) application of chloroacetamide herbicide tends to improve waterhemp control but causes increased sugarbeet injury.

Introduction
Waterhemp control in sugarbeet is our most important weed management challenge. Waterhemp is both common and troublesome in fields planted to sugarbeet for multiple reasons. First, sugarbeet is botanically related to waterhemp. Sugarbeet is a member of the Betoidae subfamily within Amaranthaceae which includes approximately 2,500 species. Second, waterhemp are small seeded broadleaf weeds, germinating and emerging near the soil surface in response to moisture and light from May through August. Third, waterhemp are prolific seed producers, capable of producing between 50,000 and 250,000 seeds depending on emergence date, plant size, and competition with the surrounding cultivated crop. Fourth, waterhemp has male and female flowers on separate plants (dioecious). That is, male plants produce pollen while female plants make seed. This unique biology creates tremendous genetic diversity in populations and results in plants that are biologically and morphologically unique. Moreover, waterhemp has a remarkable ability to adapt to control tactics and has evolved resistance to herbicides from many different classes. To date, waterhemp has evolved 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). Finally, waterhemp seeds are viable for up to six years in the soil.

The foundation of the waterhemp control program in sugarbeet has been 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.

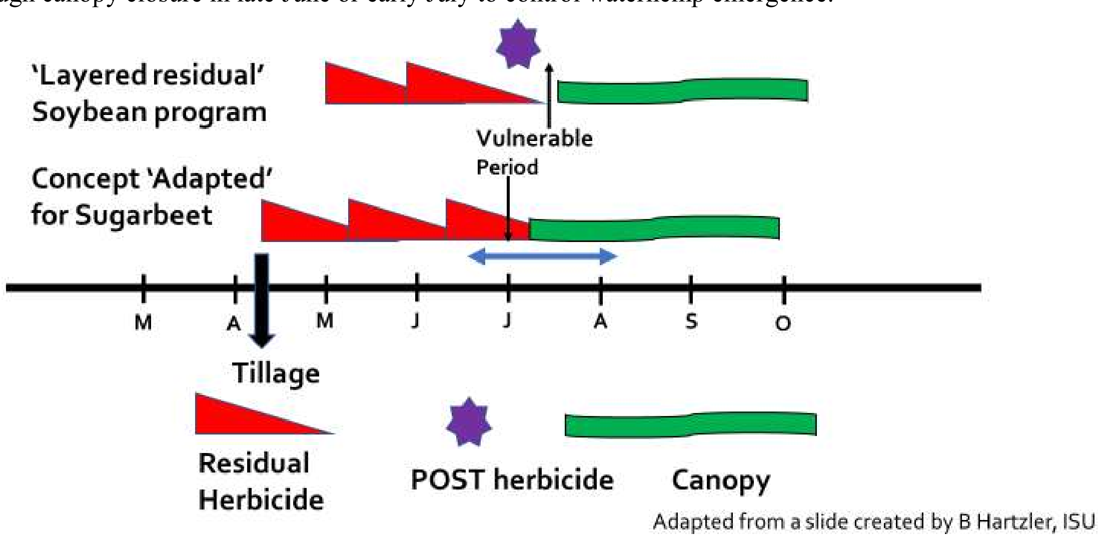


Figure 1. A demonstration of layered soil residual herbicides creating a herbicide barrier in soil from planting through canopy closure.

Our recommendations were developed from experiments conducted in 2014, 2015, and 2016 or seasons when timely rainfall incorporated soil residual herbicide into the soil shortly after application. These trials support a PRE application followed by split lay-by applications (Figure 2). Rainfall has been both localized and sporadic in 2020 and 2021 resulting in early season waterhemp escapes. Further, some producers have questioned if it makes economic sense to apply soil residual herbicides according to sugarbeet growth stage when rain is not in the forecast. Our continued research experiments, specifically 2020 experiments, like producer fields, did not received timely rainfall. The objective of this report is to discuss the performance of herbicides when inadequate activation from rainfall results in the herbicide remaining on the soil surface for days or weeks following application.

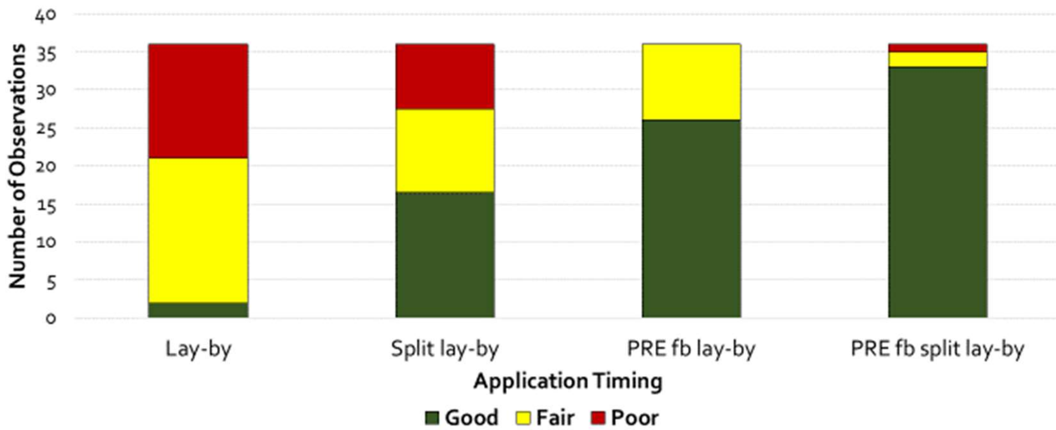


Figure 2. Number of observations with good (greater than 85%), fair (65% to 84%), and poor (less than 64%) waterhemp control in response to herbicide treatment and application timing summed across evaluations and locations, 2014 to 2016.

Materials and Methods

Waterhemp control with ethofumesate

Experiments were conducted near Blomkest and Moorhead, MN in 2020 and near Fargo, ND and Moorhead, MN in 2021. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on April 25 and May 3 at Blomkest and Moorhead, respectively, in 2020 and May 10 and May 12 at Fargo and Moorhead, respectively, in 2021. Sugarbeet was seeded in 22-inch rows at approximately 63,500 seeds per acre with 4.5 inch spacing between seeds. Herbicide treatments for 2020 experiment at Blomkest and Moorhead are found in Table 1 and herbicide treatments for the 2021 experiment at Fargo and Moorhead are found in Table 2.

Table 1. Herbicide treatments and rate, Blomkest and Moorhead, MN, 2020.

Herbicide Treatment	Application Timing	Rate (pt/A)
Untreated Check		0
Ethofumesate	Preemergence	1.5
Ethofumesate	Preemergence	3
Ethofumesate	Preemergence	4.5
Ethofumesate	Preemergence	6
Ethofumesate	Preemergence	7.5

Table 2. Herbicide treatment, application timing, and rate, Fargo, ND and Moorhead, MN, 2021.

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

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 2020 and 2021. Visible waterhemp control (0 to 100% control, 0% indicating no control, and 100% indicating complete control) was collected approximately 14, 28, 42, 56, and 70 days after treatment (DAT). Experimental design was randomized complete block with four replications in 2020 and randomized complete block design with four replications in a factorial treatment arrangement in 2021, with factors being herbicide treatment and application timing. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Waterhemp control with soil residual herbicides applied PRE and POST
Experiments were conducted near Blomkest and Moorhead, MN in 2021. Treatments are listed in Table 3. The experimental area was prepared for planting by fertilizing and conducting tillage across the experimental area. Sugarbeet was planted on May 3 at Blomkest and May 12 at Moorhead in 2021. Sugarbeet was seeded in 22-inch rows at approximately 63,500 seeds per acre with 4.5 inch spacing between seeds. 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.

Table 3. Herbicide treatment, rate, and application timing, Blomkest and Moorhead, MN, 2021.

Herbicide Treatment PRE	Residual Herbicide Treatment POST[a]	Rate (pt/A)	Sugarbeet stage (lvs)
No	Untreated Check		-
No	Warrant	3	2
No	Outlook / Outlook	0.75 / 0.75	2 / 8
No	Warrant / Warrant	3 / 3	2 / 8
No	Outlook / Warrant	0.75 / 3	2 / 8
No	Outlook / Warrant	0.75 / 4	2 / 8
No	Outlook / Warrant / Warrant	0.75 / 3 / 3	2 / 4 / 8
Etho + DM[b]	Untreated Check	2 + 0.5	PRE
Etho + DM	Warrant	2 + 0.5 / 3	PRE / 2
Etho + DM	Outlook / Outlook	2 + 0.5 / 0.75 / 0.75	PRE / 2 / 8
Etho + DM	Warrant / Warrant	2 + 0.5 / 3 / 3	PRE / 2 / 8
Etho + DM	Outlook / Warrant	2 + 0.5 / 0.75 / 3	PRE / 2 / 8
Etho + DM	Outlook / Warrant	2 + 0.5 / 0.75 / 4	PRE / 2 / 8
Etho + DM	Outlook / Warrant / Warrant	2 + 0.5 / 0.75 / 3 / 3	PRE / 2 / 4 / 8
Ethofumesate	Untreated Check	6	PRE
Ethofumesate	Warrant	6 / 3	PRE / 2
Ethofumesate	Outlook / Outlook	6 / 0.75 / 0.75	PRE / 2 / 8
Ethofumesate	Warrant / Warrant	6 / 3 / 3	PRE / 2 / 8
Ethofumesate	Outlook / Warrant	6 / 0.75 / 3	PRE / 2 / 8
Ethofumesate	Outlook / Warrant	6 / 0.75 / 4	PRE / 2 / 8
Ethofumesate	Outlook / Warrant / Warrant	6 / 0.75 / 3 / 3	PRE / 2 / 4 / 8

[a]Roundup PowerMax at 28 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, including untreated check.
[b]Etho + DM = ethofumesate + Dual Magnum

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). Visible waterhemp control was evaluated using a 0 to 100% scale (0% indicating no control and 100% indicating complete weed control) were collected approximately 14, 28, 42, 56, and 70 DAT. 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 2021.2 software package.

Results

Waterhemp control with ethofumesate

Rainfall totals for Blomkest and Moorhead, MN and Fargo, ND from April through August in 2020 and 2021 along with 30-yr averages are presented in Table 4. The number of days between ethofumesate application and the first significant rainfall for incorporating ethofumesate into soil were 1-day at Moorhead in 2020, 21 days at Blomkest in 2020, and 28 days at Fargo in 2021. Data will not be included from Moorhead 2021 due to a combination of extremely dry conditions in May and poor sugarbeet emergence which compromised the quality of the experiment.

Table 4. Monthly rainfall totals in 2020 and 2021 and 30-yr averages, Blomkest and Moorhead, MN and Fargo, ND.[a]

	Blomkest, MN			Fargo, ND			Moorhead, MN		
Month	2020	2021	Avg.[b]	2020	2021	Avg.	2020	2021	Avg.
	---Inch---								
April	1.6	1.8	2.6	4.5	1.5	1.3	5.4	2.3	1.6
May	2.1	1.4	3.1	1.5	0.9	2.8	1.6	0.7	3.2
June	4.9	1.3	4.8	3.5	3.3	4.1	3.8	4.6	4.1
July	3.9	1.7	3.7	5.9	0.9	2.8	5.3	0.9	3.2
August	4.5	5.0	3.8	5.8	3.9	2.6	5.8	3.7	2.7

[a]Data compiled from NOAA, Climate Corp, and/or NDAWN.
[b]Avg. = 30-year average.

Waterhemp control was influenced by ethofumesate rate and number of days after ethofumesate application at Moorhead and Blomkest (Figures 3 and 4). Waterhemp control from up to 7.5 pt/A of ethofumesate was less than 80% at Moorhead in 2020, regardless of receiving 0.6 inches of rain the day after application.

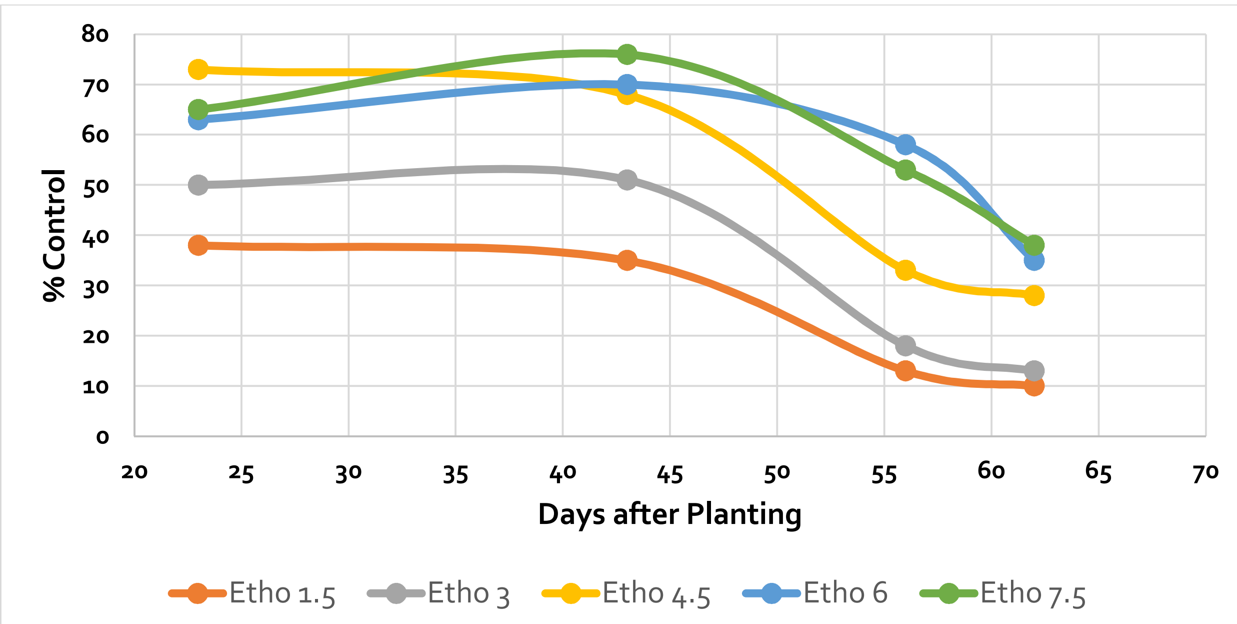


Figure 3. Visible waterhemp control 23 to 63 days after planting (DAP) in response to ethofumesate rate, Moorhead, MN, 2020.

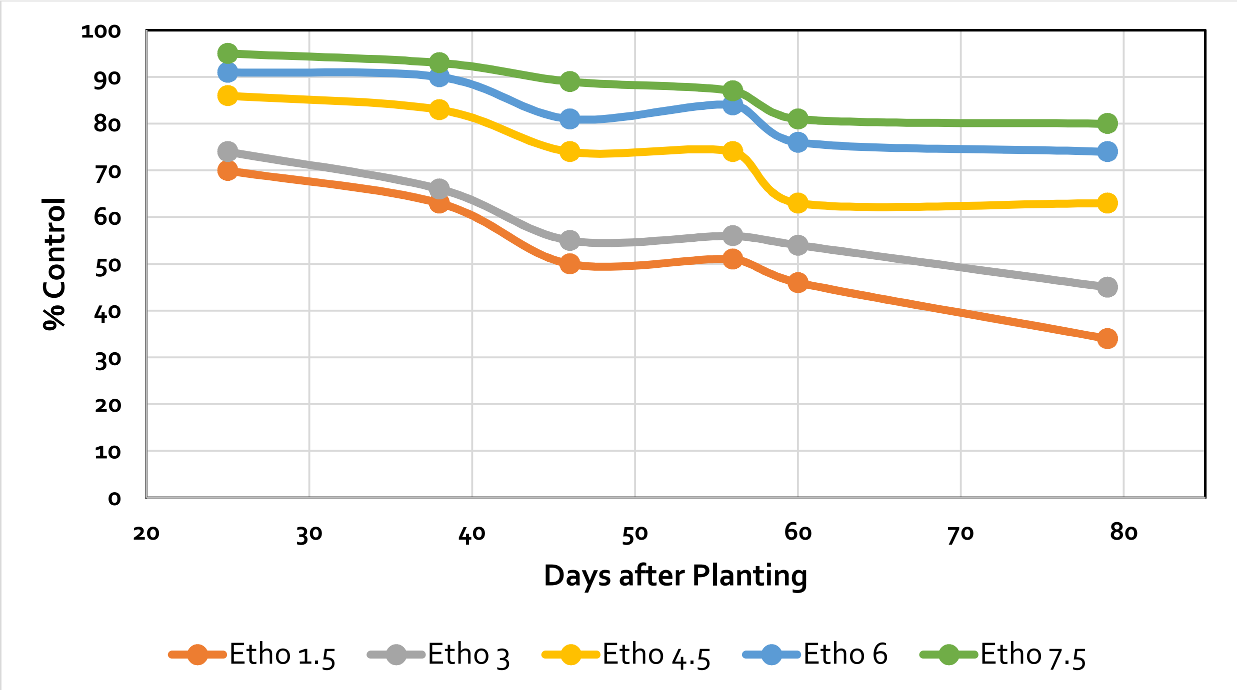


Figure 4. Visible waterhemp control 25 to 80 days after planting (DAP) in response to ethofumesate rate, Blomkest, MN, 2020.

Ethofumesate at 4.5, 6.0, and 7.5 pt/A provided up to 85% waterhemp control at Blomkest. However, ethofumesate at 1.5 and 3 pt/A provided less than 75% control. Waterhemp control results from Moorhead and Blomkest challenges the viability of ethofumesate PRE at 2 pt/A. Sub-lethal rates provide waterhemp control for a short duration or until an application of soil residual herbicides POST can be applied to sugarbeet. These data suggest sub-lethal rates are providing less than full waterhemp control, even for this short duration.

There were challenges in activating ethofumesate at the Fargo location in 2021, even with applying ethofumesate PPI. We observed differences in early and late germinating waterhemp control (Figure 5) based on application method. Ethofumesate applied PRE provided greater waterhemp control on early germinating waterhemp while ethofumesate applied PPI provided greater control on late germinating waterhemp.

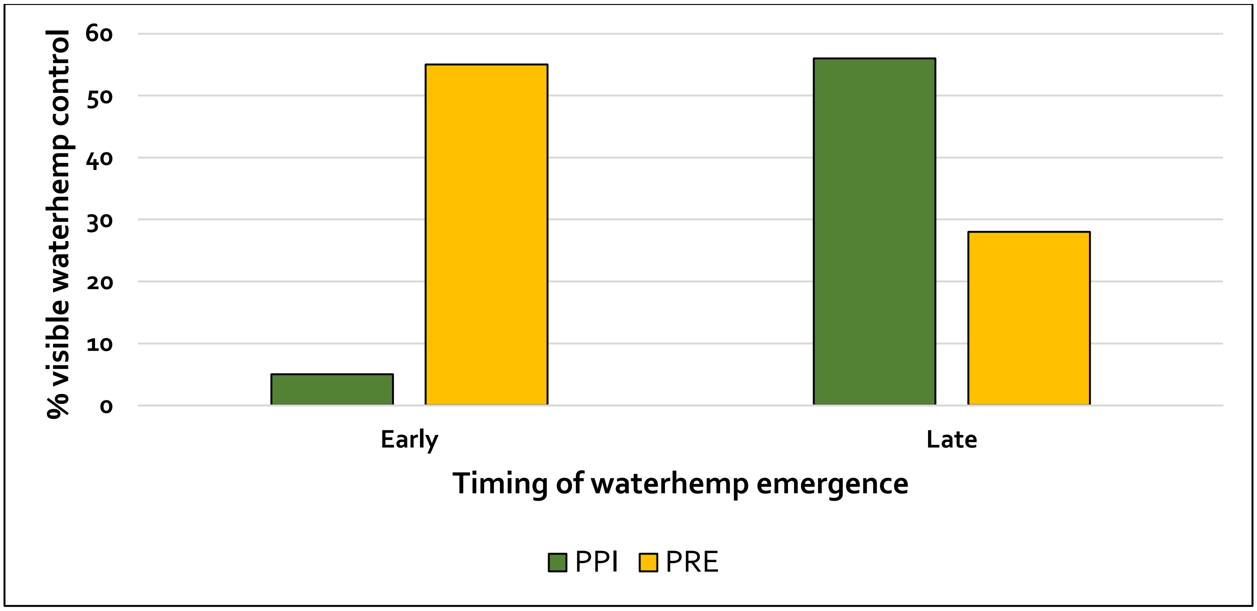


Figure 5. Early and late germinating waterhemp control in response to ethofumesate PPI and PRE, Fargo, 2021.

McAuliffe and Appleby (1984) reported ethofumesate tightly adsorbs to soil colloids and is susceptible to rapid degradation in dry soils. We believe some of the waterhemp control challenges we have observed in both our research and in commercial fields is related to chemical properties of ethofumesate as compared with chloroacetamide herbicides. For example, the ratio of herbicide bound to soil colloids (K_{OC}) versus herbicide in the soil solution is two-fold greater with ethofumesate than dimethenamid-P. In addition, dimethenamid-P water solubility is 10 times greater than ethofumesate. Although ethofumesate was incorporated after application in this study, its concentration was diluted by incorporation and tightly bound to soil colloids rendering it unavailable for waterhemp control. Control of late season waterhemp was improved since ethofumesate desorbed from soil and moved into the soil solution following rainfall events. In this experiment, ethofumesate PRE was partially incorporated into soil solution and made available for seedling uptake as a result of a 0.4-inch rainfall on May 10. The remaining ethofumesate PRE likely degraded and was unavailable for control of late emerging waterhemp, especially at the lower rates.

Waterhemp control with soil residual herbicides applied PRE and POST
A 0.8-inch rain event was measured on May 27 at Blomkest or 16 days after PRE application and 2 days after POST application to sugarbeet at the 2-lf stage (Table 5). A second 0.8-inch rainfall event was measured on June 28, or 18 days after 8-lf stage, 28 days after 4-lf stage, and 34 days after 2-lf stage application. Sugarbeet injury and waterhemp control were evaluated weekly between June 3 and July 15. Data collected June 12, June 25, and July 7 will be considered in this report. PRE treatment did not interact with POST treatment (Table 6). Thus, PRE treatment (no PRE, ethofumesate plus Dual Magnum, or ethofumesate) were averaged across POST treatment.

Sugarbeet visible growth reduction injury was evaluated 18 days after the 2-lf sugarbeet stage application. Sugarbeet injury from Warrant following Warrant or repeat Warrant applications following Outlook injured sugarbeet more than the untreated check treatment (Table 7). In addition, there were more incidents of greater than 30% sugarbeet injury in Warrant followed by Warrant or Outlook followed by Warrant followed by Warrant plots as compared with other POST treatments.

Table 5. Application information, Blomkest, MN 2021.

Date	May 11	May 25	June 1	June 10
Time of Day	9:40 AM	6:50 AM	12:40 PM	8:50 AM
Air Temperature (F)	53	70	73	82
Relative Humidity (%)	26	83	29	55
Wind Velocity (mph)	2	9	0	10
Wind Direction	W	S	-	SW
Soil Temp. (F at 6”)	47	66	67	75
Soil Moisture	Dry	Dry	Dry	Dry
Cloud Cover (%)	0	20	20	50
Sugarbeet Stage	PRE	2-lf	4-lf	8-lf
Waterhemp Height	-	0.5 inch	0.5 inch	1 inch

Table 6. Source of variation and P-values for sugarbeet injury and waterhemp control in response to treatment, Blomkest, MN, 2021.

	Sugarbeet Injury	Waterhemp Control		
Source of Variation	June 12	June 12	June 25	July 7
	--------------------------------*P-Value*----------------------------------			
Preemergence	0.0118	0.0917	0.0001	0.0001
Postemergence	0.0006	0.0001	0.0021	0.0001
Preemergence × Postemergence	0.9281	0.8540	0.6652	0.2340

Table 7. Sugarbeet visible injury, plots with 30% or greater injury, and visible waterhemp control from POST residual treatments averaged across PRE treatment, Blomkest, MN, 2021.[a]

		Sugarbeet Injury		Waterhemp Control		
Soil Residual Treatment POST[b]	Rate	18 DAT[c]		18 DAT[c]	31 DAT[c]	43 DAT[c]
	--pt/A--	--%--	--Num[d]--	------------------%------------------		
Untreated Check		8 bc	2	85 d	85 c	79 c
Outlook / Outlook	0.75 / 0.75	10 bc	3	95 ab	92 ab	88 ab
Warrant / Warrant	3 / 3	17 ab	12	86 d	89 bc	88 ab
Outlook / Warrant	0.75 / 3	8 bc	4	92 bcd	90 abc	89 ab
Outlook / Warrant	0.75 / 4	3 c	3	94 abc	91 abc	92 a
Outlook / Warrant / Warrant	0.75 / 3 / 3	22 a	14	99 a	96 a	95 a
LSD (0.10)		10		6	6	7

[a]Means not sharing any letter are significantly different at the 10% level of significance.
[b]Roundup PowerMax at 28 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC HSMOC at 1.5 pt/A + Amsol Liquid at 2.5% v/v was applied with all POST treatments, including untreated check.
[c]Days after 2- to 4-lf stage application.
[d]Number of plots out of 24 with 30% or greater visible sugarbeet growth reduction injury.

Waterhemp control was greatest from Outlook at 18 days after 2-lf sugarbeet application. Outlook is more water soluble than Warrant and likely moved into the soil more efficiently with limited rainfall. Soil residual herbicide treatments applied EPOST, POST, and LPOST was activated from the June 28 rainfall event and provided waterhemp control greater than repeat Roundup PowerMax plus ethofumesate applications.

The Blomkest experiment received 1.8-inches total rainfall in May and June. Even under these drought conditions, chloroacetamide herbicides controlled waterhemp. Outlook at the 2-lf stage, averaged across PRE treatments, provided waterhemp control greater than Warrant at the 2-lf stage or repeat applications of Roundup PowerMax plus ethofumesate. However, chloroacetamide herbicides were equally as effective at controlling waterhemp 31 and 43 days after the 2-lf stage application. Outlook followed by repeat Warrant applications (totaling 3 POST treatments) provided greater numeric waterhemp control than 2-lf POST treatments, but injured sugarbeet more than the other POST treatments.

Postemergence treatment evaluations were averaged across PRE treatments (Table 8). Ethofumesate PRE at 6 pt/A and ethofumesate + Dual Magnum PRE at 2 pt + 0.5 pt/A, respectively, averaged across POST treatments had greater sugarbeet injury than no PRE. Preemergence treatments caused greater than 30% sugarbeet injury in more plots compared to no PRE when averaged across POST treatments. However, this sugarbeet injury is considered negligible. Preemergence treatments averaged across POST treatments controlled waterhemp greater than no PRE treatments, even in drought conditions.

Table 8. Sugarbeet visible injury, plots with 30% or greater injury, and visible waterhemp control from PRE treatments averaged across POST treatment, Blomkest, MN, 2021.[a]

		Sugarbeet Injury		Waterhemp Control		
Soil Residual treatment PRE[b]	Rate	32 DAP[c]		32 DAP	45 DAP	57 DAP
	--pt/A--	--%--	--Num[d]--	------------------%------------------		
None	-	7 b	8	89 b	85 b	83 b
Ethofumesate + Dual Magnum	2 + 0.5	13 a	18	93 a	91 a	89 a
Ethofumesate	6	15 a	20	92 a	94 a	91 a
LSD (0.10)		5		3	3	3

[a]Means not sharing any letter are significantly different at the 10% level of significance.
[b]Roundup PowerMax at 28 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC HSMOC at 1.5 pt/A + Amsol Liquid at 2.5% v/v was applied with all POST treatments, including 'none'.
[c]DAP = Days after planting.
[d]Num = Total number out of 56 plots with 30% or greater visible sugarbeet growth reduction injury.

The Moorhead experiment was planted into dry soil. The first 'herbicide incorporating' rain did not occur until June 7, 26 DAP or 6 days after the 2-lf sugarbeet stage application (Table 9). The Moorhead site received 4.6-inches total rainfall in June that activated soil residual herbicides. Waterhemp control data collected on June 27, July 17, and July 27 will be discussed in this report. Sugarbeet injury from herbicide treatments will not be presented as we observed stand challenges throughout the season. Preemergence treatments interacted with POST treatments for waterhemp control evaluations collected on June 27 and July 17 (Table 10). However, the interaction can largely be explained by waterhemp control from repeat applications of Roundup PowerMax plus ethofumesate with or without PRE herbicides. Thus, a discussion of PRE treatment (no PRE, ethofumesate plus Dual Magnum, or ethofumesate) averaged across POST treatments along with a discussion of POST applied soil residual herbicides averaged across PRE treatment will be emphasized in this report.

Table 9. Application information, Moorhead, MN 2021.

Date	May 12	June 1	June 9	June 22
Time of Day	5:00 PM	1:00 PM	9:00 AM	12:00 PM
Air Temperature (F)	75	77	80	75
Relative Humidity (%)	23	29	58	42
Wind Velocity (mph)	4	6	7	3
Wind Direction	S	SE	SE	S
Soil Temp. (F at 6")	60	66	70	70
Soil Moisture	Dry	Dry	Wet	Wet
Cloud Cover (%)	20	80	100	20
Sugarbeet Stage	PRE	2-lf	4-lf	8-lf
Waterhemp Height	-	0.5 inch	0.5 inch	1 inch

Table 10. Source of variation and P-values for waterhemp control in response to treatment, Moorhead, MN, 2021.

Source of Variation	Waterhemp Control		
	June 27	July 17	July 27
	-------------------------------*P-value*-------------------------------		
Preemergence	0.0002	0.0003	0.0007
Postemergence	0.0001	0.0001	0.0001
Preemergence × Postemergence	0.0566	0.0391	0.5459

Soil residual herbicides applied at the 2-, 4-, and 8-lf stage, averaged across PRE treatment, provided waterhemp control greater than repeat Roundup PowerMax plus ethofumesate applications (Table 11). Outlook followed by repeat Warrant applications tended to provide greater waterhemp control than other treatments as time progressed. However, sugarbeet injury tended to increase with this treatment at Blomkest. The benefit of soil residual herbicides increased from 26 to 47 days after the 2-lf stage application. Likewise, waterhemp control was greater from PRE treatments, averaged across POST treatments, as compared with no PRE treatment (Table 12).

Table 11. Visible waterhemp control from POST residual treatments averaged across all PRE treatments, Moorhead, MN, 2021.[a]

Soil Residual Treatment POST[b]	Rate	Waterhemp Control		
		26 DAT[c]	40 DAT	47 DAT
	--pt /A--	----------------------------%----------------------------		
None	-	76 c	49 c	31 d
Outlook / Outlook	0.75 / 0.75	96 a	89 a	84 ab
Warrant / Warrant	3 / 3	94 ab	89 a	81 b
Outlook / Warrant	0.75 / 3	95 ab	92 a	87 ab
Outlook / Warrant	0.75 / 4	98 a	91 a	89 ab
Outlook / Warrant / Warrant	0.75 / 3 / 3	98 a	95 a	93 a
LSD (0.10)		5	10	12

[a]Means not sharing any letter are significantly different at the 10% level of significance.
[b]Roundup PowerMax at 28 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC HSMOC at 1.5 pt/A + Amsol Liquid at 2.5% v/v was applied with all POST treatments, including 'none'.
[c]DAT = Days after 2- to 4-lf stage application.

Table 12. Visible waterhemp control from PRE treatments averaged across all POST treatments, Moorhead, MN, 2021.[a]

Soil Residual Treatment PRE[b]	Rate	Waterhemp Control		
		46 DAP[c]	66 DAP	76 DAP
	(pt /A)	-----------------------%-----------------------		
None	-	89 b	76 b	67 b
Ethofumesate + Dual Magnum	2 + 0.5	93 a	84 a	78 a
Ethofumesate	6	95 a	87 a	79 a
LSD (0.10)		3	5	6

[a]Means not sharing any letter are significantly different at the 10% level of significance.
[b]Roundup PowerMax at 28 fl oz/A + ethofumesate at 6 fl oz/A + Destiny HC HSMOC at 1.5 pt/A + Amsol Liquid at 2.5% v/v was applied with all POST treatments, including 'none'.
[c]DAP = Days after Plant.

Conclusion

Soil residual herbicides are the best strategy for waterhemp control in sugarbeet. We recommend producers follow the program and use soil residual herbicides PRE, EPOST, and POST to control waterhemp in sugarbeet, regardless of moisture conditions. Ethofumesate is often tank mixed with Dual Magnum (24c local needs label) PRE which enables some early season weed control in the event that ethofumesate is not incorporated into the soil by rainfall. Producers are considering greater ethofumesate rates along with pre-plant incorporation (PPI) at application. We recommend shallow incorporation (suitable to move ethofumesate into the surface 1-inch of soil) of ethofumesate and use rates greater than 3 pt/A to ensure ethofumesate is not diluted by incorporation. Finally, we recommend applying *S*-metolachlor (Dual Magnum, Brawl, Charger Basic, Medal, Mocassin, etc.), Outlook, or Warrant at the 2- to 4- and 6- to 8-lf stage. The idea of a third lay-by treatment (2-/4-/8-lf stage vs. 2- to 4- and 6- to 8-lf stage) tended to improve waterhemp control at Moorhead and Blomkest; however, increased sugarbeet injury at Blomkest.

References

1. McAuliffe, D., and Appleby, A.P. 1984. Activity loss of ethofumesate in dry soil by chemical degradation and Adsorption. Weed Sci. 32:468-471

HERBICIDE CARRYOVER AND CROP ROTATION TO SUGARBEET

Thomas J. Peters[1]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, North Dakota State University and the University of Minnesota, Fargo, ND

Key Messages

Many herbicides are broken down by microbes in the soil.
Moisture, soil temperature, soil texture, organic matter, and soil pH influence herbicide degradation.
On farm conditions ultimately will determine herbicide persistence.
Gauge the risk of herbicide carryover based on accumulated rainfall between June 1 and September 1.

Introduction

Soil residual is an important characteristic of herbicides for crops planted in sequence with sugarbeet. It is desirable for herbicides to provide season-long weed control, especially for control of *amaranthus* species, but is not desirable for herbicides to persist across growing seasons (Figure 1). While pesticide labels provide guidance for crop rotation restrictions, environmental conditions, especially precipitation, will ultimately dictate the persistence of herbicides. Producers should be extra cautious when planning crop rotations for 2022, especially in geographies receiving less than 6-inch rainfall between June 1, 2021 to September 1, 2021.

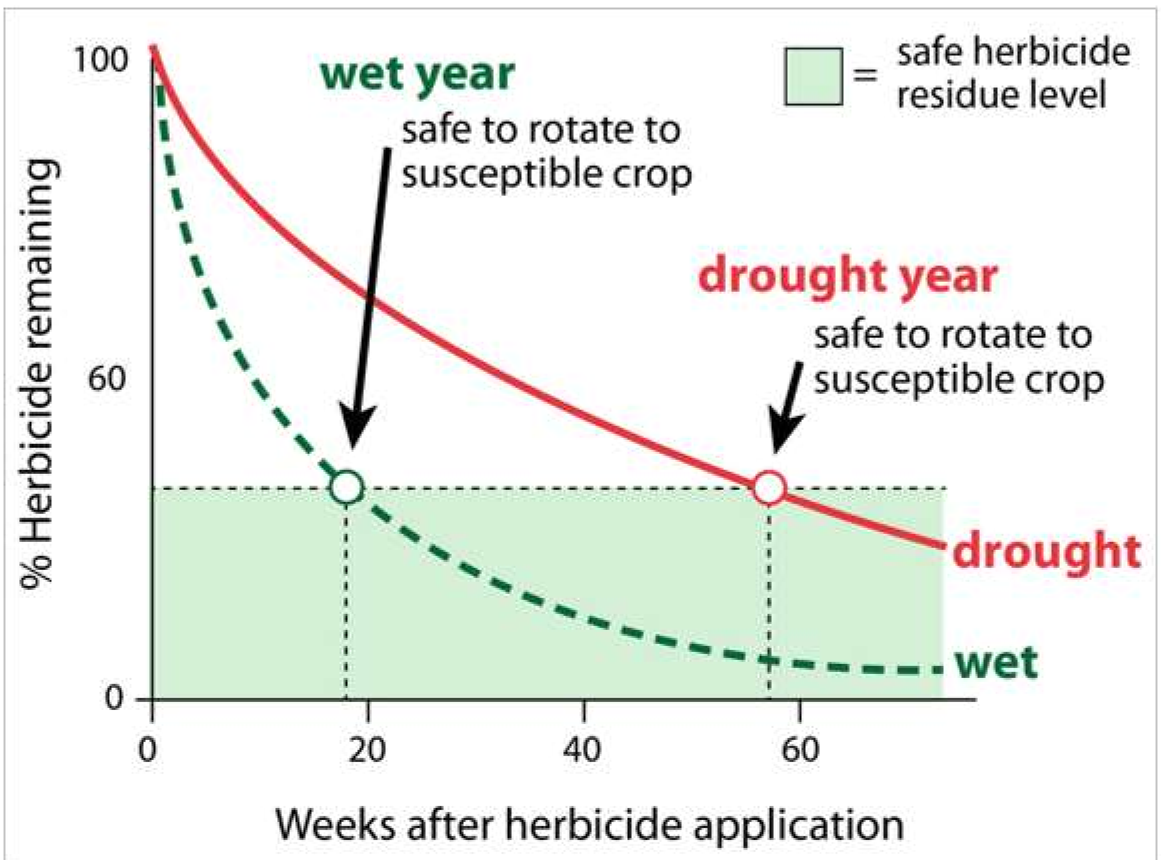


Figure 1. Colquhoun, J. 2006. Herbicide persistence and carryover. University of Wisconsin Extension publication A3819.

Factors Influencing Herbicide Carryover

Degradation of residual herbicides occur over time. Some residual herbicides, such as the chloroacetamides (group 15), degrade rapidly or in approximately three weeks. Other herbicides, such as Authority® products (group 14) or Firstrate® products (group 2), require many months before sugarbeet can be safely planted. Degradation of residual herbicides occur in different ways. Degradation by microbes in the soil is primarily responsible for herbicide breakdown. Speed of degradation is influenced by environmental and soil adaptation factors. Soil moisture and temperature are by far the most important factors in microbial activity.

Herbicide residues in the soil are deactivated in various ways including:

- Breakdown by soil microbes (most common method of degradation).
- Breakdown by chemical hydrolysis (water breaks herbicide molecules into less active pieces).
- Escape to the atmosphere as a gas (volatilization).
- Breakdown by light (photo degradation).
- Tightly bound to soil particles.

Moisture is the most important factor impacting herbicide breakdown, with microbial activity being greatest under moist but not saturated soil conditions. Herbicide breakdown by soil microbes is reduced under dry or drought conditions and carryover into the next growing season may occur. Herbicide adsorption (binding) to soil particles may also be increased with dry conditions since the herbicide moves from the soil solution as moisture is lost and is attached to soil colloids. Additionally, breakdown by chemical hydrolysis is slower when rainfall and soil moisture are limited during the growing season.

Temperature. Optimum soil microbial activity occurs in June, July, and August when soil temperatures are warm or between 70F and 85F. Herbicide breakdown is negligible before June or after August with minimal microbial activity below 50F soil temperatures. Herbicides that are broken down by chemical hydrolysis can also reduce since chemical reactions occur more slowly at lower temperatures.

Soil texture and organic matter. Herbicide degradation decreases in course textured soils or as soil organic matter decreases, due to reduced soil water holding capacity and less microbial activity. Soils with low clay content have decreased adsorption of residual herbicides, which increases the potential availability of the herbicide to sensitive plant roots when a significant rainfall occurs. Potential for injury on subsequent sensitive crops increases as organic matter and clay content decrease.

Soil pH. Chemical hydrolysis of residual herbicides within groups 2, 5, 14, and 15 are influenced by soil pH.

- Group 2 imidazolinones (IMI) persist longer under acid (low pH) soil conditions, whereas sulfonylureas (SU) persist longer in high pH soils.
- Group 5 triazines degrade slower under high pH soils.
- Group 14 sulfentrazone (Authority®) dissipates faster in high pH soils.
- Group 15 pyroxasulfone (Zidua®) dissipates faster in high pH soils.
- Group 27 mesotrione (Callisto®) dissipates faster in high pH soils.

Degradation varies across the field because soil texture, soil organic matter, pH, soil temperature, and soil moisture can also vary across the field.

Crop Rotation Restrictions

The crop rotation restrictions for residual herbicides is the period of time between herbicide application and when a sensitive crop can be planted under normal environmental conditions. Crop rotation restrictions may need to be extended by an additional season and/or a more tolerant crop seeded under drier conditions or when June 1 to September 1 rainfall is less than 6-inch. Crop rotation restrictions for a selected list of corn, soybean, or wheat herbicides used in 2020 or 2021 that may potentially affect sugarbeet in 2022 can be found in Table 1. Note Table 1 focuses on products with less than a 24-month restriction to sugarbeet. There are additional products that could be listed with long carryover concerns. Sugarbeet herbicides may also carryover to crops in the sequence (Table 2). Additional information and a complete list of crop rotation restrictions for herbicides is found on page(s) 6 and 100 to 104 of the 2022 North Dakota Weed Control Guide. In addition to a time interval, labels may also list conditions under which a particular crop may or may not be planted.

Table 1. Crop rotation restrictions for selected herbicides used before sugarbeet.[a]

Product	Active Ingredient	Group	Labeled Crop	Sugarbeet (months)
AcuronFlexi	metola, mesotr, bicyclo, benox	5,15,27,27	corn	18
Aatrex 4L	atrazine	5	corn	NCS
Armezon Pro	topramezone & dimethenamid	15, 27	corn	18
Capreno	tembo, thiencarbazone & isox	27, 2	corn	18
Callisto	mesotrione	27	corn	18
Diflexx Duo	dicamba, tembotrione & safener	4, 27	corn	10
Dimetric/Sencor	metribuzin	5	soybean	18
Everest	flucarbazone & safener	2	wheat	9
Fierce EZ	flumioxazin & pyroxasulfone		soybean	12
Flexstar	fomesafen	14	soybean	18
Halex GT	mesotr, glyph & metola	14, 9, 15	corn	18
Huskie	bromo, pyrasulf & mefenpyr	6, 27	wheat	9
Huskie Complete	bromo, pyras, mefen & mfnpr	6, 27, 2	wheat	9
Huskiie FX	bromo, pyras, flurox & mefenpy	6, 27, 4	Wheat	9
Impact	topramezone	27	corn	18
Laudis	tembotrione & safener	27	corn	10
Prowl EC/H20	pendimethalin	3	edible bean/ potato/ soybean	2CS
Raptor	imazamox	2	edible bean	18
Resicore	clopyralid, acetochlor & meso	4, 15, 27	corn	18
Starane Flex	florasulam & fluroxypyr		wheat	9
Sonalan HFP	ethafluralin	3	edible bean/ potato/ soybean	2CS
Talinor	bromoxynil & bicyclopyrone	6, 27	wheat	15
Treflan	trifluraline	3	soybean	2CS
Valor	flumioxazin	14	soybean	4-10
Varisto	bentazon & imazamox	6, 2	wheat	18
Varro	thiencarbazone & mefenpyr	2	wheat	9
Wolverine Advanced	fenox, pyrasu, bromo & mefenp	1, 27, 6	wheat	9

[a]NCS, next cropping season; 2CS, two cropping seasons

Table 2. Carryover risk to corn, soybean, and sugarbeet from commonly used herbicides.

MOA/ Family	Trade Name	Common Name	Primary Dissipation Mode	Risk of carryover injury following application to:		
				Corn	Soybean	Sugarbeet
Auxin	Stinger	clopyralid	Microbial	-	Moderate	-
ALS	Pursuit	imazethapyr	Microbial	Moderate	-	High
HPPD	Callisto	mesotrione	Microbial	-	Very low	High
HPPD	Laudis	tembotrione	Microbial	-	Low	High
PPO	Authority	sulfentrazone	Microbial	Low	-	High
PPO	FlexStar	Fomesafen	Microbial	Moderate	-	High
PPO	Sharpen	saflufenacil	Microbial	-	Low	Low
PPO	Valor	flumioxazin	Microbial	Low	-	Moderate
PSII	Aatrex	atrazine	Microbial	-	High	High
PSII	Sencor	metribuzin	Microbial	Low	-	High

Assessing Herbicide Residue in Soil

Soil samples can be collected and processed for chemical analysis to measure herbicide residue prior to seeding the next crop. While herbicide concentration can be easily measured, interpreting the result are challenging since it is difficult to associate carryover with laboratory value. Moreover, organic matter, clay content, and environment conditions, including soil moisture, will influence binding to soil. Plant bioassays are a second option and can also be conducted by growing a sensitive rotational crop in soil from a field with suspected herbicide residue and comparing to plants grown in soil that was not treated with the herbicide. However, because of field variability, the results of plant bioassays may not provide reliable recommendations. Field sampling error may also bias results, especially if soil is sampled too deep, diluting residues and increasing the risk of a false negative. Soil samples should be collected from the top two inches of soil. We recommend producers discuss both sampling and sampling location in fields with their crop consultant or agriculturalist if they intend to sample for chemical analysis or plant bioassay.

Summary

The best advice for growers in low rainfall situations following residual herbicide application is to assess their risk based on rainfall from June 1 to September 1. Consult with your agronomist, crop consultant, and/or herbicide company representatives to determine the best rotational cropping options, including planting a more tolerant crop the following year to minimize the risk of crop injury.

SUGARBEET TOLERANCE AND WATERHEMP CONTROL FROM ULTRA BLAZER IN A WEED MANAGEMENT PROGRAM

Thomas J. Peters[1], Alexa L. Lystad[2], and David Mettler[3]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, [2]Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND, and [3]Research Agronomist, Southern Minnesota Beet Sugar Cooperative, Renville, MN

Summary
Ultra Blazer (acifluorfen) must be applied alone or with glyphosate postemergence (POST) at the 6 leaf sugarbeet stage or greater.
Preemergence (PRE) applications did not affect sugarbeet injury, root yield, % sucrose, or recoverable sucrose from Roundup PowerMax, ethofumesate, Ultra Blazer and/or Dual Magnum.
Ultra Blazer in a waterhemp management program caused significant sugarbeet injury and reduced root yield and recoverable sucrose compared with Roundup PowerMax and Dual Magnum and/or ethofumesate.
Ultra Blazer is best used as a tool to control escaped waterhemp; NOT as part of a weed control program.
Waterhemp control results support Ultra Blazer application to control waterhemp escapes.

Introduction
Sugarbeet tolerance and waterhemp control from POST Ultra Blazer applications were investigated in 2019 and 2020. Two conclusions of this research were realized. First, Ultra Blazer applied at 16 fl oz/A should be timed to 6 leaf or greater sugarbeet. Ultra Blazer applied before the 6 leaf sugarbeet stage causes necrosis and stature reduction that reduces root yield and recoverable sucrose. Second, sugarbeet tolerance or waterhemp control from Ultra Blazer is influenced by adjuvant type and herbicide mixture with Ultra Blazer. We observed greater waterhemp control from Ultra Blazer mixtures with Roundup PowerMax, Stinger, and/or ethofumesate than from these herbicides applied individually. Previous research indicates Ultra Blazer postemergence provides effective control of other broadleaf weeds including kochia, redroot pigweed, palmer amaranth, and Pennsylvania smartweed.

Ultra Blazer may fit best in a weed management program with glyphosate, ethofumesate, and a chloroacetamide herbicide timed at the 6-lf sugarbeet stage or mixed with glyphosate and timed to the 8- to 12-lf stage. 2021 experiments were directed to explore both tolerance and weed control from Ultra Blazer as either a component in a weed management program or a treatment to control escape waterhemp.

Objectives
2021 objectives are a) determine if sugarbeet tolerate Ultra Blazer when applied in a waterhemp control program with Roundup PowerMax, ethofumesate, and Dual Magnum at the 6-lf sugarbeet stage; and b) evaluate sugarbeet tolerance and waterhemp control from Ultra Blazer mixtures with Roundup PowerMax, ethofumesate, Dual Magnum, and/or Stinger at the 6- to 8-lf sugarbeet stage.

Materials and Methods
Sugarbeet Tolerance
Experiments conducted in 2021 near Crookston, Hendrum, Norcross, and Murdock, MN evaluated sugarbeet tolerance from Ultra Blazer as a component in the waterhemp management program. 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.

Visible sugarbeet necrosis, malformation, and growth reduction were evaluated 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 sugarbeet 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 in a factorial treatment arrangement with factors being preemergence and postemergence herbicide. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2021.2 software package.

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

Factor A PRE Herbicide	Factor B Postemergence Herbicide	Rate (fl oz/A)	Sugarbeet stage (lf)
No	Roundup PowerMax[a] + etho[b] / Roundup PowerMax + etho	28 + 6 / 28 + 6	2 / 6-8
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	2 / 6-8
No	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer[c]	28 + 6 / 28 + 16	2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax[a] + etho / Roundup PowerMax + etho	8 + 32 / 28 + 6 / 28 + 6	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	8 + 32 / 2 + 6 + 16 / 28 + 6 + 16	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer	8 + 32 / 28 + 6 / 28 + 16	PRE / 2 / 6-8

[a]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[b]etho = ethofumesate.
[c]Ultra Blazer applied with Prefer 90 non-ionic surfactant at 0.125% v/v.

Ultra Blazer Efficacy

Efficacy experiments were conducted on natural populations of waterhemp in sugarbeet grower fields near Moorhead, Glyndon, and Blomkest, MN in 2021. We elected not to include the Moorhead site in this summary due to poor early season sugarbeet development. All treatments (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.

Visible sugarbeet necrosis, malformation, and growth reduction were evaluated as sugarbeet injury using a 0 to 100% injury scale with 0% denoting no sugarbeet injury and 100% denoting complete loss of sugarbeet stature. Weed control was also evaluated as percent biomass reduction. All evaluations were a visual estimate of injury or control in the four treated rows compared to the adjacent, two-row, untreated strip. Experimental design was a randomized complete block design with four replications in a factorial treatment arrangement with factors being preemergence and postemergence herbicides. Data were analyzed in this report as a RCBD with the ANOVA procedure of ARM, version 2021.2 software package.

Table 2. Herbicide treatment, rate, and application timing, sugarbeet efficacy.

Factor A PRE Herbicide	Factor B POST Herbicide	Rate (fl oz /A)	Sugarbeet stage (lf)
No	Roundup PowerMax[a] + etho[b] / Roundup PowerMax + etho	28 + 6 / 28 + 6	2 / 6-8
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	2 / 6-8
No	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer[c]	28 + 6 / 28 + 16	2 / 6-8
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	28 + 6 + 16 / 28 + 16 + 16	2 / 6-8
No	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + etho	8 + 32 / 28 +6 / 28 + 6	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	38 + 32 / 28 + 6 + 16 / 28 + 6 + 16	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer	8 + 32 / 28 + 6 / 28 + 16	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	8 + 32 / 28 + 6 + 16 / 28 + 16 + 16	PRE / 2 / 6-8
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	8 + 32 / 28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	PRE / 2 / 6-8

[a]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[b]etho = ethofumesate.
[c]Ultra Blazer applied with Prefer 90 non-ionic surfactant at 0.125% v/v.

Results

Sugarbeet Tolerance

Sugarbeet injury, root yield, % sucrose, and recoverable sucrose from herbicide treatments applied POST were not affected by PRE treatment (Tables 3 and 4). Sugarbeet injury occurred 7 and 14 days after treatment (DAT) from Roundup PowerMax plus ethofumesate and Dual Magnum as well as Roundup PowerMax plus Ultra Blazer and Dual Magnum compared with Roundup PowerMax plus ethofumesate alone; however, sugarbeet injury from Roundup PowerMax plus ethofumesate and Dual Magnum was the same as Roundup PowerMax plus ethofumesate alone by 21 DAT. Sugarbeet injury at 7, 14, and 21 DAT was always greater when Ultra Blazer was mixed with Roundup PowerMax and Dual Magnum.

Treatments containing Ultra Blazer reduced root yield and recoverable sucrose as compared with Roundup PowerMax plus ethofumesate or Roundup PowerMax plus ethofumesate and Dual Magnum (Table 4). However, sucrose content was not affected by Ultra Blazer. These results indicate that Ultra Blazer applied as part of a weed management program reduces sugarbeet stature, root yield, and recoverable sucrose.

Table 3. Sugarbeet injury of necrosis and growth reduction in response to herbicide treatment, averaged across four locations, 2021.[a]

PRE Herbicide	POST Herbicide	Rate	Sugarbeet Injury 7 DAT[b]	14 DAT	21 DAT
		----fl oz /A----	---------------%---------------		
No	Roundup PowerMax + etho[c] / Roundup PowerMax + etho	28 + 6 / 28 + 6	3 a	2 a	3 a
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	16 + 6 + 28 / 16 + 6 + 28	11 bc	9 b	6 a
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Ultra Blazer + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	44 d	42 c	32 b
Etho+Dual Magnum	Roundup PowerMax + etho / Roundup PowerMax + etho	32 + 8 / 28 + 6 / 28 + 6	4 ab	1 a	2 a
Etho+Dual Magnum	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	32 + 8 / 28 + 6 + 16 / 28 + 6 + 16	13 c	8 b	7 a
Etho+Dual Magnum	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Ultra Blazer + Dual Magnum	32 + 8 / 28 + 6 + 16 / 28 + 16 + 16	50 d	43 c	35 b
P-Value			**<0.0001**	**<0.0001**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAT = days after treatment.
[c]etho = ethofumesate.

Table 4. Sugarbeet root yield, % sucrose, and recoverable sucrose in response to herbicide treatment across four locations, 2021.[a]

PRE Herbicide	POST Herbicide	Rate	Root Yield	Sucrose	Recoverable Sucrose
		----fl oz/A----	-Ton/A-	--%--	---lb/A---
No	Roundup PowerMax + etho[c] / Roundup PowerMax + etho	28 + 6 / 28 + 6	38 a	15.9	10, 423 a
No	Roundup PowerMax + etho + Dual Magnum[d] / Roundup PowerMax + etho + Dual Magnum	16 + 6 + 28 / 16 + 6 + 28	36 a	15.8	10, 040 a
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Ultra Blazer + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	32 b	15.5	8,713 b
Etho+Dual Magnum	Roundup PowerMax + etho / Roundup PowerMax + etho	32 + 8 / 28 + 6 / 28 + 6	38 a	15.7	10, 223 a
Etho+Dual Magnum	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	32 + 8 / 28 + 6 + 16 / 28 + 6 + 16	37 a	15.7	10, 141 a
Etho+Dual Magnum	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Ultra Blazer + Dual Magnum	32 + 8 / 28 + 6 + 16 / 28 + 16 + 16	32 b	15.6	8, 507 b
P-Value			**<0.0001**	**0.2402**	**<0.0001**

[a]Means within a rating timing that do not share any letter are significantly different by the LSD at the 5% level of significance.
[b]DAT = days after treatment.
[c]etho = ethofumesate.

Ultra Blazer Efficacy

The experiment at Moorhead, MN had poor stands and sporadic weeds, especially early in the growing season. Due to variability, discussion will focus on results from Blomkest and Glyndon experiments.

Sugarbeet injury at Glyndon was greater than Blomkest (Table 5). Daily maximum air temperature was 75°F and 82°F on May 31 and June 1, respectively, but increased to greater than 90°F on June 3, the date of the POST application at Glyndon. Daily maximum air temperatures averaged above 90°F through June 10 at Glyndon, MN which likely contributed to sugarbeet injury. Sugarbeet injury was not limited to only treatments containing Ultra Blazer. Multiple applications of Roundup PowerMax plus ethofumesate and Dual Magnum at the 2- and 6-lf stage caused more injury than Roundup PowerMax plus ethofumesate at the 2-lf stage followed by Roundup PowerMax plus ethofumesate at the 6-lf stage.

Table 5. Sugarbeet injury from tank mixtures with Ultra Blazer, 14 DAT, Glyndon and Blomkest, MN, 2021.[a]

			Sugarbeet Injury	
PRE Herbicide	**POST Herbicide[b]**	**Rate**	**Glyndon**	**Blomkest**
		--fl oz/A--	--------%--------	
No	Roundup PowerMax + etho[c] / Roundup PowerMax + etho	28 + 6 / 28 + 6	0 d	4 c
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	15 cd	8 c
No	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer[d]	28 + 6 / 28 + 16	72 ab	33 b
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	28 + 6 + 16 / 28 + 16 + 16	84 a	43 ab
No	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	86 a	45 ab
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + etho	8 + 32 / 28 + 6 / 28 + 6	12 d	0 c
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	8 + 32 / 28 + 6 + 16 / 28 + 6 + 16	29 c	6 c
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer	8 + 32 / 28 + 6 / 28 + 16	64 b	35 b
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	8 + 32 / 28 + 6 + 16 / 28 + 16 + 16	86 a	41 ab
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	8 + 32 / 28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	86 a	49 a
LSD (0.10)			**16**	**13**

[a]Means within location not sharing any letters are significantly different by the LSD at the 10% level of significance.
[b]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[c]etho = ethofumesate.
[d]Ultra Blazer treatments applied with Prefer 90 non-ionic surfactant at 0.25% v/v.

Sugarbeet injury from treatments containing Ultra Blazer were greater than treatments containing Roundup PowerMax, ethofumesate, and/or Dual Magnum at Blomkest. However, injury was similar among treatments containing Roundup PowerMax, ethofumesate, and Dual Magnum. The addition of Stinger to Roundup PowerMax plus Ultra Blazer and Dual Magnum did not increase sugarbeet injury as compared with Roundup PowerMax plus Ultra Blazer and Dual Magnum alone. PRE herbicide did not affect sugarbeet injury.

Ultra Blazer improved waterhemp control compared with Roundup PowerMax plus ethofumesate alone or Roundup PowerMax mixtures with ethofumesate and Dual Magnum at Blomkest, but only improved waterhemp control compared with Roundup PowerMax plus ethofumesate in the absence of a PRE at Glyndon (Table 6). Blomkest was much drier than Glyndon, especially in April and May. Similar waterhemp control was observed from Ultra Blazer mixtures with Roundup PowerMax or Ultra Blazer mixtures with Roundup PowerMax and Dual Magnum at both locations. Waterhemp control was numerically greatest when Ultra Blazer was mixed with Roundup PowerMax, Dual Magnum, and Stinger. However, this treatment also caused the most sugarbeet injury at Blomkest (Table 5). Waterhemp control results support Ultra Blazer applied POST to control waterhemp escapes.

Glyphosate provided excellent common lambsquarters control at Glyndon and Blomkest (data not presented).

Table 6. Waterhemp control from tank mixtures with Ultra Blazer, 14 DAT, Blomkest and Glyndon, MN, 2021.[a]

			Waterhemp Control	
PRE Herbicide	**Postemergence Herbicide[b]**	**Rate**	**Glyndon**	**Blomkest**
		--fl oz/A--	---------%---------	
No	Roundup PowerMax + etho[c] / Roundup PowerMax + etho	28 + 6 / 28 + 6	85 b	65 e
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	28 + 6 + 16 / 28 + 6 + 16	94 ab	69 de
No	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer[d]	28 + 6 / 28 + 16	90 ab	90 ab
No	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	28 + 6 + 16 / 28 + 16 + 16	98 a	94 a
No	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	99 a	93 ab
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + etho	8 + 32 / 28 + 6 / 28 + 6	93 ab	83 bc
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + etho + Dual Magnum	8 + 32 / 28 + 6 + 16 / 28 + 6 + 16	99 a	78 cd
Dual Magnum + ethofumesate	Roundup PowerMax + etho / Roundup PowerMax + Ultra Blazer	8 + 32 / 28 + 6 / 28 + 16	96 ab	94 ab
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum / Roundup PowerMax + Dual Magnum + Ultra Blazer	8 + 32 / 28 + 6 + 16 / 28 + 16 + 16	98 a	95 a
Dual Magnum + ethofumesate	Roundup PowerMax + etho + Dual Magnum + Stinger / Roundup PowerMax + Dual Magnum + Ultra Blazer + Stinger	8 + 32 / 28 + 6 + 16 + 3 / 28 + 16 + 16 + 3	99 a	98 a
LSD (0.10)			**12**	**11**

[a]Means within a location not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[c]etho = ethofumesate.
[d]Ultra Blazer treatments applied with Prefer 90 non-ionic surfactant at 0.25% v/v.

Conclusion

Ultra Blazer applied with Roundup PowerMax and Dual Magnum increased visual sugarbeet injury and reduced root yield and recoverable sucrose as compared with Roundup PowerMax plus ethofumesate alone or in mixtures with Dual Magnum. Thus, we strongly discourage UPL or agriculturalists from recommending the tank mix of Ultra Blazer with Roundup PowerMax and Dual Magnum. Dual Magnum was the only chloroacetamide used in this experiment and it is possible the results may not translate to mixtures with Outlook or Warrant. However, our research indicates sugarbeet injury increases when oil-based formulations are mixed with Ultra Blazer.

These experiments support Ultra Blazer application to control waterhemp escapes. Ultra Blazer has been shown most effective on waterhemp less than 2-inches tall. Ultra Blazer improved waterhemp control compared with Roundup PowerMax plus ethofumesate alone and improved control from Roundup PowerMax mixtures with ethofumesate and Dual Magnum in an environment where rainfall to incorporate soil residual herbicides was lacking. Waterhemp control numerically was greatest when Ultra Blazer was mixed with Roundup PowerMax, Dual

Magnum, and Stinger. However, this treatment caused the most sugarbeet injury at Blomkest. Waterhemp control results support Ultra Blazer application to control waterhemp escapes.

CONTROLLING WATERHEMP ESCAPES IN SUGARBEET

Thomas J. Peters[1], Alexa L. Lystad[2], and David Mettler[3]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, [2]Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND, and [3]Research Agronomist, Southern Minnesota Beet Sugar Cooperative, Renville, MN

Summary
Ultra Blazer broadcast applied, Liberty or Gramoxone applied with the hooded sprayer, or inter-row cultivation at the 10- to 12-lf sugarbeet stage all improved escaped waterhemp control compared with ethofumesate preemergence (PRE) banded followed by repeat (3x) glyphosate plus ethofumesate applications at Blomkest and Moorhead in 2020 and 2021.
Treatment at the 10- to 12-lf sugarbeet stage complemented herbicide applications applied at the PRE, 2- to 4-lf, and 6- to 8-lf sugarbeet stage.
Apply chloroacetamide herbicide mixtures with glyphosate and ethofumesate at the 2- to 4-lf sugarbeet stage, even when following ethofumesate PRE.

Introduction
Sugarbeet growers use layered application of soil residual herbicides applied preemergence (PRE), early postemergence (EPOST), and postemergence (POST) to manage waterhemp in sugarbeet. These herbicides control waterhemp only after they are incorporated into the soil by rainfall. Soil residual herbicides do not control emerged weeds or weed escapes and must be addressed with the POST portion of a weed management program. Escaped waterhemp control is challenging since we currently do not have a POST herbicide effective for control of glyphosate-resistant waterhemp in sugarbeet.

We evaluated a series of ‘ideas’ to control waterhemp escapes in sugarbeet including inter-row applications of Liberty with the Redball™ 915 hooded sprayer (24c) and inter-row cultivation in 2020 as well as inter-row applications of Liberty or Gramoxone (not approved in sugarbeet) with the Redball™ 915 hooded sprayer, inter-row cultivation, and Ultra Blazer (Section 18) in 2021. The objective of these experiments was to evaluate sugarbeet tolerance and control of escaped glyphosate-resistant waterhemp using these alternative weed control methods.

Materials and Methods
Experiments were conducted on natural populations of waterhemp in a sugarbeet grower’s field near Blomkest, MN in 2020 and 2021 and on our research farm near Moorhead, MN in 2020. The experimental area was prepared for planting by applying the appropriate fertilizer and conducting tillage across the experimental area at each location. Sugarbeet was seeded in 22-inch rows at approximately 63,500 seeds per acre with 4.5 inch spacing between seeds.

Herbicide treatments were designed to create waterhemp escapes in plots that would then be treated at the 10- to 12-leaf sugarbeet stage. Herbicide treatments were ethofumesate PRE broadcast or PRE band-applied followed by Dual Magnum mixtures with Roundup PowerMax plus ethofumesate POST applied at the 2-4 and 6-8 sugarbeet leaf stage. Preemergence broadcast and POST treatments were applied with a bicycle sprayer in 17 gpa spray solution through TeeJet 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. Preemergence band treatments were applied in 11-inch strips over the center four rows of six row plots with a bicycle sprayer in 17 gpa spray solution through TeeJet 4002E nozzles pressurized with CO_2 at 40 psi.

Treatment for control of waterhemp escapes were applied at the 10- to 12-leaf sugarbeet stage and included: a) inter-row cultivation performed using a modified Alloway 3130 cultivator (Alloway Standard Industries, Fargo, ND) with 15-inch sweep shovels with a ground depth of 1.5- to 2-inch at 4 mph; b) inter-row application of Liberty or Gramoxone through TeeJet 8002 EVS nozzles pressurized with CO_2 at 40 psi with the Redball™ 915 hooded sprayer (Willmar Fabrication, LLC, Benson, MN) and c) broadcast application of Ultra Blazer applied with a bicycle sprayer in 17 gpa spray solution through TeeJet 8002 XR-flat fan nozzles pressurized with CO_2 at 40 psi. Herbicide treatments for 2020 experiment at Blomkest and Moorhead are found in Table 1 and herbicide treatments for the 2021 experiment at Blomkest are found in Table 2.

The Moorhead location was harvested in 2020. Sugarbeet were defoliated and the center two or three rows of each plot was harvested mechanically and weighed. Experimental design was randomized complete block with four replications. About a 20 lb. root sample was collected from each plot and analyzed for sucrose content and sugar loss to molasses by American Crystal Sugar Company (East Grand Forks, MN). Data from all experiments were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Table 1. Herbicide treatment, herbicide rate, application method and application timing in 2020, Blomkest and Moorhead, MN.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ethofumesate (broadcast) / Roundup PowerMax[1] + ethofumesate / Roundup PowerMax + ethofumesate	96 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Roundup PowerMax + ethofumesate / Roundup PowerMax + ethofumesate	48 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Liberty[3] Hooded sprayer	48 / 16 + 32 + 12 / 32	PRE / 4 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Liberty Hooded sprayer	48 / 16 + 32 + 12 / 32	PRE / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Inter-row cultivation	48 / 16 + 32 + 12 / mechanical	PRE / 4 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Inter-row cultivation	48 / 16 + 32 + 12 / mechanical	PRE / 8 lf / 10-12 lf

[1]Roundup PowerMax + ethofumesate was applied with Destiny HC @ 1.5 pt/A + Amsol Liquid AMS at 2.5% v/v.
[2]Ethofumesate applied using a banded application.
[3]Liberty applied with Dry AMS at 3 lb/A.

Table 2. Herbicide treatment, herbicide rate, application method and application timing in 2021, Blomkest, MN.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ethofumesate (broadcast) / Roundup PowerMax[1] + ethofumesate / Roundup PowerMax + ethofumesate	48 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Roundup PowerMax + ethofumesate / Roundup PowerMax + ethofumesate	48 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Liberty[3] Hooded sprayer	48 / 16 + 28 + 6 / 16 + 28 + 6 / 38	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Gramoxone 3.0 SL Hooded sprayer	48 / 16 + 28 + 6 / 16 + 28 + 6 / 24	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Inter-row cultivation	48 / 16 + 28 + 6 / 16 + 28 + 6 / mechanical	PRE / 4 lf / 8 lf / 10-12 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax[4]	48 / 16 + 28 + 6 / 16 + 28 + 6 / 16 + 22	PRE / 4 lf / 8 lf / 10-12 lf

[1]Roundup PowerMax + ethofumesate was applied with Destiny HC @ 1.5 pt/A + Amsol Liquid AMS at 2.5% v/v.
[2]Ethofumesate applied using a banded application.
[3]Liberty applied with Dry AMS at 3 lb/A.
[4]Ultra Blazer + Roundup PowerMax applied with Prefer 90 NIS @ 0.25% v/v + Amsol Liquid AMS at 2.5% v/v.

Results

Dual Magnum plus Roundup PowerMax and ethofumesate applied at the 2- to 4-lf stage provided waterhemp control greater than Dual Magnum plus Roundup PowerMax and ethofumesate applied at the 6- to 8-lf stage at Blomkest and Moorhead in 2020 (data not presented). Both treatments followed ethofumesate PRE in an 11-inch band at 6 pt/A in the treated area.

Results will focus on control of escaped waterhemp with inter-row cultivation, Roundup PowerMax mixed with ethofumesate, and inter-row application of Liberty with the hooded sprayer at the 10- to 12-lf stage. These POST treatments followed either ethofumesate PRE (broadcast or in a band application) and repeat applications of Roundup PowerMax plus ethofumesate, or ethofumesate PRE in a band followed by Dual Magnum plus Roundup PowerMax and ethofumesate applied at the 2- to 4-lf stage.

We observed sugarbeet injury ranging from 5% to 18%, 39 days after planting (DAP) at Blomkest in 2020 (Table 3). Injury was random within plots and seemed to be related to field variation caused by dry soil conditions; not herbicide treatment. Waterhemp control was greater than 85% across treatments at 47 DAP. Ethofumesate PRE in a band application tended to provide less control than ethofumesate PRE as a broadcast application when followed by Roundup PowerMax plus ethofumesate as well as ethofumesate PRE in a band application when followed by Dual Magnum plus Roundup PowerMax and ethofumesate. However, early season control was generally good across all treatments.

Table 3. Sugarbeet injury and waterhemp control in response to PRE and EPOST herbicides, and POST treatment control of escaped waterhemp 8 and 17 DAT, Blomkest, MN, 2020.[a]

PRE / EPOST Herbicide Treatment[b]	Sgbt inj[b] 39 DAP[c]	Wahe[b] Control 47 DAP	POST Treatment[b]	Wahe Control 8 DAT[c]	Wahe Control 17 DAT
	----------%----------			----------%---------	
Etho (broadcast) / PM + etho / PM + etho	18	100 a	Roundup PowerMax + etho	99 a	99 a
Etho (band) / PM + etho / PM + etho/	11	89 b	Roundup PowerMax + etho	69 b	79 b
Etho (band) / Dual + PM + etho / Dual + PM + etho	5	96 ab	Liberty with Redball™ 915 hooded sprayer	93 a	91 a
Etho (band) / Dual + PM + etho / Dual + PM + etho	18	100 a	Inter-row cultivation	100 a	99 a
LSD (0.10)	**NS**	**8**		**10**	**11**

[a]Means within a column not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]etho = ethofumesate; PM = Roundup PowerMax; Dual = Dual Magnum; sgbt inj=sugarbeet injury; wahe = waterhemp.
[c]DAP = days after plant; DAT = days after treatment.

Greater than 90% control of up to 6-inch escaped waterhemp was observed from the POST application of Roundup PowerMax plus ethofumesate, Liberty with the hooded sprayer, or with inter-row cultivation when following ethofumesate applied PRE broadcast. Control from these POST treatments was significantly greater than Roundup PowerMax plus ethofumesate when following ethofumesate PRE applied in the band. These results support the idea of controlling escaped waterhemp using either the hooded sprayer or inter-row cultivation.

Sugarbeet injury was negligible in the Moorhead experiment in 2020 (data not presented). Waterhemp control at 28 DAP was greater than 80% (Table 4). Control of escaped waterhemp was greatest with inter-row cultivation. Waterhemp control was least with inter-row application of Liberty with the hooded sprayer or from ethofumesate PRE band-applied followed by three Roundup PowerMax plus ethofumesate applications. No differences were observed in sugarbeet root yield (data not presented), % sucrose, or recoverable sucrose per acre. However, recoverable sucrose per acre following waterhemp control with cultivation tended to be greater than recoverable sucrose from other treatments.

Table 4. Waterhemp control 28 DAP in response to PRE and EPOST treatments, and POST treatment control of escaped waterhemp 16 DAT and yield parameters in response to POST treatment, Moorhead, MN, 2020[a].

PRE / EPOST Herbicide Treatment[b]	Wahe[b] Control 28 DAP[c]	POST Treatment[b]	Wahe Control 16 DAT[c]	Sugarbeet Yield Sucrose	Sugarbeet Yield Rec. Suc.[b]
	---%---		-----------%-----------		---lb/A---
Etho (broadcast) / PM + etho / PM + etho	89 ab	Roundup PowerMax + etho	84 b	13.6	6,555
Etho (band) / PM + etho / PM + etho/	81 b	Roundup PowerMax + etho	76 bc	13.3	6,796
Etho (band) / Dual + PM + etho / Dual + PM + etho	91 a	Liberty with Redball™ 915 hooded sprayer	68 c	13.5	6,425
Etho (band) / Dual + PM + etho / Dual + PM + etho	95 a	Inter-row cultivation	99 a	13.7	6,952
LSD (0.10)	**8**		**13**	**NS**	**NS**

[a]Means within column not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]etho = ethofumesate; PM = Roundup PowerMax; Dual = Dual Magnum; wahe = waterhemp, Rec. Suc. = recoverable sucrose.
[c]DAP = days after plant; DAT = days after treatment.

Inter-row cultivation controlled 2- to 4-inch escaped waterhemp at Blomkest (Table 3) and Moorhead (Table 4) in 2020. Inter-row application of Liberty with the hooded sprayer controlled escaped waterhemp at Blomkest but not at

Moorhead. Inconsistent results with the hooded sprayer may have been related to an equipment malfunction at Moorhead rather than the herbicide treatment.

Planned program treatments applied PRE, EPOST, and POST caused negligible sugarbeet injury and provided similar waterhemp control 40 DAP at Blomkest in 2021 (Table 5). Waterhemp control ranged from 75% to 94% with ethofumesate PRE broadcast followed by Roundup PowerMax plus ethofumesate applied at the 4- and 8-lf stages giving the greatest waterhemp control.

Table 5. Waterhemp control 40 DAP in response to PRE and EPOST treatments and POST treatments control of escape waterhemp 2 and 24 DAT, Blomkest, MN, 2021.[a]

PRE / EPOST	Sgbt Inj.[b]	Wahe[b] Control	POST	Sgbt Inj.	Wahe Control	
Herbicide Treatment[b]	40 DAP[c]	40 DAP	Treatment[b]	16 DAT[c]	2 DAT	24 DAT
	---------%--------			--------------%-------------		
Etho (broadcast) / PM + etho / PM + etho	0	94	Roundup PowerMax + etho	0 b	79 bc	78 bc
Etho (band) / PM+etho / PM+etho/	0	79	Roundup PowerMax + etho	0 b	73 c	70 c
Etho (band) / Dual+PM+etho / Dual+PM+etho	4	75	Liberty with Redball™ 915 hooded sprayer	3 b	75 c	86 ab
Etho (band) /Dual+PM+etho / Dual+PM+etho	4	79	Gramoxone with Redball™ 915 hooded sprayer	3 b	90 ab	87 ab
Etho (band) / Dual+PM+etho / Dual+PM+etho	4	78	Inter-row cultivation	0 b	96 a	93 a
Etho (band) / Dual+PM+etho / Dual+PM+etho	0	85	Ultra Blazer+PM+ NIS+ AMS	18 a	81 bc	90 ab
LSD (0.10)	**NS**	**NS**		**9**	**14**	**13**

[a]Means within a column not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]etho = ethofumesate; PM = Roundup PowerMax; Dual = Dual Magnum; sgbt Inj. = sugarbeet injury; wahe = waterhemp.
[c]DAP = days after plant; DAT = days after treatment.

Inter-row application of Gramoxone with the Redball 915 hooded sprayer or inter-row cultivation provided immediate control of 90% and 96%, respectively, 3- to 12-inch escaped waterhemp at 2 DAT. Waterhemp control from Gramoxone via the hooded sprayer was similar to Ultra Blazer plus Roundup PowerMax and similar to Roundup PowerMax plus ethofumesate when following ethofumesate broadcast PRE. Escaped waterhemp control from Gramoxone with the hooded sprayer, inter-row cultivation, Ultra Blazer plus Roundup PowerMax, and Liberty with the hooded sprayer was or tended to be greater than waterhemp control from Roundup PowerMax plus ethofumesate at 24 DAT.

Conclusions

Waterhemp control challenges in sugarbeet is forcing agriculturalists to reconsider weed management strategies and evaluate 10- to 12-lf sugarbeet growth stage treatments. Escaped waterhemp did not reduce yield (Moorhead, 2020) but produced seed that developed into a production challenge for crops grown in sequence with sugarbeet. This research found there are multiple useful tools to control escaped waterhemp including inter-row cultivation, the hooded sprayer, and Ultra Blazer.

A secondary outcome of these experiments was applying ethofumesate PRE in an 11-inch band. This application method could be utilized to save money while maintaining waterhemp control, especially if the producer is using layered residuals or herbicides applied at the 2- to 4- and 6- to 8-lf stage in sugarbeet. Also, observations suggest that the first in-season chloroacetamide application should be timed to 2- to 4-lf stage sugarbeet, even if ethofumesate PRE is applied.

ULTRA BLAZER SECTION 18 EMERGENCY EXEMPTION AND SUPPORTING EXPERIMENTS

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

[1]Extension Sugarbeet Agronomist and Weed Control Specialist, [2]Graduate Student and Research Agronomist, NDSU and Minn-Dak Farmers Cooperative, [3]Research Specialist, North Dakota State University & University of Minnesota, Fargo, ND, and [4]Research Agronomist, Southern Minnesota Beet Sugar Cooperative, Renville, MN

Summary
Ninety-five percent of respondents indicated the emergency exemption was beneficial for sugarbeet producers in Minnesota and North Dakota and contributed to overall weed management in 2021.
Ninety-two percent of respondents indicated they would willingly support application for a 2022 emergency exemption in sugarbeet.
Control from Ultra Blazer decreases as waterhemp size increases from 1-inch to greater than 6-inches.
Spray volume (gpa), ground speed (mph), and waterhemp size influenced control and regrowth. Further research and training is needed to optimize waterhemp control.

Introduction
The Environmental Protection Agency (EPA) approved a 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 2021. 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. The report contains three 2021 program objectives: a) summarize results and user experiences from the 2021 Section 18 emergency exemption for use of Ultra Blazer in sugarbeet; b) summarize an experiment developed to provide producers and agriculturalists with scientific insight as to what Ultra Blazer delivers in sugarbeet production; c) determine reduction in control from Ultra Blazer as waterhemp height increases from 2- to 6-inches.

Materials and Methods
Section 18 Emergency Exemption
Ultra Blazer was applied at 16 fl oz/A alone or with glyphosate and non-ionic surfactant (NIS) plus ammonium sulfate (AMS). One Ultra Blazer application was made per season using ground application equipment and targeted 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 June 2 through July 31, 2021.

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
Demonstrations plots were established near Casselton, ND and near Crookston, Hendrum, Foxhome and Benson, MN to train producers and agriculturalists on the plant response from Ultra Blazer alone, with glyphosate, and/or with adjuvants (Table 1).

Table 1. Herbicide treatment, rate, and application timing to Ultra Blazer demonstration plots in sugarbeet fields, 2021.

Num	Treatment	Rate (fl oz/A)	Sugarbeet Stage (lvs)
1	Ultra Blazer	16	>6
2	Ultra Blazer + Prefer 90 NIS	16 + 0.125% v/v	>6
3	Ultra Blazer + Prefer 90 NIS	16 + 0.25% v/v	>6
4	Ultra Blazer + Roundup PowerMax + Amsol Liquid AMS	16 + 28 + 2.5 % v/v	>6
5	Ultra Blazer + Roundup PowerMax + Prefer 90 NIS + Amsol Liquid AMS	16 + 28 + 0.25% v/v + 2.5 % v/v	>6

Visible sugarbeet necrosis, malformation, and growth reduction were observed as injury symptoms and evaluated 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. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Waterhemp Control as Influenced by Height

PRE, EPOST, and POST treatments (Table 2) created waterhemp size and density differences in plots. Late postemergence (LPOST) treatments were applied to evaluate control of waterhemp escapes. Treatments were applied to the center four rows of six row plots 40 feet in length using a bicycle sprayer. Herbicides were applied in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi. Visible sugarbeet necrosis, malformation, and growth reduction were observed as injury symptoms and evaluated 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. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Table 2. Herbicide treatment, rate, and application timing in waterhemp control trials, 2021.

Herbicide Treatment	Rate (fl oz/A)	Application timing (SGBT leaf stage)
Ethofumesate (broadcast) / Roundup PowerMax + ethofumesate[1] / Roundup PowerMax + ethofumesate / Roundup PowerMax + ethofumesate	96 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 6 lf / 8-10 lf
Ethofumesate[2] / Roundup PowerMax + ethofumesate[1] / Roundup PowerMax + ethofumesate / Roundup PowerMax + ethofumesate	48 / 28 + 4 / 28 + 4 / 22 + 4	PRE / 4 lf / 6 lf / 8-10 lf
Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax[3]	16 + 32 + 12 / 16 + 22	4 lf / 8-10 lf
Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	16 + 32 + 12 / 16 + 22	6 lf / 8-10 lf
Dual Magnum + Roundup PowerMax + ethofumesate / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	16 + 28 + 6 / 16 + 28 + 6 / 16 + 22	4 lf / 6 lf / 8-10 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	48 / 16 + 32 + 12 / 16 + 22	PRE / 4 lf / 8-10 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	48 / 16 + 32 + 12 / 16 + 22	PRE / 6 lf / 8-10 lf
Ethofumesate[2] / Dual Magnum + Roundup PowerMax + ethofumesate / Dual Magnum + Roundup PowerMax + ethofumesate / Ultra Blazer + Roundup PowerMax	48 / 16 + 32 + 12 / 16 + 32 + 12 / 16 + 22	PRE / 4 lf / 6 lf / 8-10 lf

[1]Roundup PowerMax + ethofumesate applied with Destiny HC @ 1.5 pt/A + Amsol AMS at 2.5% v/v.
[2]Ethofumesate applied using a banded application.
[3]Roundup PowerMax + Ultra Blazer applied with Prefer 90 NIS @ 0.25% v/v and NPak AMS at 2.5% v/v.

Results

According to a survey of sugarbeet growers and agriculturalists, Ultra Blazer at 16 fl oz/A was applied to 32,005 sugarbeet acres in 2021 (totaling 4,001 gallons of Ultra Blazer). Ninety percent or 28,711 acres were applied in Minnesota and 10% or 3,294 acres were applied in North Dakota.

The air temperature at application and variability in sugarbeet growth stage complicated Ultra Blazer application, especially applications made in early June, 2021. The maximum daily air temperature in much of the sugarbeet growing area (represented by Hillsboro, ND and Blomkest, MN) was 80 to 102°F from June 2 through at least June 15, 2021 (Figure 1). In the five years (2016 to 2020) leading up to the Section 18 application for Ultra Blazer, air temperature at application had not been greater than 85°F in any of our research trials.

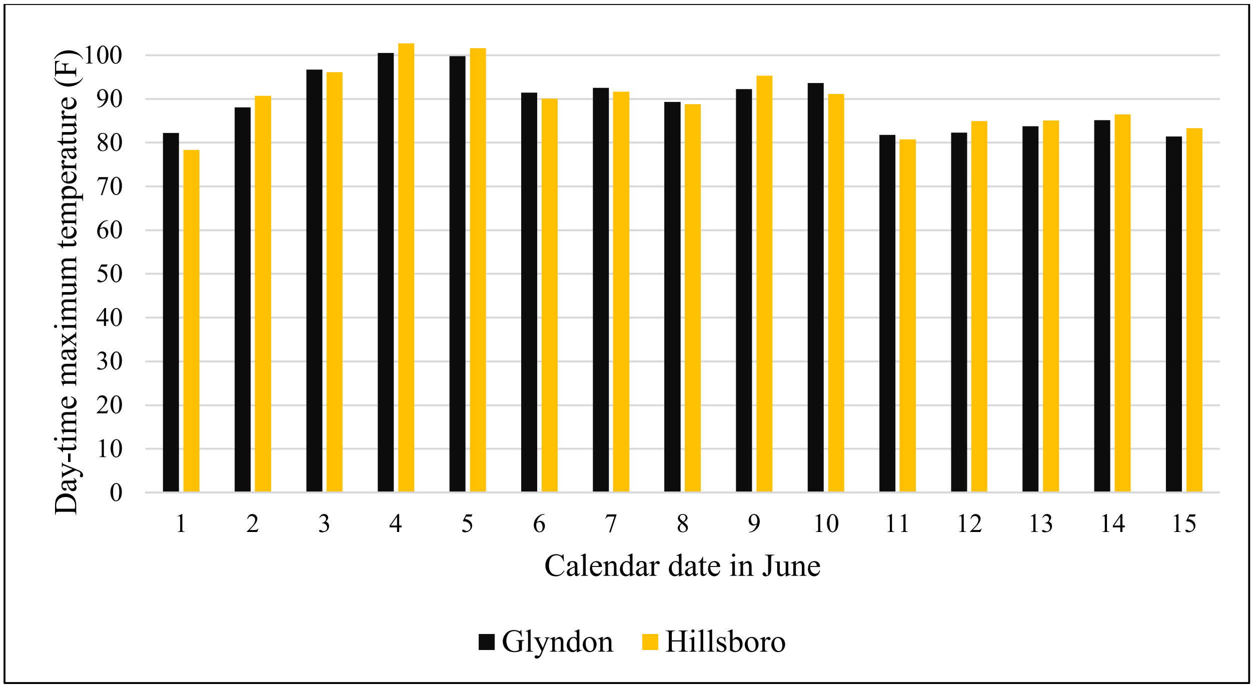


Figure 1. Day time maximum air temperature, June 1 to June 15, Hillsboro, ND and Blomkest, MN, 2021.

The variability of sugarbeet growth stage at application further complicated Ultra Blazer application. Our recommendation was for application to sugarbeet greater than the 6-lf stage. However, dry planting conditions in April and May caused variable emergence and sugarbeet stands ranged from cotyledon to 8-lf at application.

Sugarbeet producers and agriculturalists were asked in a survey to evaluate sugarbeet injury and waterhemp control from Ultra Blazer. When compiling sugarbeet injury responses, no injury = 1, slight = 2, moderate = 3, and severe injury = 4. When compiling waterhemp control responses, excellent =1, good = 2, fair = 3, and poor control = 4. When averaged across all responses, sugarbeet injury was reported as slight to moderate (2.6) and waterhemp control as good to fair (Figure 2). Only one respondent categorized sugarbeet injury as severe. Respondents from the northern Red River Valley (RRV) graded injury greater (2.8) than respondents from the southern RRV (2.4) or respondents from west central Minnesota (2.6) suggesting their lack of familiarity with or tolerance for sugarbeet injury. Waterhemp control was rated good to fair with negligible differences in responses across the growing regions. Although no unintended effects such as increased susceptibility to disease or reduced % sucrose content were reported by producers or agriculturalists, there were inconsistent results in regard to sugarbeet tolerance and waterhemp control. This indicates a need for application method refinements if Ultra Blazer is used on sugarbeet in the future. Agriculturalists and producers were asked if they found the Section 18 Emergency Exemption useful and if they supported applying for a 2022 Emergency Exemption. Ninety-five percent of the respondents found the Section 18 Emergency Exemption beneficial for sugarbeet growers and 92% supported reapplication for the Emergency Exemption in 2022.

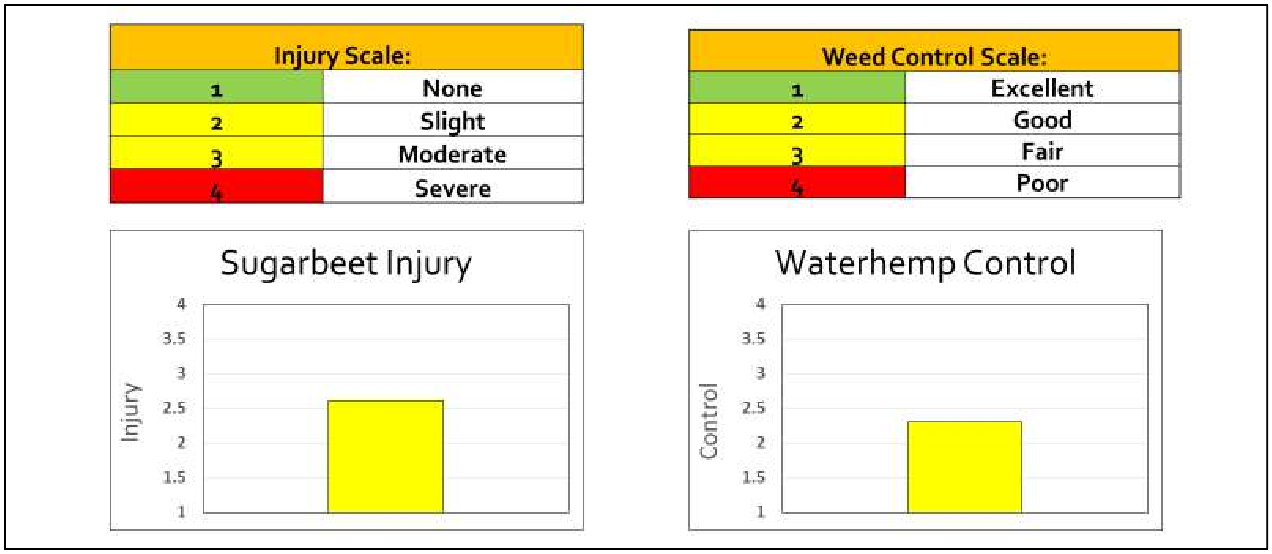


Figure 2. Results of producer and agriculturalist survey of sugarbeet injury and waterhemp control from Ultra Blazer Section 18 Emergency Exemption, Minnesota and North Dakota, 2021.

Ultra Blazer is a contact herbicide PPO inhibitor that is applied POST and is light activated. When activated, this product forms highly reactive compounds in the plants that rupture cell membranes causing fluids to leak. Injury symptoms can occur as soon as 1 to 2 hours after application. Environmental conditions will affect Ultra Blazer injury to sugarbeet. Symptoms are most apparent with bright, sunny conditions and increased humidity at application.

Efficacy is best when Ultra Blazer is used at high water volumes (15 to 25 gpa water volume) with flat fan nozzles producing a fine droplet spectrum to 'paint the plant' ensuring good coverage. Oil-based adjuvants with Ultra Blazer increase waterhemp control and sugarbeet injury as compared with non-ionic surfactants. Likewise, herbicide mixtures, including glyphosate, will potentially increase sugarbeet injury.

Sugarbeet Tolerance
Sugarbeet visual percent injury was evaluated 3 to 16 days after treatment (DAT) across locations. Sugarbeet injury ranged from 8% to 40% depending on herbicide treatment and location (Table 3). Sugarbeet injury tended to be less with Ultra Blazer alone and increased with addition of adjuvant and/or adjuvant rate. Sugarbeet injury increased when Roundup PowerMax was mixed with Ultra Blazer as compared with Ultra Blazer alone or with adjuvants. Sugarbeet injury was greatest at Benson, MN. The air temperature at Benson at 11:00AM was 95°F. Air temperature was 88°F, 79°F, 88°F, and 86°F at application at Casselton, Crookston, Foxhome, and Hendrum, respectively. Root yield, % sucrose, and recoverable sucrose was collected at Hendrum, MN. Yield parameters were collected by hand from a 37 square foot area. This is approximately 1/3 of our normal mechanically harvested area. Data was variable but suggested reduced yield when adjuvant or Roundup PowerMax was mixed with Ultra Blazer compared with applying Ultra Blazer alone. Percent sucrose was the same across treatments.

Table 3. Visual percent sugarbeet injury in response to herbicide treatment, 3 to 16 DAT at multiple locations, 2021[a].

Herbicide Treatment	Adj. Rate[b]	Casselton	Crookston	Foxhome	Hendrum	Benson
	--pt/100 gal--	---------------------------------%------------------------------				
Ultra Blazer[c]	-	9 d	9 c	10 c	8 d	-
Ultra Blazer + Prefer 90 NIS	1	14 c	10 bc	11 bc	10 cd	-
Ultra Blazer + Prefer 90 NIS	2	15 bc	15 ab	18 b	15 c	-
Ultra Blazer + Prefer 90 NIS + Amsol liquid AMS	2 + 20	-	-	-	-	35
RUPM[d] + Ultra Blazer + Amsol liquid AMS	20	19 b	20 a	25 a	21 b	-
RUPM[d] + Ultra Blazer + Prefer 90 NIS + Amsol liquid AMS	2 + 20	28 a	-	26 a	30 a	40
LSD (0.10)		**4**	**5**	**6**	**6**	**NS**

[a]Means within a location not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]Adj. Rate = Adjuvant Rate.
[c]Ultra Blazer applied at 16 fl oz/A in all treatments.
[d] RUPM = Roundup PowerMax applied at 28 fl oz/A in respective treatments.

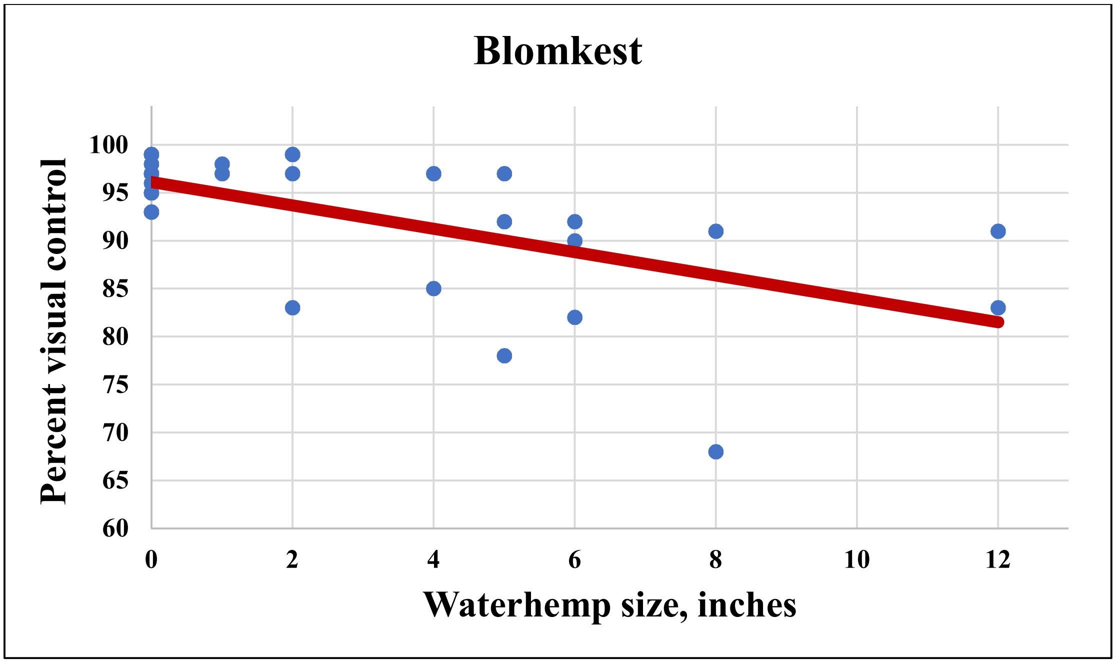
Table 4. Visual percent sugarbeet injury and sugarbeet yield parameters in response to herbicide treatment, Hendrum, MN, 2021[a].

Herbicide Treatment	Adj. Rate[b]	Sgbt inj[c]	Sgbt inj	Yield	Sucrose	Rec Suc[d]
	--pt/100 gal--	---------%---------		-Ton/A-	--%--	--lb/A--
Ultra Blazer[e]	-	8 d	0 b	27.1 a	17.8	9,002 a
Ultra Blazer + Prefer 90 NIS	1	10 cd	0 b	24.7 b	17.6	8,091 ab
Ultra Blazer + Prefer 90 NIS	2	15 c	3 b	24.4 b	17.9	8,163 ab
RUPM[f] + Ultra Blazer + Amsol liquid AMS	20	21 b	10 a	24.1 b	17.6	7,864 b
RUPM[f] + Ultra Blazer + Prefer 90 NIS + Amsol liquid AMS	2 + 20	30 a	10 a	25.2 ab	18.1	8,514 ab
LSD (0.10)		**6**	**4**	**2.4**	**NS**	**944**

[a]Means within a main effect not sharing any letter are significantly different by the LSD at the 10% level of significance.
[b]Adj. Rate = Adjuvant Rate.
[c]Sgbt inj. = Sugarbeet Injury.
[d]Rec. Suc. = Recoverable Sucrose.
[e]Ultra Blazer applied at 16 fl oz/A in all treatments.
[f]RUPM = Roundup PowerMax applied at 28 fl oz/A in respective treatments.

Waterhemp Control as Influenced by Height

Waterhemp control decreased as waterhemp size increased at Blomkest and Moorhead (Figure 3). The negative slope of the line was greater at Moorhead than Blomkest indicating waterhemp control decreased more rapidly at Moorhead than at Blomkest in response to waterhemp height. Air temperature was 75°F at application at Moorhead and Blomkest. Sugarbeet size and growth stage was greater at Moorhead, which may have reduced herbicide coverage on waterhemp as compared with the Blomkest location.



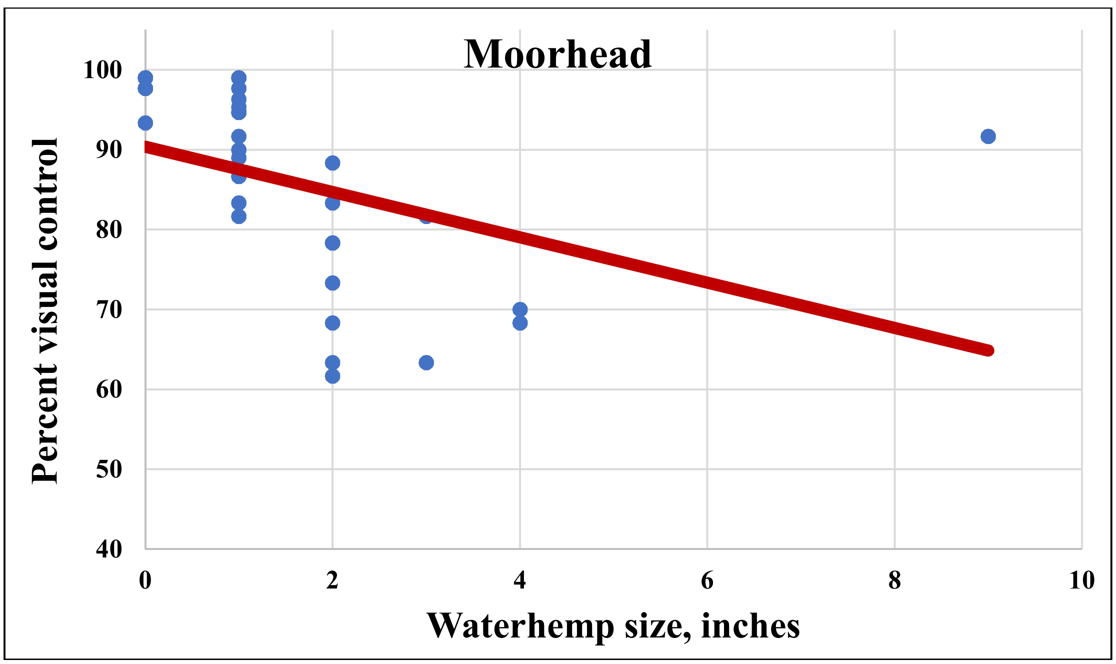


Figure 3. Visual percent waterhemp control in response to waterhemp size, Blomkest and Moorhead, MN, 2021.

Conclusion

Using Ultra Blazer will be a compromise between sugarbeet injury and weed control. Methods to improve control such as adjuvant selection and rate or herbicides tank-mixed with Ultra Blazer, as well as environmental conditions at application, must be considered as different combinations will increase sugarbeet injury. Application must be timed to sugarbeet greater than 6-lf sugarbeet with the prospect that weed escapes range from 2- to 4-inches. We learned in 2021 that producers are willing to sacrifice sugarbeet safety to control weed escapes. Further research is needed to improve spray quality including selection of nozzles and spray volume to optimize weed control.

Appendix.

2021 Ultra Blazer Section 18 Emergency Exemption

Please answer the following questions.

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

How many acres were sugarbeet treated with Ultra Blazer for weed control? ____________________

Record sugarbeet injury from Ultra Blazer?

None Slight Moderate Severe

Record weed control from Ultra Blazer in sugarbeet?

Excellent Good Fair Poor

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

YES NO

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

YES NO

Would you like to use Ultra Blazer again in 2022?

YES NO.

Write comments to provide additional details regarding your experiences.

____

____

____

KOCHIA CONTROL IN SUGARBEET AND CROPS IN SEQUENCE WITH SUGARBEET

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

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

Summary

Identify the weed challenges in your fields and prepare for sugarbeet by planting crops with effective weed control herbicides.
Kochia control in sugarbeet is greatest when Roundup PowerMax postemergence (POST) follows ethofumesate preemergence (PRE) applied at 6 or 7.5 pt/A or two or three applications of Roundup PowerMax + ethofumesate POST applied to kochia less than 3-inches tall during the season.
Kochia control from Ultra Blazer is inconsistent; likely due to kochia size at required Ultra Blazer application timing in sugarbeet.
Successful kochia control requires a program approach throughout the crop sequence, including sugarbeet production.

Introduction

Glyphosate-resistant (GR) kochia is reemerging as a weed control challenge for sugarbeet growers in Minnesota, North Dakota, and eastern Montana. Kochia is unique from other weed control threats in that there are few effective weed control options in sugarbeet. Kochia typically emerges in April and May, but some kochia biotypes emerge as late as June. Kochia is most severe when drought conditions reduce both sugarbeet stands and early season growth and development. Finally, kochia interferes with sugarbeet root yield by virtue of its rapid growth, resulting in sugarbeet suffocation due to enormous growth potential.

Herbicides are a major component of kochia control programs. 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, North Dakota, and eastern Montana. 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. Glyphosate-resistant kochia is widespread and concerning to farmers since glyphosate is relied upon in many cropping systems. The objectives of this research were to 1) evaluate non-glyphosate herbicide options in sugarbeet or crops grown in sequence with sugarbeet and; 2) provide kochia control options in Minnesota and North Dakota fields when corn, soybean, or wheat are seeded 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 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 fallow, wheat, and 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 within a crop rotation including corn, soybean, spring wheat, and spring barley. However, 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.

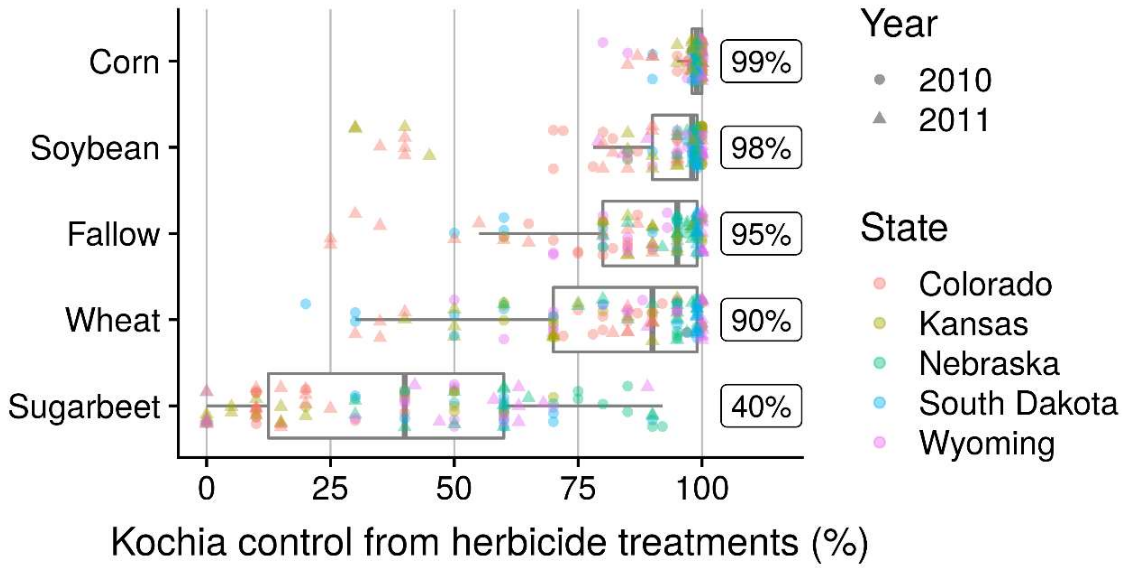


Figure 1. Kochia control, 30 days after final application of herbicide treatment, labeled for corn, soybean, fallow, wheat, and sugarbeet. Each point represents a plot in a field. Percentages are the median kochia control from herbicide treatments within each crop.

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.

Spring

Corn

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)

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)

Capreno (3 fl oz) + PowerMax + atrazine (0.38 to 0.5 lb) EPOST (V2 to V4 corn, (less than 3-inch kochia) (requires RR Corn)

Soybean

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)

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)

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

Spring Wheat

Huskie FX[6] (full rate)

Starane NXT[7] (full rate)

Talinor[8] (full rate)

---

[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.

Sidney Sugars, Western North Dakota and Eastern Montana. Kochia management in western North Dakota is complicated by irrigation practices on some acres. The following are a series of activities recommended by Dr. Brian Jenks for corn, soybean and wheat production in sequence with sugarbeet.
Fall. After fall ridging and before corn, soybean or spring wheat.
Valor[1] at 3 oz/A after fall ridging
We recommend no spring re-ridging since tillage will disturb the herbicide layer.
Plan for fall Valor reducing spring kochia emergence 70%
Spring. Corn, soybean or small grains.
Corn
Verdict (10 fl oz minimum 15 fl oz is better) + atrazine[2] (0.38 lb) + AMS + MSO applied POST to emerged kochia and PRE to corn
Sharpen[3] (2-3 fl oz) + atrazine to reduce cost, applied POST to emerged kochia and PRE to corn
Roundup PowerMax + Status (5 fl oz) POST (requires RR corn). Glyphosate will get grasses but Verdict offers a different mode of action.
Soybean
Gramoxone or dicamba (XtendFlex soybeans are required) for burndown control of emerged kochia.
Fierce EZ[4] (full rate for soil type) fb Roundup PowerMax + dicamba or Liberty (dicamba or Liberty requires XtendFlex soybeans)
Fierce EZ may not get emerged kochia in spring burndown and twelve months may not be enough time to sugarbeet in dry conditions.
Liberty (requires Enlist, LibertyLink, LLGT27, or XtendFlex soybean) must be applied on less than 3-inch kochia and requires warm temperatures, sun, and humid conditions.
Spring Wheat
Gramoxone or a Gramoxone + Sharpen mix in the spring burndown.
Starane NXT[5] (full rate) or Huskie FX[6] (full rate) (the goal is to apply 1.5 to 2 oz/A fluroxypyr per acre)
Cleansweep D or Kochiavore (both have Starane + bromoxynil + 2,4-D). First choice is Huskie FX.

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.

Material and Methods
Field experiments. Field experiments were conducted on natural kochia populations that were a mixture of glyphosate susceptible and glyphosate resistant biotypes near Horace, ND and Manvel, ND in 2021 (Table 1). Soil residual herbicides were applied before and after planting. The entire experimental area was tilled using a Kongskilde s-tyne cultivator with rolling baskets once preplant soil residual herbicides were applied to remove variability with tillage treatments. Sugarbeet was seeded in 22-inch rows at about 61,000 seeds per acre with 4.7 inch spacing between seeds. Treatments were applied with a bicycle sprayer through appropriate nozzles and CO_2 pressured to deliver 17 GPA spray solution to the center four rows of six row plots, 35 feet in length. Experiments were conducted to evaluate soil applied applications of ethofumesate PRE and POST applications of Betamix, Ultra Blazer, and ethofumesate rates and timings to maximize kochia control and minimize sugarbeet injury.

---
[1] Valor requires up to 10 months after application crop rotation restriction to sugarbeet; tillage effects restriction.
[2] Atrazine requires a second cropping season after herbicide application crop rotation restriction to sugarbeet.
[3] Sharpen requires 5-6 months after application crop rotation restriction to sugarbeet (depending on rate used).
[4] Fierce EZ requires up to 12 months after application crop rotation restriction to sugarbeet.
[5] Starane NXT requires a 9 month after application crop rotation restriction to sugarbeet.
[6] Huskie FX requires a 9 month after application crop rotation restriction to sugarbeet.

Table 1. Herbicide treatment, rate, and application timing, Horace and Manvel ND, 2021.

Treatment	Rate (fl oz/A)	Kochia (inches)
Etho[1] / RU PowerMax[2]	64 / 28	PPI / 3
Etho / RU PowerMax	96 / 28	PPI / 3
Etho / RU PowerMax	120 / 28	PPI / 3
Etho / RU PowerMax	64 / 28	PRE / 3
Etho / RU PowerMax	96 / 28	PRE / 3
Etho / RU PowerMax	120 / 28	PRE / 3
Etho + RU PowerMax[3] / Etho + RU PoweMax	4 +28 / 4 + 28	1 / 3
Ultra Blazer[4]	16	3
Ultra Blazer + RU PowerMax + Etho	16 + 28 + 4	3

[1] etho = ethofumesate.

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

[3]Roundup PowerMax + ethofumesate 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.

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 2021.2 software package.

Greenhouse experiment. An experiment was conducted in the greenhouse to determine kochia control from Ultra Blazer. Kochia was grown in a flat containing a general-purpose greenhouse growing media (PRO-MIX BX, Quackertown, PA) and transplanted to 4 × 4-inch greenhouse pots. Herbicide treatments (Table 2) were applied when kochia reached 4-inches tall using a DeVries Generation III spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet 8001XR nozzle calibrated to deliver 10.5 GPA spray solution at 40 psi and 3 mph. Visual percent kochia control was evaluated using a 0% to 100% scale (0 is no control and 100 is complete control) 14 and 21 days after application (DAA). Data was analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Table 2. Herbicide treatment, rate, and application timing, greenhouse, 2021.

Treatment	Rate (fl oz /A)	Kochia (inches)
Ultra Blazer	16	4
Ultra Blazer + NIS	16 + 0.25% v/v	4
Ultra Blazer + PowerMax + AMS + NIS	16 + 28 + 2.5% v/v +0.25% v/v	4
Untreated Control		4

Results and Discussion

Ethofumesate followed by Roundup PowerMax. A rain event to incorporate ethofumesate occurred 19 and 13 DAA at Horace and Manvel, respectively, in 2021. At Horace, kochia control was similar from Roundup PowerMax following ethofumesate averaged across rates and application method (Table 3). At Manvel, kochia control tended to be greater from Roundup PowerMax following ethofumesate applied PRE and average across rates as compared with kochia control from Roundup PowerMax following ethofumesate applied PPI. Incorporation moves ethofumesate into the soil. However, caution must be taken to ensure incorporation does not move ethofumesate too deep into the soil. Kochia control across locations tended to increase when ethofumesate was applied at 6 or 7.5 pt/A as compared with kochia control from ethofumesate at 4 pt/A. Kochia population was glyphosate-susceptible at both sites, so there were only modest differences across treatments following glyphosate application. Kochia control is greatest in sugarbeet when Roundup PowerMax follows ethofumesate and is applied to small kochia escapes or when Roundup PowerMax alone (not presented) or tank mixed ethofumesate is repeated three times during the growing season, beginning when kochia is less than 3-inches tall.

Table 3. Visible kochia control in response to herbicide treatment, Horace and Manvel ND, 2021.[1]

		Kochia Control			
		Horace		Manvel	
Treatment	Rate	28 DAT	42 DAT	7 DAT	21 DAT
	---fl oz/A---	---------------------------%-------------------------			
Etho[2] / RU PowerMax[3]	64 / 28	85 b	70 d	73 b	78 abc
Etho / RU PowerMax	96 / 28	90 ab	83 bc	73 b	79 abc
Etho / RU PowerMax	120 / 28	97 a	94 a	80 ab	82 ab
Etho / RU PowerMax	64 / 28	86 b	73 cd	93 a	92 a
Etho / RU PowerMax	96 / 28	94 a	88 ab	80 ab	86 ab
Etho / RU PowerMax	120 / 28	92 ab	76 cd	88 ab	94 a
Etho + RU PowerMax[4] / Etho + RU PowerMax	4 +28 / 4 + 28	85 b	70 d	85 ab	75 bc
Ultra Blazer[5]	16	25 c	10 e	50 c	32 d
Ultra Blazer + RU PowerMax + Etho	16 + 28 + 4	91 ab	73 cd	80 ab	66 c
LSD (0.10)		**8**	**11**	**16**	**13**

[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]etho = ethofumesate.
[3]Roundup PowerMax applied with Prefer 90 NIS at 0.25%v/v and Amsol Liquid AMS at 2.5% v/v.
[4]Roundup PowerMax + ethofumesate applied with Destiny HC HSMOC at 1.5 pt/A and Amsol Liquid AMS at 2.5 % v/v.
[5]Ultra Blazer applications applied with Prefer 90 non-ionic surfactant at 0.125% v/v.

Kochia control with Ultra Blazer. Kochia control from Ultra Blazer across locations and years has been inconsistent (Table 4). Some of the inconsistency is attributed to kochia size at application since Ultra Blazer application must be timed to sugarbeet growth stage. Ultra Blazer application for control of glyphosate-resistant kochia must be used in a program approach with products providing partial kochia control.

Table 4. Visible kochia control in response to herbicide treatment, Horace and Manvel ND, 2020 and 2021.[1]

		Horace		Manvel	
Treatment[2]	Rate	2020	2021	2020	2021
	---fl oz/A---	-------------------------%-------------------------			
Ethofumesate PRE / RU PowerMax	120 / 28	75 a	92 a	80 b	94 a
Ultra Blazer	16	25 b	25 b	83 b	33 c
Ultra Blazer + RU PowerMax	16 + 28	86 a	91 a	96 a	66 b
LSD (0.10)		**10**	**8**	**11**	**13**

[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]All POST treatments applied with Prefer 90 NIS at 0.25%v/v and Amsol Liquid AMS at 2.5% v/v.

Ultra Blazer plus Roundup PowerMax with AMS and NIS improved visible kochia control compared with Ultra Blazer alone (Table 4, Table 5) and tended to provide greater fresh weight reduction compared with Ultra Blazer alone with or without NIS (Table 5). The greenhouse experiment was a two-replication demonstration experiment, so the results were variable. Kochia control was less 21 DAA as compared with 10 DAA, due to incomplete kochia kill and regrowth following herbicide treatment.

Table 5. Visible kochia control and kochia fresh weight reduction in response to herbicide treatment, 10, 18, and 21 DAT, greenhouse, 2021.[1]

Treatment	Rate	Visible Kochia Control		Fresh Weight Reduction
		10 DAT	18 DAT	21 DAT
	--fl oz /A--	---------------------%--------------------------		
Ultra Blazer	16	55 a	30 c	23 b
Ultra Blazer + NIS	16 + 0.25% v/v	55 a	55 b	37 ab
Ultra Blazer + RU PowerMax + AMS + NIS	16 + 28 + 2.5% v/v + 0.25% v/v	78 a	80 a	68 a
Untreated Control	-	0 b	0 d	-
LSD (0.20)		**22**	**15**	**41**

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

Kochia was grown up to 4-inches tall before application in the greenhouse to ensure treatment differences. Previous research, along with our own field observations, reinforce the importance of kochia size at Ultra Blazer application. Wicks (Wicks et al. 1997) reported kochia control was dependent on size at Ultra Blazer application (Figure 2). In general, their results suggest kochia size should be less than 2-inches to achieve 60% or greater kochia control at 32 fl oz/A. Ultra Blazer at 16 fl oz/A is the maximum rate in sugarbeet.

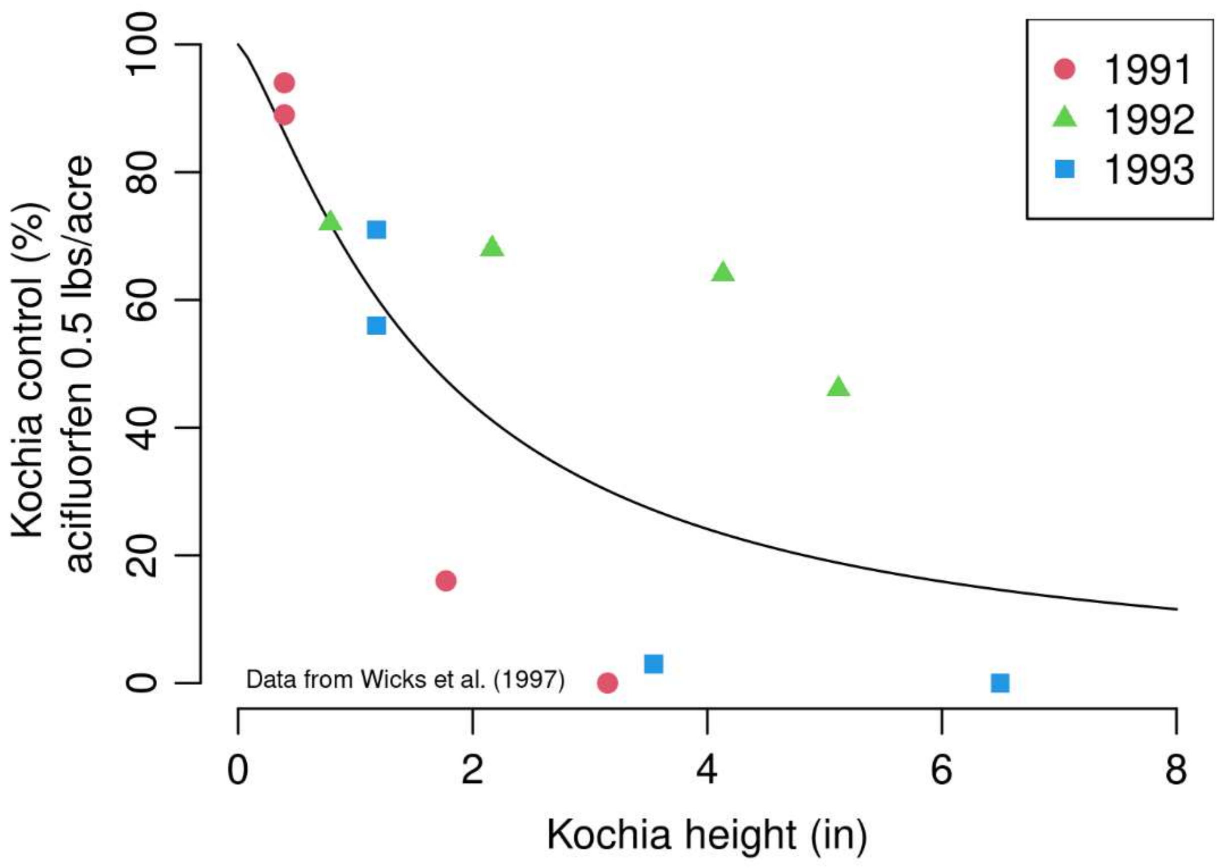


Figure 2. Visible kochia control (%) in response to Ultra Blazer at 2 pt/A at various kochia height (in), 1991, 1992, and 1993. Figure adapted by Kniss using data from Wicks et al. 1997.

Recommendations in sugarbeet

Eastern North Dakota and Minnesota. Ethofumesate at 6 pt/A or greater 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. At this point, we do not have sufficient information to support kochia control in sugarbeet with Ultra Blazer or Ultra Blazer plus glyphosate.

Sidney Sugars, Recommendations in Sugarbeet. The biotype in western North Dakota appears to be resistant, or glyphosate control is influenced by environmental conditions at application. We recommend spraying small kochia with full glyphosate rates and adjuvants. We recommend a program approach including ethofumesate (fall or spring applied) followed by glyphosate. At this point, we do not have data to support Ultra Blazer use in sugarbeet in Williams or McKenzie counties in North Dakota or eastern Montana.

Fall. After fall ridging and before sugarbeet.

Ethofumesate (Nortron, Ethotron, Nektron, or Ethofumesate 4SC) at 4 to 6 pt/A depending on organic matter (OM) and soil texture.

Up to 3 pt/A if spring ethofumesate application follows fall application. We recommend no spring re-ridging since tillage will disturb the herbicide layer.

Spring. Sugarbeet plant.

Ethofumesate PRE at 3 to 6 pt/A depending on OM and soil texture.

Apply ethofumesate as early as possible to, and in advance of, spring rains.

Glyphosate plus ethofumesate, POST. A total of 12 fl oz/A ethofumesate can be applied in sugarbeet.

Use full rates of glyphosate products with adjuvants depending on formulation.

Apply to 3-inches or less kochia with water volumes to achieve good coverage.

Acknowledgements

We wish to thank Mr. Scott Johnson, Manvel, ND, for his collaboration with field research in 2020 and 2021.

References

Peters TJ and Luecke AB (2016) Kochia control in sugarbeet – a progress report. Sugarbeet Res Ext Rep. 46:41-44

Peters TJ and Lystad AL (2021) Kochia control in sugarbeet. Sugarbeet Res Ext Rep. 51:18-23

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

Wicks GA, Martin AR and Hanson GE (1997) Controlling kochia (*Kochia scoparia*) in soybean (*Glycine max*) with postemergence herbicides. Weed Technol. 11:567-572

COMMON LAMBSQUARTERS CONTROL WITH THE BENSON, MN SEED SOURCE

Thomas J. Peters[1], Ryan M. Borgen[2], and Alexa L. Lystad[3]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist and [3]Senior Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND, and [2]Research Specialist,
North Dakota State University

Summary
Greenhouse experiments confirmed the Benson common lambsquarters seed source is not as sensitive to glyphosate treatment as compared with the greenhouse common lambsquarters seed source.
We will continue to conduct experiments, searching for an effective tank mixture partner.
We will continue to recommend full glyphosate rates, glyphosate with adjuvants, and glyphosate mixtures, when possible, for common lambsquarters control.

Introduction
I spoke with a producer about concerns with controlling common lambsquarters with glyphosate near Benson, MN in 2021. The conversation was compelling enough that I decided to visit the field since glyphosate-resistant common lambsquarters is a threat to sugarbeet growers. The field was indeed a population of common lambsquarters that was not sufficiently controlled with glyphosate. We elected to conduct a probe experiment. We also collected seed for greenhouse evaluation at sugarbeet harvest.

Materials and Methods
A field experiment was conducted on indigenous populations of common lambsquarters in a field near Benson, MN in 2021. Sugarbeet was at the 8-lf stage and escaped common lambsquarters were 12-inches tall at application. 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. Application information can be found in Table 1. Visible sugarbeet injury (0% to 100%, 100% indicating complete loss of sugarbeet stature) and common lambsquarters control (0% to 100%, 100% indicating complete control) were collected at multiple time points. The number of surviving common lambsquarters plants per plot (4 rows spaced 22-inch and 35 ft long) were counted at multiple time points and seed was collected shortly before sugarbeet harvest. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Table 1. Application information, Benson, MN 2021.

Date	June 10, 2021
Time of Day	10:00AM
Air Temperature (F)	95F
Relative Humidity (%)	42%
Wind Velocity (mph)	3 mph
Wind Direction	W
Soil Temp. (F at 6”)	80F
Soil Moisture	dry
Cloud Cover (%)	-
Sugarbeet stage	8 lvs
Common lambsquarters height	up to 12-inches

A greenhouse experiment was conducted with a putative glyphosate sensitive and resistant common lambsquarters seed source. Common lambsquarters seeded in a flat filled with PROMIX general purpose greenhouse media (Premier Horticulture, Inc., Quakertown, PA) to 1-inch was transplanted in 4 × 4-inch pots. Four common lambsquarters plants per pot was grown to approximately 4-inches at 75F to 81F 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® 8001 XR nozzle calibrated to deliver 10.5 gpa spray solution at 40 psi and 3 mph. Visible common lambsquarters control (0% to 100%, 100% indicating complete control) was evaluated 5, 14, 28, and 35 days after treatment (DAT). Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Results and Discussion

Common lambsquarters control generally was the same across glyphosate treatments at the field experiment near Benson, MN. Roundup PowerMax alone provided only 80% common lambsquarters control and control was improved when adjuvants were combined with glyphosate or glyphosate and adjuvant mixtures with ethofumesate (Table 2).

Table 2. Visible common lambsquarters control in response to treatment, Benson, MN, 2021.[a]

Herbicide Treatment[b]	Herbicide rate	Lambsquarters Control: Count per plot	Lambsquarters Control: 113 DAT[c]
	------fl oz /A------	---Number---	--%--
PowerMax	28	3.5 a	80
PowerMax	32	3.0 a	80
PowerMax + Prefer 90 NIS+ AMS	28 + 0.25% + 2.5 %	0.5 b	90
PowerMax + Prefer 90 NIS+ AMS	32 + 0.25% + 2.5 %	2.3 a	89
PowerMax + ethofumesate +NIS + AMS	28 + 6 + 0.25% + 2.5%	0.8 b	96
LSD (0.20)		1.4	NS

[a]Means within a rating that do not share any letter are significantly different by the LSD at the 20% level of significance.
[b]NIS=Non-ionic surfactant; AMS=liquid ammonium sulfate
[c]DAT=Days after treatment

We observed glyphosate symptomology on the greenhouse common lambsquarters source within 3 DAT. Symptomology develop slower with the Benson seed source but control was similar 5 DAT (Table 3). Roundup PowerMax applied on the greenhouse seed source improved common lambsquarters control 14 DAT compared with glyphosate alone, glyphosate with adjuvants or glyphosate, adjuvants, and herbicide mixtures, 14 DAT.

Table 3. Visible common lambsquarters control in response to treatment, Benson, MN and greenhouse seed source, greenhouse, 2022.[a]

Herbicide Treatment[b]	Herbicide rate	Seed Source[c]	Lambsquarters Control: 5 DAT[d]	14 DAT	28 DAT	35 DAT
	------fl oz /A------		-------------------%------------------			
PowerMax	28	Benson	40 b	53 bc	65 bc	71 bc
PowerMax	32	Benson	20 c	55 bc	72 b	78 b
PowerMax + Prefer 90 NIS[c]+ AMS[d]	28 + 0.25% + 2.5 %	Benson	43 ab	63 b	70 bc	78 b
PowerMax + Prefer 90 NIS+ AMS	32 + 0.25% + 2.5 %	Benson	40 b	53 bc	67 bc	70 bc
PowerMax + Nortron + Destiny HC + AMS	32 + 6 + 1.5 pt + 2.5%	Benson	13 c	47 bc	55 c	54 d
PowerMax + Spin-Aid + Destiny HC + AMS	32 + 20 + 1.5 pt + 2.5%	Benson	5 c	43 c	56 bc	55 cd
PowerMax	28	GH	45 ab	99 a	99 a	99 a
PowerMax + Prefer 90 NIS+ AMS	32 + 0.25% + 2.5 %	GH	60 a	97 a	97 a	99 a
PowerMax	32	GH	50 ab	93 a	95 a	97 a
LSD (0.10)			14	15	14	12

[a]Means within a rating that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]NIS = non-ionic surfactant; AMS = ammonium sulfate
[c]Seed Source was collected from near Benson, MN in 2021; greenhouse seed source collected in 2021.
[d]DAT=Days after treatment

Adjuvants, ethofumesate or phenmedipham (Spin-Aid) did not improve common lambsquarters control from glyphosate at 28 or 32 fl oz/A on the Benson common lambsquarters seed source. At 35 DAT, we began to observe evidence of lambsquarters regrowth, although overall control continued to slowly improve, 14 to 35 DAT.

Roundup PowerMax at 28 fl oz/A controlled common lambsquarters using the greenhouse seed source (Figure 1). Roundup PowerMax at 28 or 32 fl oz/A did not control common lambsquarters using the Benson seed source, although sugarbeet probably would have a competitive advantage over the surviving common lambsquarters. We also observed segregation, Roundup PowerMax controlling one or two but not all common lambsquarters within the pot.

Figure 1. Common lambsquarters from left to right: untreated control; Roundup PowerMax at 28 fl oz/A, Benson source; Roundup PowerMax at 32 fl oz/A, Benson source; Roundup PowerMax at 28 fl oz/A, greenhouse source.

Conclusions

We are monitoring two common lambsquarters seed sources where Roundup PowerMax is not providing acceptable control. We intend to conduct field experiments to further evaluate common lambsquarters control.

VOLUNTEER ROUNDUP READY CANOLA CONTROL WITH ULTRA BLAZER

Thomas J. Peters[1], Ryan M. Borgen[2], and Alexa L. Lystad[3]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist and [3]Senior Research Specialist
North Dakota State University & University of Minnesota, Fargo, ND, and [2]Research Speicalist,
North Dakota State University

Summary
Ultra Blazer applied at 16 fl oz/A with non-ionic surfactant at 0.125% v/v controlled 2- to 3-inch and 4- to 6-inch canola.
Although sugarbeet safety was not an objective of this experiment, we remind producers that sugarbeet must be greater than 6-lf stage for application of Ultra Blazer.

Introduction
Volunteer Roundup Ready® Canola is one of the most difficult weeds to control in sugarbeet. Our previous research established UpBeet (triflusulfuron-methyl, group 2) as the most effective herbicide for volunteer canola control. Volunteer canola germinates and emerges across time in sugarbeet so repeat UpBeet applications are the only effective approach for control. Sugarbeet Extension recommends two or three repeat UpBeet applications at 0.5 to 0.75 lb/A once volunteer canola has reached the 2-lf stage.

Adam Bernhardson from North Star Ag Services wrote and mentioned that Flexstar, (fomesafen, group 14) at low rates has proven to be an excellent way to control volunteer canola in soybean. Adam inquired if Ultra Blazer might be equally as effective in sugarbeet since the herbicides share the same mode of action. The objective of this experiment was to determine control of 2- to 3-inch and 4- to 6-inch volunteer canola from Ultra Blazer.

Materials and Methods
A single greenhouse experiment was conducted in 2022. Pots were filled with PROMIX general purpose greenhouse media (Premier Horticulture, Inc., Quakertown, PA) and four equally spaced canola seeds were planted to a depth of 1-inch in 4 × 4-inch pots. Canola were grown to 2- to 3-inch and 4- to 6-inch at 75F to 81F under natural light supplemented with a 16 h photoperiod of artificial light. Herbicide treatments (Table 1) were applied using a spray booth (Generation III, DeVries Manufacturing, Hollandale, MN) equipped with a TeeJet® 8001 XR nozzle calibrated to deliver 10.5 gpa spray solution at 40 psi and 3 mph. Visible canola control (0% to 100%, 100% indicating complete control) was evaluated 3, 7, and 14 days after treatment (DAT). Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2021.2 software package.

Table 1. Herbicide treatment, rate, and volunteer RR canola growth stage, NDSU greenhouse complex, 2022.

Herbicide Treatment	Herbicide rate	Sugarbeet stage
	-------fl oz /A-------	--leaves--
Untreated Control	-	-
Ultra Blazer	16	2-3
Ultra Blazer + NIS[a]	16 + 0.25%	2-3
Ultra Blazer + PowerMax + AMS[b] + NIS	16 + 28 + 2.5% v/v +0.25% v/v	2-3
Ultra Blazer	16	4-6
Ultra Blazer + NIS	16 + 0.25%	4-6
Ultra Blazer + PowerMax + AMS + NIS	16 + 28 + 2.5% v/v +0.25% v/v	4-6

[a]NIS=non-ionic surfactant
[b]AMS=liquid ammonium sulfate

Results and Discussion

Ultra Blazer alone, Ultra Blazer with non-ionic surfactant (NIS) or Ultra Blazer with Roundup PowerMax and NIS and ammonium sulfate (AMS) controlled 2- to 3-inch canola, 8 DAT. Control from Ultra Blazer with NIS or Ultra Blazer with Roundup PowerMax with NIS and AMS provided similar control, 8 DAT, on 4- to 6-inch canola. However, Ultra Blazer alone provided less 4- to 6-inch canola control than Ultra Blazer with NIS, 8 DAT. However, sugarbeet must be greater than the 6-lf stage to achieve acceptable sugarbeet safety.

Table 2. Visual growth reduction in response to herbicide treatment and growth stage, greenhouse, 2022.[a]

Herbicide Treatment	Herbicide rate	Growth Stage	Canola growth reduction 3 DAT[b]	3 DAT	8 DAT	8 DAT	13 DAT
	------fl oz /A------	--lvs--	-------------------------%-------------------------				
Untreated Control			0 d	0 c	0 b	0 c	0 b
Ultra Blazer	16	2-3	50 c	-	97 a	-	98 a
Ultra Blazer + NIS[c]	16 + 0.25%	2-3	78 a	-	98 a	-	99 a
Ultra Blazer + PowerMax + AMS[d] + NIS	16 + 28 + 2.5% v/v + 0.25% v/v	2-3	60 b	-	99 a	-	99a
Ultra Blazer	16	4-6	-	65 b	-	81 b	-
Ultra Blazer + NIS	16 + 0.25%	4-6	-	73 ab	-	94 a	-
Ultra Blazer + PowerMax + AMS + NIS	16 + 28 + 2.5% v/v + 0.25% v/v	4-6	-	76 a	-	96 a	-
LSD (0.10)			9	10	2	6	1
P-Value			0.0001	0.0001	0.0001	0.0001	0.0001

[a] Means within a rating that do not share any letter are significantly different by the LSD at the 10% level of significance.
[b]DAT=Days after treatment
[c]NIS=Non-ionic surfactant
[d]AMS=liquid ammonium sulfate

Conclusions

Ultra Blazer controls volunteer RR canola. NIS is usually recommended with Ultra Blazer. NIS with Ultra Blazer improved control of 4- to 6-inch canola as compared with Ultra Blazer alone. We did not attempt to control canola greater than 6-inches. It would surmise that Ultra Blazer would provide control of canola greater than 6-inches, provided there was good coverage.

TURNING POINT SURVEY OF WEED CONTROL AND PRODUCTION PRACTICES IN SUGARBEET IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2021

Tom J. Peters[1], Mohamed F.R. Khan[1], Alexa Lystad[2], and Mark A. Boetel[3]

[1]Extension Sugarbeet Specialist and [2]Sugarbeet Research Specialist

North Dakota State University & University of Minnesota, Fargo, ND

and

[3]Professor, Dept. of Entomology, North Dakota State University

The sixth annual weed control and production practices live polling questionnaire was conducted using Turning Point Technology at the 2022 winter Sugarbeet Grower Seminars. Responses are based on production practices from the 2021 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 indicated the county in which the majority of their sugarbeet were produced (Tables 1, 2, 3, 4). Survey results represent approximately 162,042 acres reported by 168 respondents (Table 5) compared with 193,050 acres represented in 2019. The average sugarbeet acreage per respondent grown in 2021 was calculated from Table 5 at 965 acres compared with 697 acres in 2019.

Survey participants were asked a series of questions regarding their production practices used in sugarbeet in 2021. Sixty percent of respondents indicated wheat was the crop preceding sugarbeet (Table 6), 26% indicated corn, and 10% indicated soybean. Preceding crop varied by location with 94% of Grand Forks growers indicating wheat preceded sugarbeet and 70% of Willmar growers indicated corn as their preceding crop. Eighty-two percent of growers who participated in the winter meetings used a nurse or cover crop in 2021 (Table 7) which increased from 77% in 2019. Cover crop species also varied widely by location with wheat being used by 40% of growers at the Grafton meeting and barley being used by 57% of growers at the Wahpeton meeting.

Growers indicated weeds were their most serious production problem in sugarbeet in 2021 (Table 8) with 32% of all respondents naming weeds compared with CLS (Cercospora Leaf Spot) being named most serious problem by 42% of participants in 2019. In 2021, CLS was the most serious problem for 29% of respondents and emergence or stand was named as most serious by 23% of respondents.

Waterhemp was named as the most serious weed problem in sugarbeet in 2021 by 73% of respondents (Table 9) compared with 54% in 2019. Thirteen percent of respondents indicated kochia, 7% said common ragweed, and 3% of respondents indicated common lambsquarters were their most serious weed problem in 2021. The increased presence of glyphosate-resistant waterhemp and kochia are likely the reason for these weeds being named as the worst weeds. Troublesome weeds varied by location with greater than 93%, 89%, and 93% 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 5 glyphosate applications in their 2021 sugarbeet crop (Table 10) with a calculated average of 1.99 applications per acre. The calculated average in 2019 was 2.16 applications per acre.

Glyphosate was most commonly applied with a chloroacetamide herbicide postemergence (lay-by) in 2021 with 49% of responses indicating this herbicide combination was used (Table 11). Glyphosate applied with a broadleaf herbicide postemergence was the second most common herbicide used in sugarbeet in 2021 with 31% of responses. Glyphosate alone and glyphosate plus a grass herbicide were the third and fourth most common at 10% and 7% of the responses, respectively.

Preplant incorporated (PPI) or preemergence (PRE) herbicides were applied by 75% of survey respondents in 2021 (Table 12). Thirty-one percent of Grafton survey participants applied a PPI or PRE herbicide compared with 13% in 2019. Conversely, 90% of Wahpeton survey participants applied a PPI or PRE herbicide in sugarbeet in 2021 compared with 89% in 2019. 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 herbicide was *S*-metolachlor with 32% of all responses followed by a combination of *S*-metolachlor plus ethofumesate with 25% of responses. Of the growers who indicated using a soil-applied herbicide, 51% indicated excellent to good weed control from that herbicide (calculated from Table 13).

The application of soil-residual herbicides applied 'lay-by' to the 2021 sugarbeet crop was indicated by 86% of respondents (Table 14). *S*-metolachlor was the most commonly applied lay-by herbicide with 45% of responses. The majority of growers responding at the Willmar meeting indicated using Outlook (83% of responses), while S-metolachlor was more commonly applied by growers of the Fargo (93% of responses) and Wahpeton (62% of responses) meetings.

Satisfaction of weed control from lay-by applications ranged from excellent to unsure (Table 15). Of respondents indicating they applied a lay-by herbicide, 78% indicated good or fair weed control (calculated from Table 15). Less than normal rainfall in April and May reduced the efficacy of PRE, early postemergence (EPOST), and postemergence (POST) applied soil-residual herbicides.

The Environmental Protection Agency (EPA) approved a 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 2021. 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. Thirty-seven percent of respondents applied Ultra Blazer in 2021 (Table 16). Of the growers who used Ultra Blazer, 14% applied Ultra Blazer alone, 12% applied Ultra Blazer with NIS and 8% tank mixed Ultra Blazer with glyphosate, NIS, and AMS.

Satisfaction of weed control from Ultra Blazer ranged from excellent to poor (Table 17). Of respondents indicating they applied Ultra Blazer, 27% indicated excellent to good weed control (calculated from Table 17).

Row-crop cultivation of the 2021 sugarbeet crop was reported by 32% of respondents (calculated from Table 18). Twelve percent reported row-crop cultivation on less than ten percent of their acres (Table 18). Conversely, 8% reported row-crop cultivation on 100% of their acres.

Hand-weeding the 2021 sugarbeet crop was reported by 75% of respondents (Table 19). Most respondents who hand-weeded indicated 10-50% of their acres were hand-weeded. Fewer than half of the respondents indicated hand-weeding at the Fargo meeting, while greater than half the participants at the Grafton, Grand Forks, and Willmar meetings reported some hand weeding.

Table 1. 2022 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Cass	2	29
Clay	1	14
Norman[1]	2	29
Richland	1	14
Traill	1	14
Total	7	100

[1]Includes Mahnomen County

Table 2. 2022 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Grand Forks	1	6
Kittson	1	6
Marshall	2	13
Pembina	4	25
Walsh	6	37
Other	2	13
Total	16	100

Table 3. 2022 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Grand Forks	7	18
Mahnomen	1	3
Marshall	2	5
Polk	17	43
Traill	1	3
Walsh	2	5
Other	9	23
Total	39	100

Table 4. 2022 Wahpeton Grower Seminar - Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Clay	7	10
Grant	6	9
Richland	16	25
Traverse	3	5
Wilkin	33	51
Total	65	100

Table 5. Total sugarbeet acreage operated by respondents in 2021.

Location	Responses	Acres of sugarbeet <99	100-199	200-299	300-399	400-599	600-799	800-999	1000-1499	1500-1999	2000+
		-----% of responses-----									
Fargo	12	17	0	0	17	17	8	0	17	17	8
Grafton	16	13	6	0	13	19	6	19	13	6	6
Grand Forks	38	13	8	2	11	16	11	11	8	2	18
Wahpeton[1]	65	0	11	0	34	0	17	38	0	0	0
Willmar	37	24	5	11	3	16	14	3	16	5	3
Total	168	11	8	3	5	23	7	11	8	18	6

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

Table 6. Crop grown in 2020 that preceded sugarbeet in 2021.

Location	Responses	Previous Crop Barley	Canola	Sweet Corn	Field Corn	Dry Bean	Potato	Soybean	Wheat	Other
		-----% of responses-----								
Fargo	14	0	0	0	0	0	0	7	86	7
Grafton	15	0	0	0	0	20	7	7	66	0
Grand Forks	39	0	0	0	3	0	0	0	94	3
Wahpeton	65	0	0	0	14	0	0	20	66	0
Willmar	40	0	0	20	70	0	0	8	3	0
Total	173	0	0	5	21	2	1	10	60	1

Table 7. Nurse or cover crop used in sugarbeet in 2021.

Location	Responses	Barley	Oat	Rye	Wheat	Other[1]	None
		-----% of responses-----					
Fargo	10	30	0	0	30	0	40
Grafton	15	40	7	0	40	0	13
Grand Forks	38	55	0	3	18	0	24
Wahpeton	62	57	3	8	19	2	11
Willmar[2]	-	-	-	-	-	-	-
Total	125	52	2	5	22	1	18

[1]Includes Mustard and 'Other'

[2]Information not collected during Wilmar Grower Seminar.

Table 8. Most serious production problem in sugarbeet in 2021.

Location	Responses	CLS[1]	Rhizo-mania	Aph[2]	Rhizoc-tonia	Fusarium	Herbicide Injury	Root Maggot	Weeds	Stand[3]
			-----------------------------% of responses--							
Fargo	14	58	0	0	14	7	0	0	7	14
Grafton	17	59	0	6	0	0	0	12	6	17
Grand Forks	39	36	0	0	8	0	0	2	26	28
Wahpeton	63	21	0	0	13	0	2	0	41	23
Willmar	40	15	0	0	13	0	5	0	43	24
Total	173	29	0	1	10	1	2	2	32	23

[1]Cercospora Leaf Spot

[2]Aphanomyces

[3]Emergence/Stand

Table 9. Most serious weed problem in sugarbeet in 2021.

Location	Responses	palmer[1]	colq	cora	kochia	gira	rrpw	RR Canola	wahe
		-----------------------------------% of responses---------------------------							
Fargo	14	0	0	7	0	0	0	0	93
Grafton	14	0	7	0	57	0	7	7	22
Grand Forks	39	0	8	26	23	5	3	3	32
Wahpeton	65	0	2	2	5	0	2	0	89
Willmar	43	0	2	0	5	0	0	0	93
Total	175	0	3	7	13	1	2	1	73

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

Table 10. Average number of glyphosate applications per acre in sugarbeet during 2021 season.

Location	Responses	0	1	2	3	4	5
		--------------------------% of responses----------------------------					
Fargo	11	0	27	73	0	0	0
Grafton	11	0	27	55	18	0	0
Grand Forks	39	3	5	82	10	0	0
Wahpeton	64	0	16	64	20	0	0
Willmar[1]	-	-	-	-	-	-	-
Total	125	1	14	70	15	0	0

[1]Information not collected during Wilmar Grower Seminar.

Table 11. Herbicides used in a weed control systems approach in sugarbeet in 2021.

Location	Responses	Glyphosate Application Tank-Mixes					
		Gly Alone	Gly+Lay-by	Gly+Broadleaf	Gly+Grass	Other	None Used
		--------% of responses--------					
Fargo	17	6	59	35	0	0	0
Grafton[1]	-	-	-	-	-	-	-
Grand Forks	30	18	43	37	0	0	2
Wahpeton[1]	-	-	-	-	-	-	-
Willmar	40	5	78	35	25	5	0
Total	87	10	49	31	7	2	1

[1]Information not collected during Grafton or Wahpeton Grower Seminar.

Table 12. Preplant incorporated or preemergence herbicides used in sugarbeet in 2021.

Location	Responses	PPI or PRE Herbicides Applied					
		S-metolachlor	ethofumesate	Ro-Neet SB	S-metolachor +ethofumesate	Other	None
		--------% of responses--------					
Fargo	17	53	23	0	12	0	12
Grafton	13	15	8	0	8	0	69
Grand Forks	43	22	12	0	12	5	49
Wahpeton	67	42	12	0	33	3	10
Willmar	41	22	27	0	37	0	15
Total	181	32	16	0	25	2	25

Table 13. Satisfaction in weed control from preplant incorporated and preemergence herbicides in 2021.

Location	Responses	PPI or PRE Weed Control Satisfaction					
		Excellent	Good	Fair	Poor	Unsure	None Used
		--------% of responses--------					
Fargo	14	21	50	21	0	0	7
Grafton	10	0	20	10	10	0	60
Grand Forks	38	0	40	13	0	0	47
Wahpeton	65	3	62	25	6	0	4
Willmar	42	2	36	40	7	5	10
Total	169	4	47	25	5	1	18

Table 14. Soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2021.

Location	Responses	Lay-by Herbicides Applied				
		S-metolachlor	Outlook	Warrant	Other	None
		---% of responses---				
Fargo	14	93	7	0	0	0
Grafton	11	18	9	0	0	73
Grand Forks	41	49	10	2	2	37
Wahpeton	64	62	34	2	0	2
Willmar	41	10	83	15	2	2
Total	171	45	35	5	1	14

Table 15. Satisfaction of weed control from soil-residual herbicides applied early postemergence (lay-by) in sugarbeet in 2021.

Location	Responses	Lay-by Weed Control Satisfaction					
		Excellent	Good	Fair	Poor	Unsure	None Used
		---% of responses---					
Fargo	12	34	50	8	8	0	0
Grafton	12	0	8	17	17	0	58
Grand Forks	46	9	48	9	4	4	26
Wahpeton	61	2	57	36	3	0	2
Willmar	43	5	37	51	5	0	2
Total	174	7	46	29	5	1	12

Table 16. Herbicides applied with Ultra Blazer in sugarbeet in 2021.

Location	Responses	Ultra Blazer Application Tank-Mixes					
		UB Alone	UB+NIS	UB+Gly	UB+Gly+NIS+AMS	Unsure	None Used
		---% of responses---					
Fargo	11	0	27	0	9	0	64
Grafton	12	0	0	0	0	0	100
Grand Forks	46	4	10	4	4	0	78
Wahpeton	62	32	13	2	8	0	45
Willmar	37	3	14	5	16	0	62
Total	168	14	12	3	8	0	63

Table 17. Satisfaction in weed control from Growers' reporting Ultra Blazer applied in sugarbeet in 2021.

Location	Responses	Satisfaction of Weed Control from Ultra Blazer			
		Excellent	Good	Fair	Poor
		-----% of responses-----			
Fargo	3	0	33	67	0
Grafton	1	0	0	100	0
Grand Forks	11	0	45	55	0
Wahpeton	33	4	18	42	36
Wilmar	13	0	23	46	31
Total	61	2	25	47	26

Table 18. Percent of sugarbeet acres row-crop cultivated in 2021.

Location	Responses	% Acres Row-Cultivated				
		0	< 10	10-50	51-100	>100
		-----% of responses-----				
Fargo	9	67	22	11	0	0
Grafton	13	62	23	15	0	0
Grand Forks	45	84	13	3	0	2
Wahpeton[1]	-	-	-	-	-	-
Willmar	36	53	6	14	6	22
Total	103	68	12	10	2	8

[1]Information not collected during Wahpeton Grower Seminar.

Table 19. Percent of sugarbeet acres hand-weeded in 2021.

Location	Responses	% Acres Hand-Weeded				
		0	< 10	10-50	51-100	>100
		-----% of responses-----				
Fargo	11	55	36	0	0	9
Grafton	11	46	36	18	0	0
Grand Forks	45	31	53	16	0	0
Wahpeton[1]	-	-	-	-	-	-
Willmar	34	35	29	15	12	9
Total	101	25	29	40	3	3

[1]Information not collected during Wahpeton Grower Seminar.

SURVEY OF WEED CONTROL AND PRODUCTION PRACTICES ON SUGARBEET IN WESTERN NORTH DAKOTA AND EASTERN MONTANA IN 2021

Thomas J. Peters[1], Alexa Lystad[2], Mohamed F.R. Khan[1], and Mark A. Boetel[3]

[1]Extension Sugarbeet Specialists and [2]Research Specialist

North Dakota State University & University of Minnesota, Fargo, ND

and

[3]Research and Extension Entomologist, Dept. of Entomology, North Dakota State University

The twenty-first annual weed control and production practices survey was mailed and polled in 2021 to sugarbeet growers in western North Dakota and eastern Montana. Growers were requested to evaluate weed control and sugarbeet injury from specific herbicides, and to list the most important weed and production problems. In addition, growers were requested to list insecticide use, fungicide use, sugarbeet acreage, acres of hand-weeded sugarbeet, and weed control and crop injury evaluations. Insecticide use and fungicide use portions of the survey can be found in the Entomology and Plant Pathology sections of the 2021 Sugarbeet Research and Extension Reports.

Growers planted 31,500 acres of sugarbeet in eastern Montana in 2021. Twenty-one growers representing about 25% of the total acres responded to the survey. All of the 7,801 acres reported were Roundup Ready® (RR) sugarbeet.

Table 1 is a summary of herbicide use and performance averaged over all counties. The number of responses for an herbicide treatment is listed and the acres treated are expressed as a percentage of the total reported acreage. Multiple herbicide treatments are tabulated for each herbicide treatment, thus the number of responses in Table 1 exceeds the total number of growers who responded to the survey. Also, multiple herbicide treatments on the same acreage are listed separately in the tables, thus acres treated exceeds 100%. The ratings of weed control and sugarbeet injury are presented as the percentage of growers evaluating weed control as excellent, good, fair, or poor and injury as none, slight, moderate, or severe.

The herbicide trade names listed in the tables are original trade names. The original trade names also represent the generic formulations of the same active ingredient. Thus, Nortron also represents Ethofumesate 4SC, Ethotron, and Nektron; Stinger also represents Clean Slate and Spur; Dual Magnum as a lay-by herbicide also represents Brawl, Cinch, Charger Basic, Medal, and Mocassin; Outlook also represents Commit; and 'Grass Herbicide' represents Assure II, Select, Select Max, Arrow, Clethodim 2EC, Intensity, Section, Shadow, Volunteer, and Targa.

Total sugarbeet acreage treated with herbicides in 2021 was 146% (Table 1), compared to 128% in 2017, 223% in 2015, 220% in 2014, and 219% in 2011. Postemergence herbicides were applied 2.7 times per acre in 2021, compared to 2.4 times per acre in 2017, 2.2 times in 2015, 2.2 times in 2014 and in 2011. Preemergence (PRE) herbicides were only used on 22% of reported acres and glyphosate was the only reported PRE herbicide used. The most common herbicide treatment in 2021 was glyphosate. Stinger and Betamix were the only herbicides other than glyphosate used by respondents in 2021.

Growers were asked if they anticipated using a preplant incorporated (PPI) or preemergence (PRE) herbicide in the 2022 growing season in sugarbeet. Twenty-nine percent of respondents answered yes. The remaining 71% of respondents said they do not anticipate using a PPI or PRE herbicide in the 2022 growing season in sugarbeet.

Zero percent of all survey respondents reported excellent weed control for postemergence herbicides in 2021 (Table 1), compared to 38% in 2017, 46% in 2015, 50% in 2014, and 75% in 2011. Fifty-two percent of survey respondents reported no sugarbeet injury in 2021, compared to 86% in 2017, 92% in 2015, 78% in 2014, and 74% in 2011. The average number of glyphosate applications applied POST per acre in RR sugarbeets in 2021 was 2.81 (Calculated from Table 2 values).

Sugarbeet acreage managed by survey respondents in 2021 varied from 90 acres to 1,055 acres (Table 3). The average number of sugarbeet acres per respondent was 371 acres, respectively, in 2021 (Table 4).

Forty-five acres of sugarbeet were seeded with a cover crop in 2021. An unnamed crop was used as a cover crop.

A summary of the "most serious production problem" responses from 1989 to 2021 is shown in Table 5. In 2021, 58% of respondents named weeds as their "most serious production problem" in sugarbeet. In 2021, 18% of respondents also named weather as their most serious production problem in sugarbeet.

Kochia was named most often in 2021 as the "worst weed" problem by 90% of respondents (Table 6). Five percent of respondents named "redroot pigweed" or "wild oats" as a "worst weed" problem in 2021.

Row crop cultivation was used by 43% of survey respondents in 2021. Seventy-eight percent of respondents who utilized row crop cultivation made one pass. Twenty-two percent of respondents who utilized cultivation indicated making two passes.

Hand weeding has virtually disappeared in western North Dakota and eastern Montana with 90% of growers reporting no hand weeding in 2021 (Table 7). The effectiveness of glyphosate applied to RR sugarbeet probably accounts for the near disappearance of hand weeding. Those who did hand weed, paid $31 to $40 per acre for that method of weed control (Table 8)

Wheat was the main crop to directly precede the 2021 sugarbeet crop (Table 9). Sixty percent of reported acres were preceded by wheat, 20% by corn, 9% by an 'other' crop, 5% by dry bean, 3% by soybean, and 3% by fallow.

The majority of respondents (35%) to this year's survey considered an agriculturist their most useful resource (Table 10). Twenty-nine percent of respondents considered their local agronomist as their most used resource. Twenty-five percent of respondents considered University Extension system (NDSU/MSU) as their most used resource. Nine percent of respondents indicated the internet was their most useful resource. Many respondents indicated using more than one of the listed resource options.

The preferred method of receiving technical information in 2021 was undecided. (Table 11). Nineteen percent of respondents use apps and 12% do not use apps but prefer them. Nineteen percent prefer hard copies.

The average age of grower in western North Dakota and eastern Montana who responded to this survey is 50-59 (Table 13). Forty-four percent of respondents were 50-59, 22% were 60-69, 19% were 30-39, 11% were 70-79, and 4% were 40-49.

Table 1. Summary of all herbicides used in sugarbeet in western North Dakota and eastern Montana in 2021. Twenty-one growers reported on 7,801 acres.

			Acres Treated	% of Responses Reporting Weed Control					% of Responses Reporting Crop Injury				
Treatment	No. of Responses	Acres Treated	% of Total	NR*	Exc	Gd	Fr	Pr	NR	None	Slt	Mod	Sev
A. PRE-EMERGENCE HERBICIDES													
Glyphosate PRE	4	1,740	22	25	-	-	50	25	25	50	25	-	-
Total-PRE	**4**	**1,740**	**22**	**100**					**100**				
B. POSTEMERGENCE HERBICIDES													
Glyphosate	19	5,661	73	4	-	35	17	4	4	52	4	-	-
Glyphosate + Stinger	2	801	10	-	-	50	-	50	-	50	50	-	-
Betamix	2	130	2	-	-	-	-	100	50	-	50	-	-
Total-POST	**23**	**6,592**	**85**										
C. OTHER WEED CONTROL METHODS													
Cultivations	9	3,031	39	11	11	33	44	-	22	44	22	-	11
Total-Other Methods	**9**	**3,031**	**39**	**100**	**-**	**-**	**-**	**-**	**100**	**-**	**-**	**-**	**-**
TOTAL ALL TREATMENTS	**36**	**11,363**	**146**										

*NR=No Response;Exc=Excellent;Gd=Good;Fr=Fair;Pr=Poor;Slt=Slight;Mod=Moderate;Sev=Severe

Table 2. Glyphosate use rates per acre across all POST application timings in sugarbeet by county in 2021.

		lb ae/A				fl. oz./A[2]									
County	Total[1]	Other	0.7 to 0.84	0.85 to1.0	>1.0	22	24	26	28	29	30	32	34	40	64
		---% of responses---													
Roosevelt	7	57	-	-	43	-	-	-	-	-	-	-	-	-	-
Dawson	7	14	-	-	-	-	-	-	-	-	-	57	-	29	-
McKenzie	19	32	-	16	52	-	-	-	-	-	-	-	-	-	-
Prairie	3	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Richland	28	36	11	25	7	-	-	-	-	-	-	21	-	-	-
Williams	7	57	-	-	43	-	-	-	-	-	-	-	-	-	-

[1] Total number of glyphosate applications made during the year.
[2]Based on a 4.5 lb/gal. acid equivalent formulation of glyphosate

Table 3. A summary of sugarbeet acres produced by survey respondents from 2001 to 2021.

	Responses	Sugarbeet Acres									
Year	number	1-49	50-99	100-199	200-299	300-399	400-599	600-799	800-999	1000-1500	>1500
		--% of respondents--									
2021	21	0	5	19	32	19	5	10	0	10	0
2019[1]	-	-	-	-	-	-	-	-	-	-	-
2017	32	3	9	19	25	22	9	3	6	3	0
2015	22	0	19	10	28	24	14	5	0	0	0
2014	23	4	0	13	39	22	13	4	0	4	0
2011	20	0	20	15	15	35	0	10	0	5	0
2009	15	7	40	13	7	13	7	13	0	0	0
2007	21	5	19	5	19	10	24	0	14	5	0
2005	24	4	13	17	13	38	8	4	0	4	0
2003	44	11	16	21	11	24	5	5	3	5	0
2001	64	5	15	28	20	9	5	11	2	5	2

[1]Responses not recovered from grower meeting.

Table 4. Total sugarbeet acreage operated by survey respondents in 2021.

		Acres of sugarbeet								
County	Respondents	<50	50-99	100-199	200-299	300-399	400-599	600-799	800-999	1000+
		--% of respondents--								
Roosevelt	3	-	-	-	33	-	-	-	-	66
Dawson	4	-	25	-	25	50	-	-	-	-
McKenzie	6	-	-	-	32	17	17	17	-	17
Prairie	1	-	-	100	-	-	-	-	-	-
Richland	10	-	-	30	30	10	-	10	-	20
Williams	2	-	-	-	-	-	-	50	-	50
Total	26	-	4	15	27	15	4	12	-	23

Table 5. A summary of the most serious production problem responses from 2001 to 2021.

Year	Number of Respondents	Weeds	Weather	Root Diseases[1]	Labor Management	Emergence/ Stand	Cercospora Leaf Spot	No Problem	Insect Damages[2]
		---% of respondents---							
2021	22	58	18	5	0	5	9	5	0
2019[3]	-	-	-	-	-	-	-	-	-
2017	37	16	16	11	0	27	3	14	14[b]
2015	22	0	18[a]	27	0	18	14	9	14[b]
2014	20	0	0	35	10	5	35	15	5
2011	17	18	0	47	6	0	12	18	-
2009	14	0	7	29	0	29	7	21	-
2007	18	44	6	17	6	11	6	5	-
2005	21	48	10	10	0	14	0	5	-
2003	41	36	7	22	5	10	5	12	-
2001	64	23	3	6	2	25	39	0	-

[1]Root Diseases include aphanomyces, fusarium, rhizoctonia, and rhizomania.
[2]Insect Damages include Root maggot, root aphid, springtails, and nematode.
[3]Responses not recovered from grower meeting.
[a]Hail Damage in 2015.
[b]Springtails in 2015 and 2017.

Table 6. A summary of the worst weed responses from 2001 to 2021.

Year	Number of Responses	RRPW[1]	COLQ	KOCZ	NISH	WIOA	Other[2]	None
		---% of responses---						
2021	22	5	0	90	0	5	0	0
2019[a]	-	-	-	-	-	-	-	-
2017	32[b]	13	23	33	3	8	15	8
2015	24	12	21	17	4	8	21	17
2014	23	13	30	9	9	4	4	30
2011	21	5	33	10	0	5	19	29
2009	18	0	22	17	6	6	-	22
2007	20	5	15	75	0	0	-	-
2005	24	8	13	75	0	0	-	-
2003	44	11	16	61	0	0	-	-
2001	64	14	16	62	2	0	-	-

[1]RRPW=redroot pigweed, COLQ=common lambsquarters, KOCZ=kochia, NISH=nightshade, WIOA=wild oat,
[2]OTHER=common mallow, foxtail, common cocklebur, smartweed; (1), (1), (1), (1) respectively in 2017.
[a]Responses not recovered from grower meeting.
[b]Multiple responses.

Table 7. A summary of hand weeded acres as a percent of acres planted from 2001 to 2021.

Year	Respondent Acres Planted	Hand Weeded % of acres planted
2021	7,801	<1
2019[a]	-	-
2017	10,622	0
2015	6,132	0
2014	7,556	0
2011	6,134	6
2009	3,441	<1
2007	8,346	51
2005	7,733	41
2003	11,732	38
2001	22,125	23

[a]Responses not recovered from grower meeting.

Table 8. A summary of the cost of hand weeding plus hand thinning from 2001 to 2021.

Year	Responses	Dollars per Acre 0	1-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	>60
		% of responses												
2021	21	90	0	0	0	0	0	5	5	0	0	0	0	0
2019[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2017	32	100	0	0	0	0	0	0	0	0	0	0	0	0
2015	22	100	0	0	0	0	0	0	0	0	0	0	0	0
2014	23	100	0	0	0	0	0	0	0	0	0	0	0	0
2011	20	95	0	0	0	0	0	5	0	0	0	0	0	0
2009	15	93	0	0	0	0	0	0	0	0	7	0	0	0
2007	21	29	0	4	0	10	14	10	0	0	14	0	10	10
2005	24	50	0	4	4	8	4	4	4	3	8	4	8	0
2003	38	39	0	5	11	13	0	11	16	3	0	0	0	3
2001	65	69	2	0	3	6	8	3	5	0	2	0	2	2

[a]Responses not recovered from grower meeting.

Table 9. Percent of sugarbeet acres seeded in 2021 into various crop residues by county.

County	No. of responses	Acres planted	Crop Preceding Sugarbeet: Corn	Dry Bean	Soybean	Wheat	Barley	Fallow	Other
			% of acres planted						
Roosevelt	4	1,064	8	-	-	92	-	-	-
Dawson	7	925	-	49	16	29	-	-	6
McKenzie	7	1,635	9	-	-	91	-	-	-
Prairie	1	165	100	-	-	-	-	-	-
Richland	14	3,282	20	-	-	75	-	-	5
Williams	2	767	-	-	-	41	-	59	-
Total	35[a]	7,838[a]	20	5	3	60	0	3	9

[a]Multiple counties and acres reported per one response.

Table 10. Most used resources for information on sugarbeet production in western North Dakota and eastern Montana by county in 2021.

County	No. of Responses[1]	Agriculturalist	Local Agronomist	MSU	NDSU[2]	Internet[3]	No Response
		% of responses					
Roosevelt	6	17	32	17	17	17	-
Dawson	9	44	22	-	22	12	-
McKenzie	14	29	21	7	29	14	-
Prairie	2	50	50	-	-	-	-
Richland	22	41	27	14	9	9	-
Williams	2	-	100	-	-	-	-
Total	55	35	29	9	16	11	-

[1]Response was multiple choice, each survey taker could select multiple.
[2]NDSU/U of MN Extension Publication or Website.
[3]NDAWN Website.

Table 11. Preferred method of receiving technical information in western North Dakota and eastern Montana by county in 2021.

County	No. of Responses[1]	Use Apps and Prefer	No App Use but Prefer	Prefer Hard Copies	Undecided	No Response
		% of responses				
Roosevelt	3	-	33	-	66	-
Dawson	4	-	50	25	25	-
McKenzie	6	17	-	33	50	-
Prairie	1	-	-	-	100	-
Richland	10	40	-	20	40	-
Williams	2	-	-	-	100	-
Total	26	19	12	19	50	-

[1]Response was multiple choice, each survey taker could select multiple.

Table 12. Average age of respondent in 2021.

County	Respondents[a]	Age of Respondents							
		20-29	30-39	40-49	50-59	60-69	70-79	80-89	No Response
		---% of respondents---							
Roosevelt	3	-	66	-	33	-	-	-	-
Dawson	4	-	25	-	25	50	-	-	-
McKenzie	6	-	-	-	66	33	-	-	-
Prairie	1	-	-	-	-	-	100	-	-
Richland	11	-	18	9	37	18	18	-	-
Williams	2	-	-	-	100	-	-	-	-
Total	27	0	19	4	44	22	11	0	0

[a]Multiple responses per county.

SOIL MANAGEMENT PRACTICES

NOTES

SOIL MANAGEMENT FOR SUGARBEET PRODUCTION

N. Cattanach[1], J. F. Mathew[1], S. Sigdel[1], A. Wick[1], M. Berti[2], A. Chatterjee[1]
1. Department of Soil Science, North Dakota State University
2. Department of Plant Science, North Dakota State University

INTRODUCTION

Wind/water erosion are responsible for significant soil loss in the Red River Valley of North Dakota and Minnesota. Intensive tillage operations in the fall and spring accelerate the soil erosion processes particularly during early spring (prior to stand establishment) and after harvest. Fields with crops having minimum residue cover like sugarbeet, soybean, after harvest are particularly prone to erosion. During 2021 growing season, on-farm field experiments were conducted to determine the influence of three promising soil conservation practices, (i) stale seedbed, (ii) fall-seeded cover crop (interaction with nitrogen fertilizer application time), and (iii) interseeded cover crop on sugarbeet yield and quality parameters.

Stale seedbeds receive primary tillage in the fall but sugarbeet are planted in the spring without any additional tillage. Spring tillage operation may cause significant loss of soil moisture and stand emergence can be adversely affected due to the dry spell after planting. Moreover, hard rains after a spring tillage can create significant crusting on the soil surface for clay, clay loam and silt loam soils. Eliminating tillage operations will also save money on fuel and machinery. The objective of this study was to investigate the effect of eliminating spring tillage in sugarbeet production system.

Cover crops have potential to improve soil health and nutrient use efficiency through reducing erosion and nutrient losses. Moreover, legumes as cover crops can add atmospheric N_2 through symbiotic fixation. Fall seeded cover crops are most common, planted in fall and terminated following year before planting. Another option is to interseed cover crops in sugarbeets at mid- or late-growing season, in between the application of herbicide (glyphosate) and canopy closure. Selection of cover crop species and planting time are critical to optimize the benefits from cover crops. In the Red River Valley of ND and MN, some growers apply fertilizer-N in fall, but this may lead to significant loss of N through leaching during snowmelt in early spring. Cover crops can protect fertilizer N by reducing leaching loss. Interaction between fertilizer N application time (fall vs. spring) and cover crop species may improve the sugarbeet N use efficiency. Three trials, (i) stale seedbed, (ii) fall-seeded cover crops and N management, and (iii) interseeding cover crops, were conducted to achieve the goal of soil conservation under sugar beet production system, during 2021 growing season.

METHODS

Trials were conducted at Ada, MN (47.3198, -96.3856). Initial soil properties are presented in Table 1. Soils are very deep, formed in silty glacial lacustrine sediments and delta sediments on glacial lake plains (Coarse-silty, mixed, superactive, frigid Aeric Calciaquolls). Previous crop was spring wheat. Each plot measured 11 feet wide and 30 feet long, and 22 inches row spacing (six rows). Initial soil sample was collected on Sept. 1, 2020 and recommended N, P, and K were applied in the form of urea, MAP and MOP, respectively. During 2021 growing season, early spring was extremely dry and stand establishment was poor (Fig.1). A glyphosate tolerant cultivar was planted at 63,000 plants per acre at 4.5 inches spacing using John Deere planter for all three trials on April 29. Three applications of glyphosate were applied for weed control and recommended fungicides were applied to control Cercospora leafspot. The two-middle rows of the 6-row were harvested on September 29, 2021. Plots were mechanically defoliated, and a scale mounted harvester was used to dig and weigh the sugar beetroots from the center two rows of each plot. A sub-sample of 15-20 sugar beetroots were analyzed to determine sucrose concentration and recoverable sucrose at American Crystal Sugar Quality Tare Lab, East Grand Forks, MN.

Table 1. Initial soil properties of experimental site located at Ada, MN

Depth	Organic matter%	Soil pH	CEC meq/kg	EC dS/m	Nitrogen (lb/ac)	Olsen-Phosphorus (ppm)	Potassium (ppm)	Sulfur (lb/ac)	Fertilizer N (lb/ac)	P_2O_5 (lb/ac)	K_2O (lb/ac)
0-6”	2.1	8.4	25.2	0.15	6.4	6	50	32	120	55	90
6-24”		8.5		0.13	3.5			78			

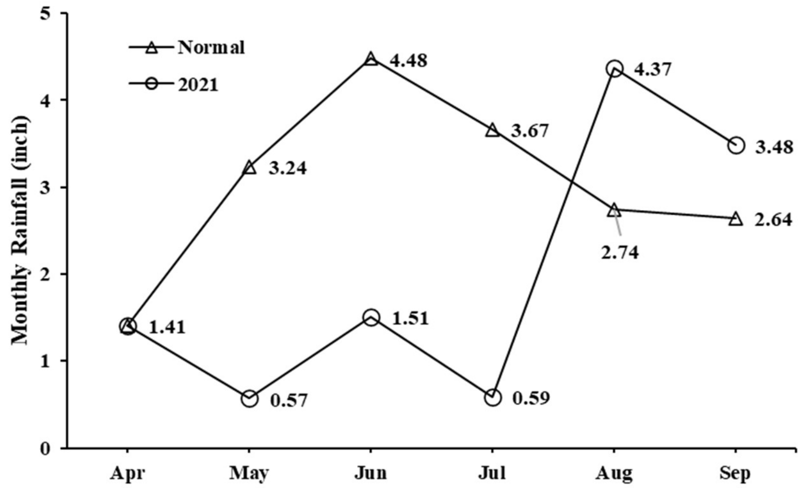


Figure. 1. Monthly rainfall distribution during growing season in comparison to normal (Source: NDAWN)

For the stale seedbed trial, three treatments were (i) conventional (fall and spring tillage), (ii) trash wheels in the down position at planter (Stale- TW down), and (iii) trash wheels in up position at planter (Stale- TW up), laid out in strip with four replicates. The stale seedbed treatments were planted directly into last year's fall tillage (2020). The field had been tilled only once last fall. Typically, when planting into stale seedbed, the field would have been worked once in the fall soon after combining the wheat, and then fertilized and tilled again in mid- to late-October in preparation for planting directly into the seedbed in the spring. Recommended fertilizers were applied on the soil surface prior to planting. Seedbed was uneven at planting because of only being worked once last fall. Also, there was a large amount of wheat straw residue on the soil surface, and conditions at planting were extremely dry leading to poor or uneven germination across the plots. Conventional treatment was fertilized and incorporated into the soil with a field cultivator prior to planting. Therefore, perhaps there was less loss of fertilizer on the conventional treatments than the stale seedbed treatments. Because we tilled the conventional treatments, we may have dried out the soil losing moisture and affecting the germination. Weather conditions at planting of the stale seedbed was hot, dry, and windy.

For the fall seeded cover crop trial, three cover crop treatments, (i) control (no cover crop), (ii) winter wheat, and (iii) cereal rye, and three fertilizer-nitrogen (N) application time treatments, (i) 100% of recommended N in fall, (ii) 100% of recommended N in spring, and (iii) 50% of recommended N in fall and rest 50% in spring before planting, were laid out in factorial randomized block design with four replicates. On Sept. 4, cover crop seeds, cereal rye (ND Dylan) and winter wheat (Jerry) at the rate of 40 lb/ac, were broadcasted; and on the same day, fall fertilizer N treatments were also broadcasted. In spring, cover crop biomass production was determined by clipping biomass within 2 ft by 2 ft quadrat per plot on April 22 and glyphosate was applied to terminate cover crops. Cover crop biomass was dried at 130°F and weighed. Dried biomass was ground using a Wiley mill and analyzed for total N. Cover crop tissue samples were digested with H_2SO_4-salicylic acid and N was analyzed using Kjeldahl distillation method. Biomass N uptake was determined by multiplying biomass with tissue N concentration. For all plots, soil samples within 0-6" depth were collected in fall (Oct 13, 2020), spring (Apr. 21, 2021) and at harvest (Sep. 9, 2021) to determine inorganic N availability.

For cover crop interseeding trial, recommended fertilizers were broadcasted and incorporated, and sugar beet was planted like other trials. On June 22nd, cover crops were interseeded only for middle two rows used for harvesting. Cereal rye (ND Dylan), winter wheat (Jerry) and pea (Austrian)were planted at the rate of 20 lb/ac, brown mustard (Kodiak) and brown flax (CDC Neela, Meridian Seeds) were planted at 10 lb/ac and winter camelina (Joelle) was planted at 6 lb/ac. Cover crop seeds were seeded using a V-shaped hoe with two blades 6-inch apart to make a parallel furrow to simulate planting with a commercial interseeder. The furrows were half-inch deep and centered in each of sugarbeet rows. Cover crop seeds were distributed evenly into the furrows by hand; furrows were then covered with soil. Due to dry condition, cover crop growth was sporadic and not enough for biomass determination. Sugarbeet root yield and quality parameters, and soil N availability were analyzed using the general linear model (GLM) of the Statistical Analysis System 9.4 (SAS Inc., Cary, NC). Probabilities equal to or less than 0.05 were considered significant for main and interaction effects. The least significant differences (LSD) test was used to separate difference between treatment means if analysis of variance indicated the presence of such differences.

RESULTS AND DISCUSSION

Experiment l. Effect of different stale seedbed preparation on sugar beet production

Eliminating spring tillage had no negative effect on stand germination, yield, and quality parameters (Table 2). Stand count at harvest data showed variations across replicates for all three treatments. Conventional tillage practice had the highest root yield, but stale seedbed with trash-wheel up had the highest sugar and lowest sugar loss to molasses.

Table 2. Influence of stale seedbed preparation on stand count (per 100 ft) at harvest, root yield and quality parameters at Ada, MN during 2021 growing season. *Values in bracket indicate standard deviation

Treatments	Stand count	Yield (ton/ac)	Sugar%	SLM%
Conventional	148(16)	31.2(3.9*)	17.1(0.6)	1.26(0.2)
Stale-TW down	154(15)	29.4(4.8)	16.9(0.8)	1.26(0.1)
Stale-TW up	149(20)	29.8 (4.4)	17.2(0.7)	1.18(0.2)
P<0.05	NS	NS	NS	NS

SLM: Sugar loss to molasses

Experiment 2. Effect fall-seeded cover crops and fertilizer nitrogen (N) application time on sugar beet production

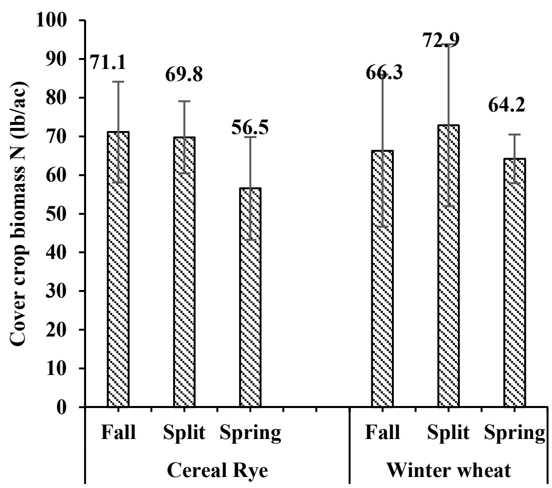


Figure 2. Cover crop biomass nitrogen (lb N/ac) in response to cover crop species and fertilizer nitrogen application timing. Means were not significant at 95% level.

Table 3. Effect of two fall-seeded cover crops (CC) and fertilizer-nitrogen application time (Time) on sugarbeet yield (tons/ac) and quality parameters at Ada, MN during 2021 growing season.

Factors	Root yield (ton ac^{-1})	Sugar (%)	SLM (%)
CC			
Control	23.6	13.4	1.53^{A}
Cereal Rye	20.9	14.3	1.39^{B}
Winter wheat	25.9	13.9	1.49^{AB}
Time			
Fall	23.8	14.0	1.42^{B}
Spring	21.9	13.4	1.55^{A}
Split	24.7	14.3	1.44^{B}
Coeff. Var.	20.9	6.97	8.62
CC	0.05	0.07	0.04
Time	0.39	0.11	0.02
CC×Time	0.85	0.41	0.45

SLM: Sugar loss to molasses

Selection of cereal rye and winter wheat and fertilizer N application time had no effect (*P*<0.05) on the N removal in cover crop biomass (Fig. 2). However, for both cover crops, lower biomass N for spring applied fertilizer treatment compared with fall and split application indicated that a portion of fertilizer-N applied in fall was taken up by cover crop biomass. The reduction in biomass N removal was higher for rye than wheat (although differences were not significant).

Influence of cover crop and fertilizer-N application time interactions on sugarbeet root yield, sugar concentration and sugar loss to molasses percent (SLM) was presented in Table 3. Cover crop and fertilizer N timing did not affect root yield and sugar concentration. Cover crop selection and fertilizer N timing both had significant effect on SLM percent. Control (without cover crop) had the highest impurities or SLM and significantly higher than plots under cereal rye, but similar to winter wheat. These results suggest that cereal rye has potential to reduce SLM concentration by removing the excess soil N available during root development. Cereal rye removed more soil N than winter wheat.

Table 4. Effect of Fall seeded cover crops (CC) and nitrogen application time (Time) on soil nitrate (ppm) availability within 0-6" soil depth during Fall 20 (Oct. 13, 2020), Spring 21 (Apr.21, 2021) and Fall 21 (Sep. 9, 2021)

Factors	Fall 20	Spring 21	Fall 21
CC		Inorganic N (ppm)	
Control	19.7	27.8^{A}	5.33
Cereal Rye	23.2	3.08^{C}	5.46
Winter wheat	21.7	13.6^{B}	4.75
Time			
Fall	39.0^{A}	24.2^{A}	5.17
Spring	6.54^{B}	6.58^{C}	5.58
Split	19.0^{B}	13.7^{B}	4.79
Coeff. Var.	78.7	41.1	39.2
CC	0.88	<0.01	0.66
Time	0.01	<0.01	0.64
CC×Time	0.78	0.01	0.53

Cover crop had significant effect on soil inorganic N concentration only in spring 2021, before planting sugarbeet. Control soils had the highest soil available N than both cover crop treatments. Winter wheat had higher soil available N than cereal rye. Fertilizer N application timing had significant effect on surface soil inorganic N concentration in fall of 2020 and spring 2021. At both sampling time, fall N application had the highest soil available N, followed by split N application treatment; the lowest soil available N was observed under spring N application. From September 2 (fertilizer N applied) to October 13 (soil sampled for inorganic N) of 2020, fall application of fertilizer-N increased inorganic N concentration because mineralization does not cease until soil temperature drop below 50˚F. Cover crop and fertilizer N application timing did not influence the residual soil N sampled after harvest during fall of 2021.

Cover crop particularly cereal rye has potential to reduce the loss of fall applied N. Cereal rye also can improve sugar recovery by removing the excess N availability without a significant (P<0.05) effect on root yield and sugar concentration. Spring applied N can increase the SLM% particularly when sugar beet plant growth suffers due to the hot and dry condition.

<u>Experiment 3. Effect of cover crop interseeding on sugarbeet production</u>

Table 5. Effect of cover crop interseeding on sugarbeet yield and quality and soil available nitrogen within 0-6" depth at harvest

Cover crop species	Root yield (tons/ac)	Sugar%	SLM%	Soil NO_3 (ppm)
No cover crop	20.9(3.9)	13.9(0.4)	1.42(0.1)	5.00(1.2)
Camelina	19.8(2.6)	13.4(0.4)	1.61(0.2)	4.75(0.9)
Mustard	22.5(7.8)	14.0(1.3)	1.58(0.1)	5.50(2.7)
Cereal rye	20.5(6.2)	13.5(1.3)	1.52(0.2)	3.50(0.6)
Winter wheat	21.3(3.8)	13.1(0.8)	1.47(0.2)	4.50(0.7)
Flax	25.9(5.5)	13.8(1.8)	1.56(0.2)	4.13(0.8)
Pea	23.3(6.9)	14.4(1.6)	1.41(0.3)	6.38(1.4)
P<0.05	NS	NS	NS	NS

SLM: Sugar loss to molasses; *values in bracket indicate standard deviation of mean

Cover crops were interseeded following a rain but germination was extremely poor due to dry spell and high air temperature near 90˚F. Cover crop biomass was not sampled. Cover crop interseeding had no significant effect on root yield, sugar, and SLM concentrations, and residual surface soil inorganic N concentrations. Cover crop interseeding is not an option for years having low rainfall and warm summer months.

ACKNOWLEDGEMENT

Funding for these research trials were partially supported by Sugar beet board of Research and Education and General Mills. We appreciate the support of our collaborating growers, Glen Brandt, and Danny Brandt. Gannon Rockstad and Karter Wasberg helped us in research plot management and soil sampling.

SUGARBEET PHYSIOLOGY/STORAGE/PRODUCTION PRACTICES/ECONOMICS

NOTES

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

Daniel Kaiser[1], Mark Bloomquist[2], and David Mettler[2]

[1]/University of Minnesota Department of Soil, Water, and Climate, St Paul, MN
[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:

Evaluate nitrogen fertilizer requirement for sugar beet.
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.
Determine if polymer coated urea (ESN) blends with urea results in greater root yield and recoverable sugar per acre when applied in the fall.
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 (Table 1). 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°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 3 for the urea rate trial and Table 4 for the urea source trial. 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 5. 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. 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.

Sugar beet emergence was significantly impacted by N rate at both locations and the rate by time interaction was significant at both sites (Table 3 and Figure 1). 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.

Urea source impacted emergence at both locations (Table 6). 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. 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 4). Root yield responded to 130 lbs of total N (applied N plus nitrate-N in a four-foot soil sample) at Hector (Figure 2). 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 varied by urea source only at Hector (Table 6). 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.

The decrease in plant population did not impact sugar beet root yield at either location. The loss of population was compensated by the sugar beet plants which increased the mass of roots per plant (not shown). While higher rates of N as spring urea could reduce yield the effect on root yield should be minimal if the variety planted can compensate by growing larger roots. 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 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 3). 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. Urea source had a relatively minor impact on recoverable sucrose (Table 6). 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 stud in Figure 4. Recoverable sucrose was not impacted by urea rate at Crookston 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 5). For the source trial there was no impact of urea source on recoverable sucrose per acre at Crookston, 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 nitrate concentrations were determined following sampling in early to mid-July. Samples from 2021 have yet to be analyzed so the data are not included in this report.

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

Acknowledgments

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

Literature Cited

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

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

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

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

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

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

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

	Date of					Soil		
Location	Urea Application		Planting	Tissue Sampling	Harvest	Series	Texture†	Classification‡
Crookston	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

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

‡Ae, aeric; T, typic

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

	0-6" Soil Test				Soil Test Nitrate-N	
Location	Olsen P	Ammonium Acetate K	pH	SOM	0-2'	2-4'
	----------ppm----------			----%----	--------------------lb/ac--------------------	
				Urea Rate Trials		
Crookston	9	159	8.2	3.0	25	43
Hector	8	168	7.3	5.4	21	39
				Urea Source Trials		
Crookston	12	140	8.2	2.3	39	70
Hector	7	151	7.6	4.0	25	68

Table 3. 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.

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

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

Table 4. 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.

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

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

Table 5. 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.

Time	Emergence		Petiole N		Yield		Rec. Sugar (ton)		Rec Sugar (acre)	
	CRX	H	CRX	H	CRX	H	CRX	H	CRX	H
	------%------		----ppm----		--tons/ac--		---lb/ton---		----lb/ac----	
					Urea Rate Trial					
Fall	79a	86a	na	na	19.4	39.5	326a	246a	6340	9690

Spring	72b	74b	na	na	19.1	39.6	316b	240b	6027	9479
					Urea Source Trial					
Fall	--	84	--	na	--	33.9	--	261	--	8587b
Spring	--	83	--	na	--	34.6	--	260	--	8859a

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

Table 6. 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 N		Yield		Rec. Sugar (ton)		Rec Sugar (acre)	
Source	CRX	H	CRX	H	CRX	H	CRX	H	CRX	H
	------%------		----ppm----		--tons/ac--		---lb/ton---		----lb/ac----	
None	86.4a	78.6cd	na	na	18.1	29.9f	345.6a	261.5ab	6259	7092d
Urea	69.7ef	88.1a	na	na	16.7	31.6def	336.2ab	261.9ab	5612	8639abcd
AMS	78.9bc	86.6a	na	na	19.5	36.7abc	325.1bc	270.1a	6339	9768ab
33% ESN	73.7de	85.6ab	na	na	15.7	39.0a	329.0b	263.5ab	5163	9839a
66% ESN	77.1bcd	80.1bcd	na	na	18.5	30.7ef	329.9b	260.1b	6104	8094bcd
100% ESN	80.8b	88.5a	na	na	19.6	34.2bcde	332.1b	262.0ab	6510	7596cd
Instinct	68.4f	75.2d	na	na	17.9	34.0bcde	329.2b	257.1b	5909	8412abcd
Super-U	74.1cde	84.8ab	na	na	19.0	33.1cdef	314.8c	246.0c	5965	8922abc
Agrotain	77.3bcd	84.6abc	na	na	18.7	37.6ab	327.7b	259.8b	6145	8909abc
Anvol	72.5def	80.4bcd	na	na	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

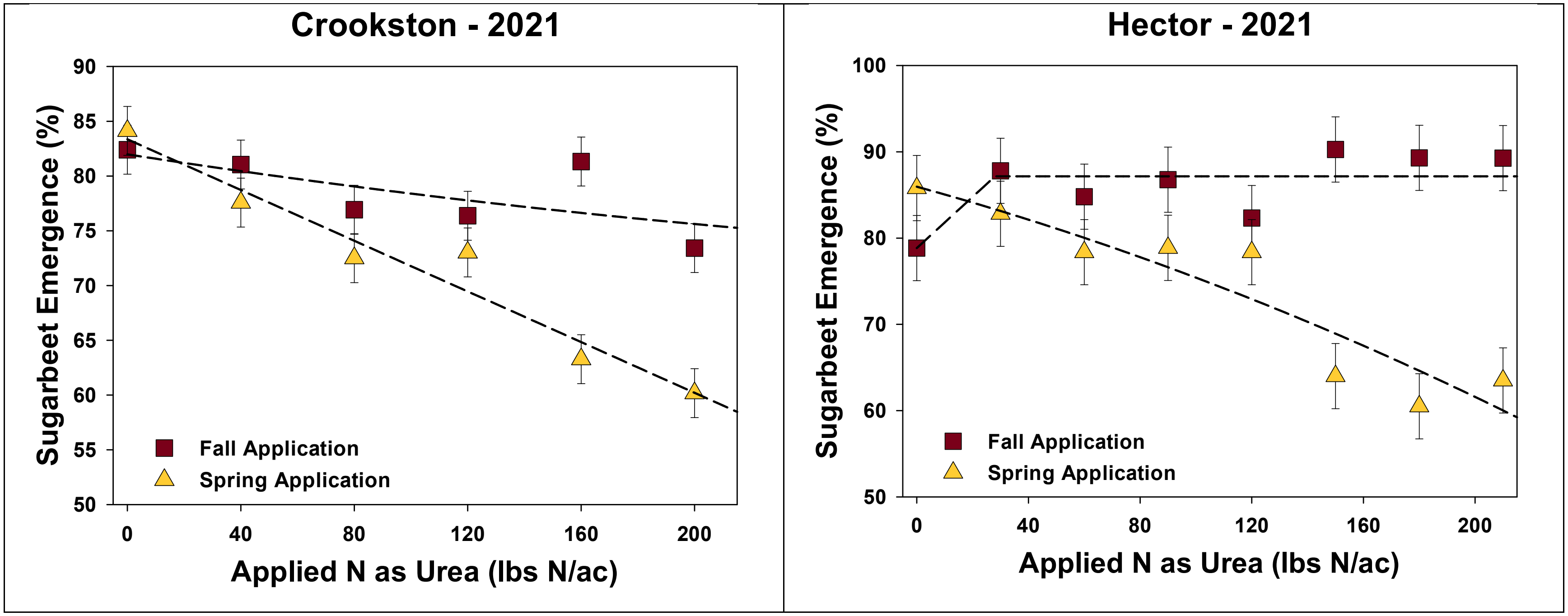


Figure 1. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) on sugar beet emergence at two Minnesota locations during the 2021 growing season.

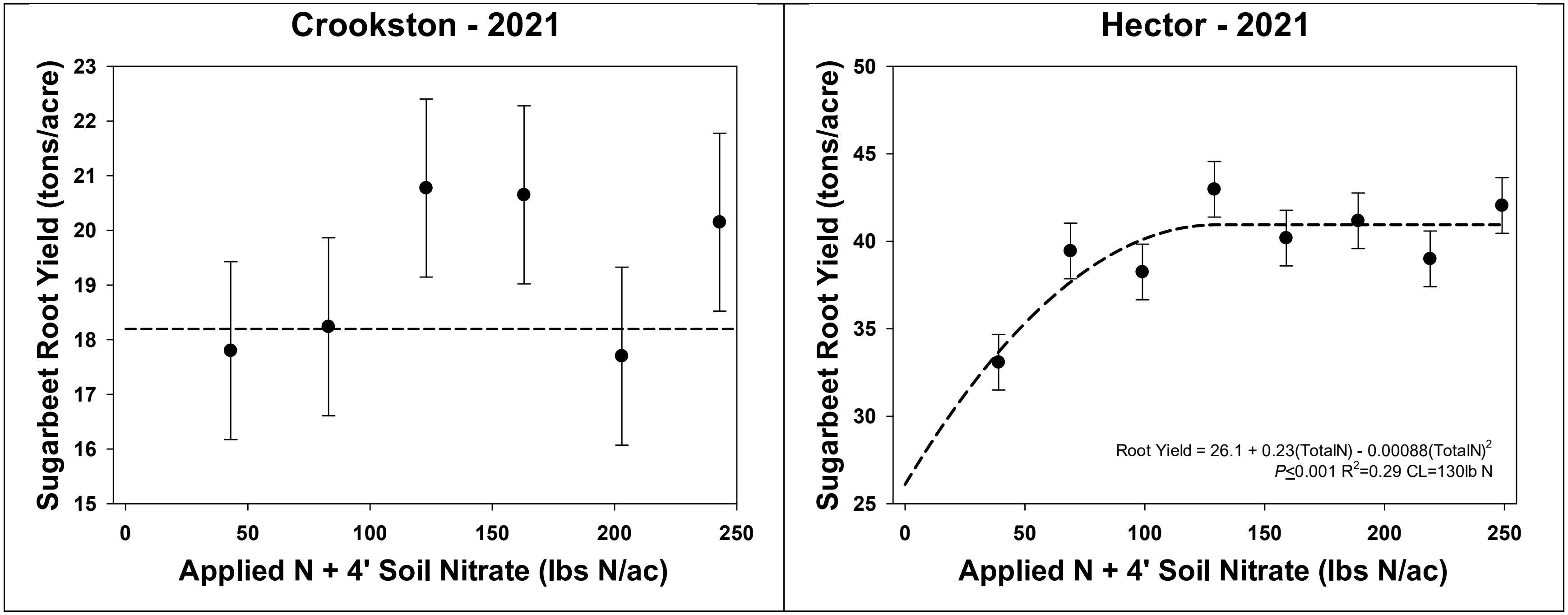


Figure 2. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet root yield at two Minnesota locations during the 2021 growing season.

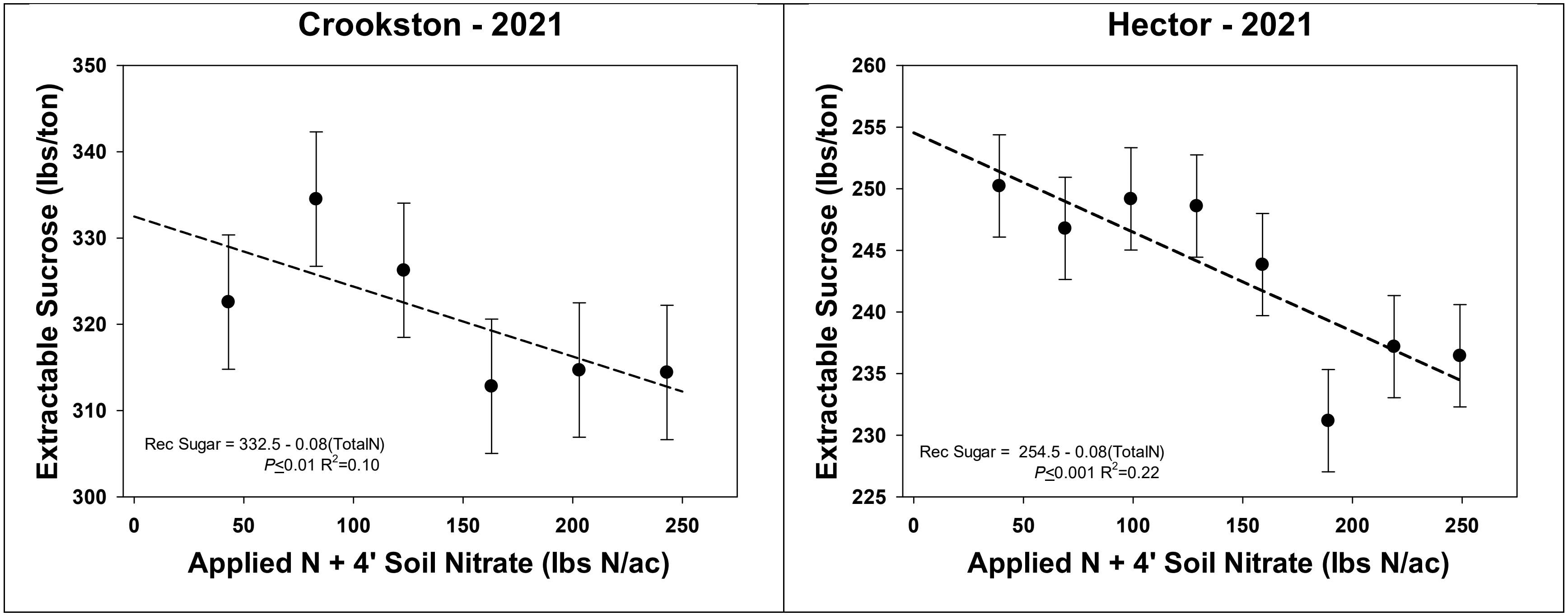


Figure 3. Effect of nitrogen applied as spring urea plus the nitrate in a four-foot on sugar beet extractable sucrose per ton at two Minnesota locations during the 2021 growing season.

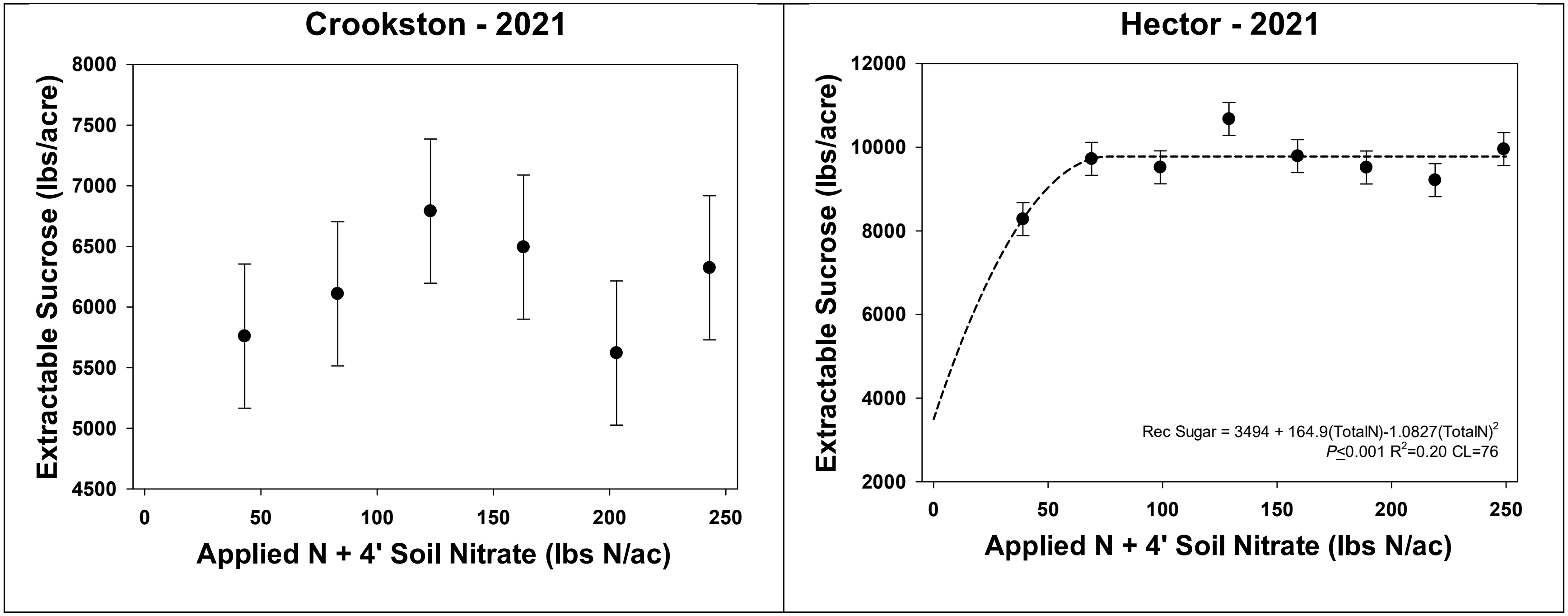


Figure 4. Effect of nitrogen applied as fall or spring urea (data averaged for both timings) plus the nitrate in a four-foot on sugar beet total extractable sucrose per acre at two Minnesota locations during the 2021 growing season.

Data not available	

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

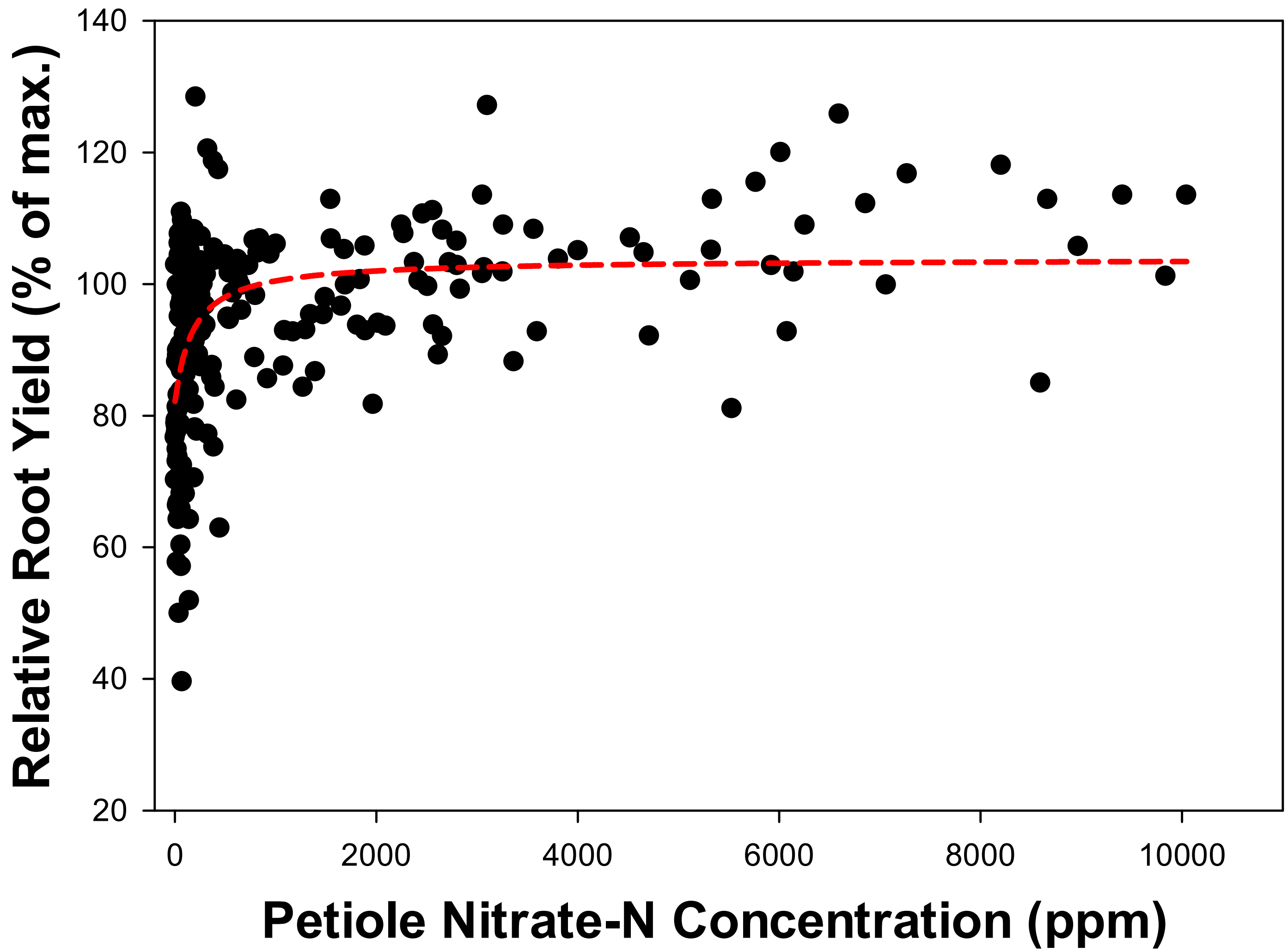


Figure 6. Relationship between relative sugar beet root yield (% of site maximum yield) and nitrate concentration in the uppermost fully developed petiole sampled in early- to mid-July.

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

Melissa L. Wilson
Assistant Professor, University of Minnesota - Department of Soil, Water, and Climate, St Paul, MN

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:

The effect of timing of manure application in the soybean, corn, sugarbeet rotation.

Manure application significantly affected 2 of the 3 sites.

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.

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.

The effect of manure application timing in the rotation and the application of N fertilizer before sugarbeet production.

No interaction occurred between N fertilizer application and manure management for any yield or quality variable measured at 2 of the 3 sites.

N fertilizer rate increased root yield and extractable sucrose per acre at 2 of the 3 sites.

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.

N fertilizer application decreased extractable sucrose per ton at 2 of the 3 sites. This could affect the payment.

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

Objectives:

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

Materials and Methods:

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

Table 1. Main plot treatments.

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

Various manure application rates acted as treatments for the subplots (see table 2). The treatments were comprised of a high application rate (about 14,400 and 15,400 gallons per acre at the Murdock and Nashua sites, respectively), a low application rate (about 9,500 and 10,300 gallons per acre at the Murdock and Nashua sites, respectively), or no manure applied. The 'high' and 'low' rates were chosen based upon the rates typically offered by the large dairies specific to each region. Where manure was not applied in the first year, the crops were fertilized with commercial nutrients according to the state University guidelines. In years 2 and 3, state University fertility guidelines were utilized to apply commercial fertilizers to all plots, taking into account any residual fertility credits from the initial manure application.

Table 2. Subplot treatments.

Treatment	Year 1	Year 2	Year 3
a	Fertilizers	Fertilizers	Fertilizers
b	Manure low rate (fertilizers if needed to balance crop nutrient needs)	Fertilizers w/ second year manure N credit	Fertilizers w/ third year manure N credit
c	Manure high rate (fertilizers if needed to balance crop nutrient needs)	Fertilizers w/ second year manure N credit	Fertilizers w/third year manure N credit

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

Preliminary Results:

Year 1 following manure application - This experiment began in the fall of 2019 at a farm site near Murdock, MN and in fall 2020 at a farm site near Nashua, MN. Both sites followed a corn crop. Manure was surface applied and incorporated within 24 hours of application. Fertilizers were applied as appropriate in the spring prior to planting crops. Initial soil samples and manure samples were collected and analyzed (Table 3). At the Murdock site, corn (Enesvedt E-696RR), soybean (Stine Liberty Link GT27), and sugarbeet (SESVDH 863) were planted on April 30 to May 1, 2020 and maintained according to typical practices in the region. At the Nashua site, corn (Dekalb DKC49-44RIB), soybean (Dekalb AG10XF1), and sugarbeet (ACH 973) were planted on May 3, 2021.

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

Initial soil test results		Manure characteristics		Manure as-applied (lb/acre)†		
		Nutrient	(lb/1000 gal)	Nutrient	High rate	Low rate
Murdock site – Fall 2019						
pH	8.0	Total N	16-22	Total N	321	155
Nitrate – 0-24" (lb/ac)	40	Ammonium-N	12-13.5	First year N‡	177	85
Olsen P (ppm)	7	Total P_2O_5	6-13	Total P_2O_5	196	62
K (ppm)	190	Total K_2O	20-21	Total K_2O	300	187
Nashua site – Fall 2020						
pH	7.3	Total N	25	Total N	380	260
Nitrate – 0-24" (lb/ac)	16.5	Ammonium-N	13.1	First year N‡	209	143
Bray P (ppm)	53	Total P_2O_5	14	Total P_2O_5	219	145
K (ppm)	194	Total K_2O	21	Total K_2O	321	212

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

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

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

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

Nutrient Source	Yield (tons/acre)	Extractable Sucrose (lb/ton)	Extractable Sucrose (lb/acre)	Sucrose Purity (%)
Murdock site – 2020 growing season				
Fertilizer only	32.7a†	297a	9,710a	91.2a
Low dairy manure rate	35.8a	286a	10,266a	90.85ab
High dairy manure rate	35.6a	292a	10,380a	90.78b
Nashua site – 2021 growing season				
Fertilizer only	39.5a	282a	11,195a	91.2a
Low dairy manure rate	38.0a	283a	10,756a	91.8a
High dairy manure rate	41.4a	271a	11,282a	90.8a

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

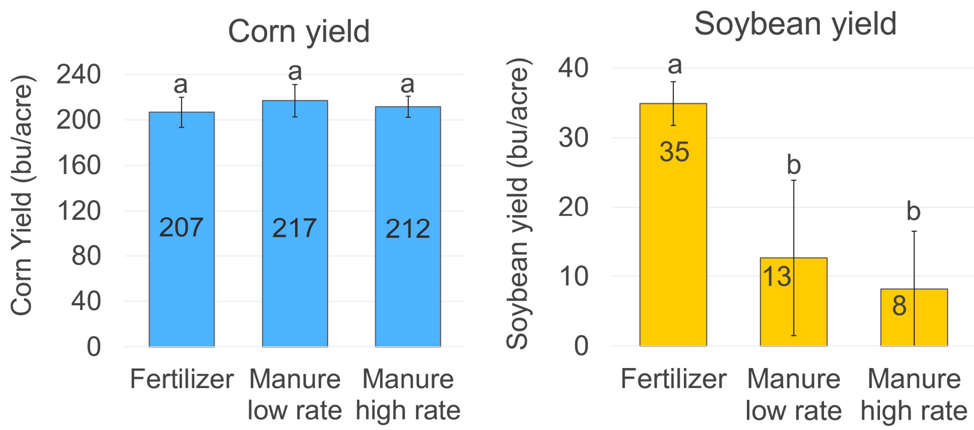


Figure 1. Corn (adjusted to 15.5% moisture) and soybean (adjusted to 13% moisture) yield at Murdock site in 2020. Manure was fall applied at 14,400 gallons per acre (high rate) or 9,500 gallons per acre (low rate) and fertilizer was spring applied. Different letters above a bar within a graph indicate a significant difference (p <0 .05).

At the Nashua site, sugarbeets were harvested on September 26, 2021. As with the Murdock site, there were no significant differences between treatments on yield or extractable sucrose (per ton or per acre). One difference between sites is that sucrose purity was not affected by treatments at Nashua (Table 5). Soybeans were harvested on November 4, 2021 and manured plots tended to have higher yield than the fertilizer only plots, though differences were not significant (Figure 2). Corn was harvested on October 18, 2021. The low manure rate tended to have lower yield than the fertilizer only and high manure rate plots (Figure 2), but differences were not significant.

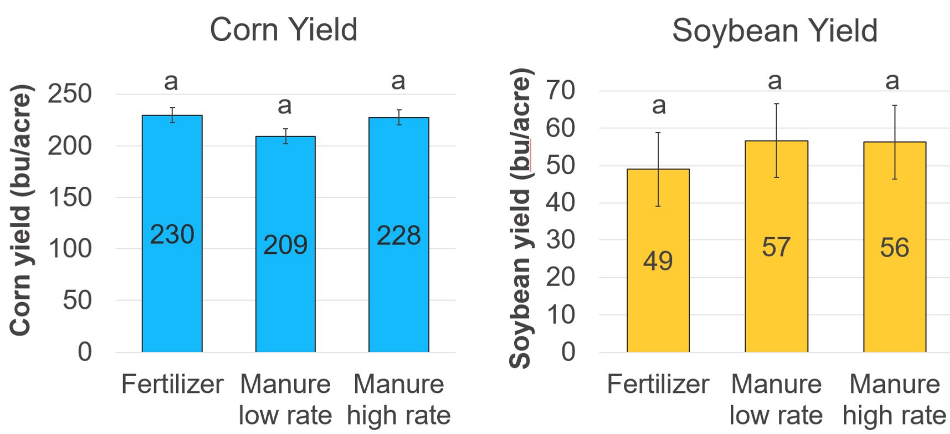


Figure 2. Corn (adjusted to 15.5% moisture) and soybean (adjusted to 13% moisture) yield at the Nashua site in 2021. Manure was fall applied at 15,400 gallons per acre (high rate) or 10,300 gallons per acre (low rate) and fertilizer was spring applied. Different letters above a bar within a graph indicate a significant difference ($p < 0.05$).

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. There was a 39 and 80 lb/acre nitrogen credit for the low and high rate manure plots, respectively. Initial soil samples from the top six and 24 inches of soil (Table 5) indicated that there were differences in nutrient content across treatments. 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. 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. Soil test phosphorus levels varied, though ranged from medium to high levels. 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. At the Murdock site, corn (Enesvedt E-696RR), soybean (Stine Liberty Link GT27), and sugarbeet (Beta 9952) were planted on May 1, 2021 and maintained according to typical practices in the region. This year, Soygreen® was applied to the soybean plots to potentially reduce issues with iron-deficiency chlorosis. Similar soil and plant samples were collected in the second year as in the first year, though samples are still currently being analyzed.

Table 5. Soil test results for the Murdock site in fall 2020. 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		
Initial soil test results	**Nitrate 0-24" (lb/ac)**	**Olsen P (ppm)**	**K (ppm)**
Previous crop sugarbeet (going into soybean)			
Fertilizer-only	37	10	157
Low-rate manure	33	9	178
High-rate manure	37	12	243
Previous crop soybean (going into corn)			
Fertilizer-only	29	10	155
Low-rate manure	143	12	201
High-rate manure	222	15	247
Previous crop corn (going into sugarbeet)			
Fertilizer-only	100	12	157
Low-rate manure	55	12	178
High-rate manure	38	10	229

At the Murdock site, sugarbeets were harvested on October 12, 2021. There were no significant differences between treatments on yield, extractable sucrose (per ton or per acre), or sucrose purity (Table 6). Soybeans were harvested on October 8, 2021 (Figure 3). Soybeans were not as affected by iron deficiency chlorosis this year, though random spots in the field were hit. The only exception was one low-rate manure plot (of four total) that was consistently looked poor across the growing season. The high-rate manure plots yielded similarly to the fertilizer only plots. Corn was harvested on October 25, 2021 by hand because the corn had lodged during a recent windstorm. Both treatments with manure tended to have higher yield than the fertilizer only plot (Figure 3), but the difference was only significant for the high-rate manure plots.

Table 6. Yield, extractable sucrose (per ton and per acre), and sucrose percent purity at the Murdock site the second year after manure application.

Nutrient Source	**Yield (tons/acre)**	**Extractable Sucrose (lb/ton)**	**Extractable Sucrose (lb/acre)**	**Sucrose Purity (%)**
Murdock site – 2021 growing season				
Fertilizer only	40.0a†	272a	10,846a	92.2a
Low dairy manure rate	40.0a	270a	10,844a	91.4a
High dairy manure rate	40.7a	271a	11,051a	91.7a

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

The trials at both research sites will continue into 2022. It will be the last year of the study for the Murdock site (third year after manure application) and the second year for the Nashua site. As before, manure nitrogen credits and soil tests will be used to adjust fertilizer rates as needed.

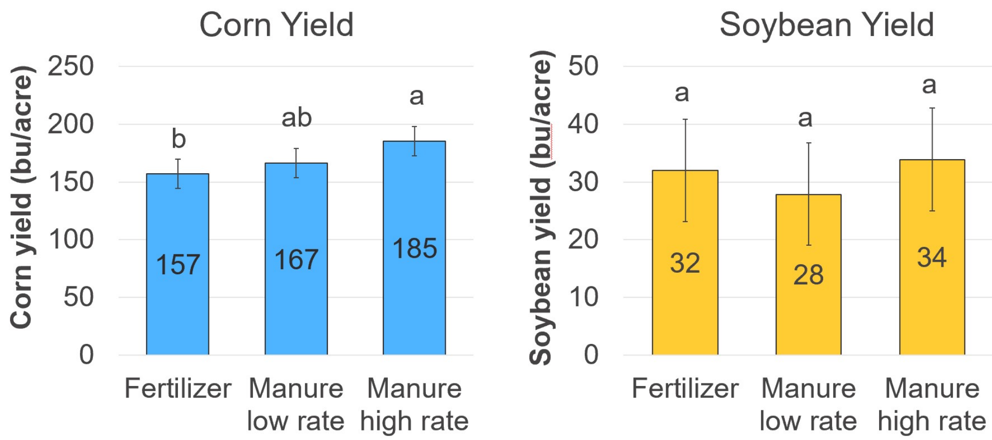


Figure 3. Corn (adjusted to 15.5% moisture) and soybean (adjusted to 13% moisture) yield at the Murdock site in 2021. Manure was fall applied two years ago at 15,400 gallons per acre (high rate) or 10,300 gallons per acre (low rate) and fertilizer was spring applied. In this second year, only fertilizer 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 ($p < 0.05$).

References:

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

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

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

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

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

ENTOMOLOGY

NOTES

TURNING POINT® SURVEY OF SUGARBEET INSECT PEST PROBLEMS AND MANAGEMENT PRACTICES IN MINNESOTA AND EASTERN NORTH DAKOTA IN 2021

Mark A. Boetel[1], Professor
Mohamed F.R. Khan[2], Professor
Thomas J. Peters[2], Associate Professor
Peter C. Hakk[3], Research Specialist

[1]Department of Entomology, North Dakota State University, Fargo, ND
[2]North Dakota State University & University of Minnesota, Fargo, ND
[3]Plant Pathology Department, North Dakota State University, Fargo, ND

Attendees of the 2022 Winter Sugarbeet Grower Seminars held at Fargo, Grafton, and Wahpeton, ND were asked about their 2021 insect pest problems and associated management practices in a live polling session by using a Turning Point® interactive personal response system. Unfortunately, inclement winter weather forced cancellation of the in-person seminar at Grand Forks, and it was replaced with a virtual meeting. Therefore, no survey data were collected from the Grand Forks seminar. Other problems that affected the volume of data collected and the coverage area of the 2022 surveys included software failures at the Fargo and Grafton seminar locations that either precluded administering some insect pest management questions or resulted in lost data. Additional errors at the Wahpeton seminar involved either elimination or errantly rewritten response options.

Initial questioning at all surveyed locations involved identifying the county in which grower respondents produced the majority of their sugarbeet crop in 2021. Those results are presented in Tables 1, 2, and 3).

Table 1. 2022 Fargo Grower Seminar – county in which sugarbeet was grown in 2021

County	Number of responses	Percent of responses
Cass	2	29
Clay	1	14
Norman/Mahnomen	2	29
Richland	1	14
Traill	1	14
Totals	7	100

Table 2. 2022 Grafton Grower Seminar – county in which sugarbeet was grown in 2021

County	Number of responses	Percent of responses
Grand Forks	1	6
Kittson	1	6
Marshall	2	13
Pembina	4	25
Walsh	6	38
Other	2	12
Totals	16	100

Table 3. 2022 Wahpeton Grower Seminar – county in which sugarbeet was grown in 2021

County	Number of responses	Percent of responses
Clay	7	11
Grant	6	9
Richland	16	25
Traverse	3	4
Wilkin	33	51
Totals	65	100

This report is based on production activities on an estimated 67,200 acres of sugarbeet grown in 2021 by 93 survey respondents that attended the 2022 Fargo, Grafton, and Wahpeton Winter Sugarbeet Grower seminars (Table 4). The majority (32%) of respondents reported growing sugarbeet on between 300 and 599 acres during the 2021 production season. An additional 24% of producers grew sugarbeet on between 600 and 999 acres, whereas 11% produced sugarbeet on less than 200 acres. Similar to previous years, 12% of respondents reported growing sugarbeet on 1,500 acres or more in 2021.

Table 4. Ranges of sugarbeet acreage operated by respondents in 2021

Location	Number of responses	<99	100-199	200-299	300-399	400-599	600-799	800-999	1000-1499	1500-1999	2000+
		Acres of sugarbeet									
		% of responses									
Fargo	12	17	0	0	17	17	8	0	17	17	8
Grafton	16	12	6	0	12	19	6	19	12	6	6
Wahpeton	65	3	6	14	14	18	14	12	9	8	2
Totals	93	6	5	10	14	18	12	12	11	9	3

From a combined total of 77 respondents at the Fargo, Grafton, and Wahpeton seminars, 43% overall indicated that grasshoppers were their worst insect pest problem during the 2021 growing season, and 17% reported that the sugarbeet root maggot was their worst insect pest problem (Table 5). However, majority of respondents at both Grafton (69% of respondents) and Fargo (36% of respondents) identified the sugarbeet root maggot as their worst insect pest problem. Other insect groups reported as being problematic included Cutworms (13% of all seminar location respondents, and 17% of respondents at Wahpeton), springtails (9 and 4% of respondents at Fargo and Wahpeton, respectively), and wireworms (9% of Fargo seminar respondents).

Table 5. Worst insect pest problem in sugarbeet in 2021

Location	Number of responses	Springtails	Cutworms	Lygus bugs	Wireworms	Root maggot	White grubs	Grass-hoppers	None
		% of responses							
Fargo	12	9	0	0	9	36	0	27	19
Grafton	13	0	0	0	0	69	0	23	8
Wahpeton	52	4	17	0	0	0	4	52	23
Totals	77	4	13	0	1	17	3	43	19

Questions on insecticidal seed treatment use were mistakenly omitted from the survey set at the Wahpeton seminar, so data for those questions only pertain to respondents at Fargo and Grafton (Table 6). Seed treatment insecticides were used in 2021 by a total of 86% of all respondents at the Fargo and Grafton seminars, with the majority (81%) of producers reporting that they planted seed treated with Poncho Beta insecticidal seed treatment, and just 5% overall using Cruiser-treated seed. All use of Cruiser was reported by attendees of the Grafton seminar. There was no reported use of seed treated with NipsIt Inside in 2021, irrespective of growing area surveyed. Averaged across the two seminar locations where this question was asked (Fargo and Grafton), 14% of respondents reported not using an insecticidal seed treatment.

Table 6. *Seed treatment* insecticide use for sugarbeet insect pest management in 2021

Location	Number of responses	Poncho Beta	Cruiser	NipsIt Inside	None
		% of responses			
Fargo	11	73	0	0	27
Grafton	10	80	10	0	10
Totals	21	81	5	0	14

Planting-time granular insecticides were used in 2021 by an average of 32% of grower attendees of the Fargo, Grafton, and Wahpeton seminars (Table 7). An overall average of 28% of growers at these meetings reported using Counter 20G at planting time, whereas only 3% of attendees reported applying Lorsban 15G for planting-time protection of their sugarbeet crop from insect pests. Counter 20G use as a planting-time treatment by Fargo, Grafton, and Wahpeton seminar respondents was at 55, 29%, and 21%, respectively. An additional 4% of respondents at the Wahpeton seminar reported applying Lorsban 15G or a chlorpyrifos-based generic granular equivalent product for planting-time protection of their sugarbeet crop. Overall, 68% of respondents across all three grower seminars reported that they did not use a granular insecticide at planting for insect management in 2021.

Table 7. *Planting-time granular* insecticides used for insect pest management in sugarbeet during 2021

Location	Number of responses	Counter 20G	Lorsban 15G	Thimet 20G	Other	None
		--------% of responses--------				
Fargo	11	55	0	0	0	45
Grafton	7	29	0	0	0	71
Wahpeton	47	21	4	0	2	72
Totals	65	28	3	0	2	68

Averaged across the two seminar locations where the question was asked (Fargo and Grafton), the low (5.25 lb product/ac) rate of Counter 20G was most the most commonly used (22% of all grower seminar attendees) planting-time granular insecticide for insect management in 2021 (Table 8). An additional 13% used Counter 20G at its moderate labeled rate (7.5 lb/ac), and another 9% applied it at the highest allowable rate of 8.9 lb/ac.

The majority of Fargo (42%) and Grafton (70%) respondents reported no use of a granular insecticide at planting in 2021. All respondents at both Fargo and Grafton who used a planting-time granular insecticide reported using Counter 20G. The survey question relating to planting-time granular application rates for data presented in Table 8 was errantly excluded at the Wahpeton seminar in 2022.

Table 8. Application rates of *planting-time granular* insecticides used for sugarbeet insect pest management in 2021

Location	Number of responses	Counter 20G			Lorsban 15G			Other	None
		9 lb	7.5 lb	5.25 lb	13.4 lb	10 lb	6.7 lb		
		--------% of responses--------							
Fargo	13	8	17	33	0	0	0	0	42
Grafton	10	10	10	10	0	0	0	0	70
Totals	23	9	13	22	0	0	0	0	57

Due to technical problems at the Fargo and Wahpeton grower seminars, the only data collected on postemergence insecticide use for root maggot control in 2021 was obtained at the Grafton seminar (Table 9). Overall, 73% of Grafton attendees reported that they applied a postemergence insecticide for sugarbeet root maggot control in 2021, which was a major increase over the 55% that reported using an insecticide for postemergence root maggot control in 2020.

Table 9. *Postemergence* insecticide use for *sugarbeet root maggot* management in 2021

Location	Number of responses	Lorsban (4E, Advanced, or a generic)	Mustang Maxx	Asana	Other liquid	Counter 20G	Lorsban 15G	Thimet 20G	None
		--------% of responses--------							
Grafton	15	40	0	0	0	0	7	27	27

Forty percent of the Grafton seminar respondents reported using a sprayable liquid formulation of chlorpyrifos, and 27% indicated that they applied Thimet 20G for postemergence root maggot control in 2021 (Table 9). Reported use of Thimet in 2021 by Grafton seminar attendees more than doubled that which was reported from that location during the previous year. An additional 7% of those respondents reported applying Lorsban 15G for postemergence root maggot management in 2021, which was similar to the reported use of that product by Grafton respondents in previous years (e.g., 8% in 2020). Twenty-seven percent of survey respondents at Grafton indicated that they did not apply a postemergence insecticide to manage the sugarbeet root maggot in 2021.

Satisfaction with insecticide applications made for root maggot management in 2021 was rated as good to excellent by 90% of Grafton respondents (Table 10). That was a 9% increase in grower ratings of insecticide performance for root maggot control during 2020. An additional 10% of Grafton respondents rated their satisfaction with root maggot control tools as being fair. It should be noted that, due to low attendance at the Grafton grower seminar, a small number of responses was received for this question.

Table 10. *Satisfaction* with insecticide treatments for sugarbeet root maggot management in 2021

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		----------------	----------------	% of responses	----------------	----------------
Grafton	11	20	70	10	0	0

As presented in Table 11, an average of 48% of attendees at the Fargo and Grafton grower seminar locations used an insecticide for planting-time protection against springtails. The majority of those respondents, averaged across both locations, used Counter 20G (20%), whereas Poncho Beta seed treatment and Mustang Maxx were used by 16 and 8% of respondents, respectively. An overall average of 4% of respondents reported using Midac sprayable liquid insecticide for springtail control. This was the first reported use of Midac in the growing area in these surveys. About 48% of all growers surveyed at the two seminar locations reported not using any insecticide for springtail control, which was identical to the number recorded for the 2020 growing season.

At the Fargo seminar, Counter 20G and Poncho Beta were used by 27% and 20% of respondents, respectively, and 13% reported applying Mustang Maxx as their choice for springtail control in 2021. Midac was reported as being used by 7% of Fargo respondents, but no use of this material was reported by Grafton attendees. Insecticide use for springtail management by Grafton seminar attendees was evenly split between Poncho Beta and Counter 20G at 10% of respondents each. The majority (80%) of attendees at the Grafton seminar indicated that they did not use an insecticide to for protection from springtail injury. This question was mistakenly excluded at the Wahpeton grower seminar, so no data were collected on springtail management for that growing area.

Table 11. Insecticide use for *springtail* management in 2021

Location	Number of responses	Cruiser	NipsIt Inside	Poncho Beta	Mustang Maxx	Counter 20G	Midac	Other	None
		----------	----------	----------	% of responses	----------	----------	----------	----------
Fargo	15	0	0	20	13	27	7	0	33
Grafton	10	0	0	10	0	10	0	0	80
Totals	25	0	0	16	8	20	4	0	52

As presented in Table 12, an average of 71% of grower respondents surveyed at the Fargo and Grafton seminar locations rated their insecticide performance for springtail management as good to excellent, and no participants viewed their insecticide performance as either fair or poor. Satisfaction among Fargo attendees, with regard to insecticide performance for springtail control, was fairly strong, with 75% rating their insecticide performance as either good or excellent. Interestingly, 50% of Grafton respondents rated their springtail control as excellent, and the remaining 50% responded as unsure.

Table 12. *Satisfaction* with insecticide treatments for springtail management in 2021

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		-------------------------------------% of responses-------------------------------------				
Fargo	14	8	67	0	0	25
Grafton	13	50	0	0	0	50
Totals	27	7	64	0	0	29

Although questions regarding use of insecticides for *Lygus* bug management in sugarbeet were presented to attendees of the Fargo and Grafton grower seminars, 100% of respondents, averaged across locations, reported that they did not use an insecticide *Lygus* control in 2021 (data not shown). This question was mistakenly excluded from being asked at the Wahpeton seminar.

Despite higher grasshopper populations occurring in 2021 than is typically observed in the growing area most years, only small numbers of grower respondents reported using insecticides to control them. Although the numbers of responses to this question were somewhat low, largely due to low grower seminar attendance in 2022, the results were consistent. All grower respondents at both Fargo and Grafton that reported applying an insecticide in 2021 for grasshopper control chose to use a sprayable liquid formulation of chlorpyrifos (Table 13). Averaged across the two seminar locations, 41% of respondents applied an insecticide for this purpose, and slightly more respondents at Grafton carried out an insecticide application for grasshopper control than did the Fargo respondents. This question was mistakenly excluded from the survey at the Wahpeton seminar location.

Table 13. Insecticide use for *grasshopper* management in 2021

Location	Number of responses	Asana	Lannate	Lorsban (4E, Advanced, or generic)	Movento	Mustang Maxx	Other	None
		--% of responses--						
Fargo	10	0	0	36	0	0	0	64
Grafton	13	0	0	46	0	0	0	54
Totals	23	0	0	41	0	0	0	59

Unfortunately, a software failure resulted in the loss of data for the question pertaining to satisfaction with insecticide performance for grasshopper control. As such, only data from the Grafton seminar location are presented in Table 14. Good to excellent grasshopper control was reported by 100% of Grafton seminar respondents, indicating that chlorpyrifos likely performed well for this use in 2021.

Table 14. *Satisfaction* with insecticide treatments for *grasshopper* management in 2021

Location	Number of responses	Excellent	Good	Fair	Poor	Unsure
		-------------------------------------% of responses-------------------------------------				
Grafton	14	33	67	0	0	0

Regarding spray output used for postemergence insecticide applications, 100% of grower respondents at the Grafton grower seminar location reported that they applied the insecticides in an output volume that ranged between six and 10 gallons per acre (GPA) in 2021 (Table 15). This differed considerably from previous surveys. For example, between 56 to 63% of respondents at the 2021 Fargo, Grafton, and Grand Forks seminars indicated that they applied their postemergence insecticides in a 6- to 10-GPA spray volume during the 2020 growing season.

Table 15. Spray volume output used for ground-applied postemergence insecticide applications in 2021

Location	Number of responses	1–5 GPA	6–10 GPA	11–15 GPA	16–20 GPA	> 20 GPA
		------------------------------------	------------------------------------	% of responses	------------------------------------	------------------------------------
Grafton	13	0	100	0	0	0

Overall, 58% of all respondents at the 2022 Winter Sugarbeet Grower Seminars (Grafton and Wahpeton locations combined) reported that their insecticide use in 2021 did not differ from the previous five years (Table 16). Although this was somewhat consistent among locations, the most significant change observed was that 33% of Grafton Growers Seminar attendees reported an increase in insecticide use in 2021 when compared to previous years. An additional 11% of respondents at the Wahpeton seminar location indicated that their insecticide use in sugarbeet had increased. The combination of increased sugarbeet root maggot infestation levels and numerous grasshopper outbreaks in the northern Red River Valley, combined with additional grasshopper problems in the MinnDak Farmers Cooperative growing area likely contributed to the reported insecticide use increases in 2021.

Table 16. Insecticide use in sugarbeet during 2021 compared to the previous 5 years

Location	Number of responses	Increased	Decreased	No Change	No Insecticide Use
		------------------------------------	------------------------------------	% of responses	------------------------------------
Grafton	12	33	0	67	0
Wahpeton	54	11	4	55	30
Totals	66	15	3	58	24

SUGARBEET ROOT MAGGOT FLY MONITORING IN THE RED RIVER VALLEY IN 2021

Mark A. Boetel, Professor
Jacob J. Rikhus, Research Specialist

Department of Entomology, North Dakota State University, Fargo, ND

Sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), fly activity was monitored at 150 grower field sites throughout the Red River Valley during the 2021 growing season. This effort was carried out as a collaborative effort between the NDSU Department of Entomology and American Crystal Sugar Company.

The 2021 growing season marked the fourth consecutive year in which root maggot fly activity had increased when compared to the previous year (Figure 1). In fact, 2021 had the highest overall average fly infestation levels in the last 15 years since the expanded fly monitoring program began in 2007. The most intense SBRM fly activity was observed in the central and northern Red River Valley in 2021. This suggests that control efforts between 2017 and 2020 were unsuccessful in reducing overall population levels for many producers.

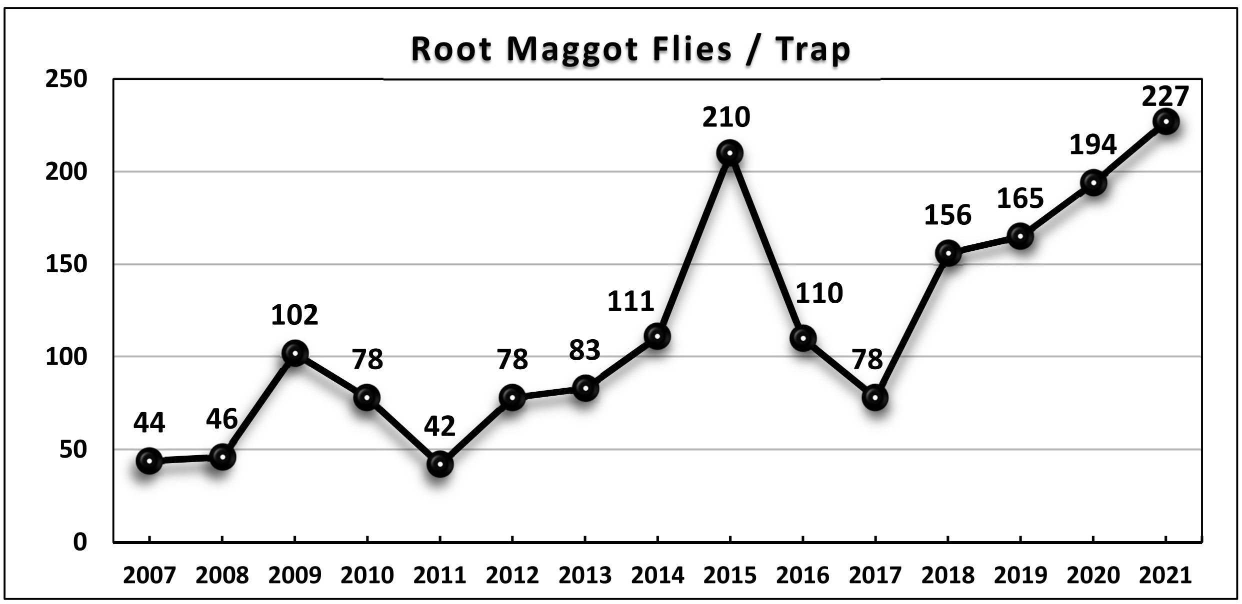


Figure 1. Yearly averages of sugarbeet root maggot flies captured on sticky-stake traps (Blickenstaff and Peckenpaugh, 1976) in the Red River Valley from 2007 to 2021.

High to severe levels of SBRM fly activity (i.e., cumulative capture of at least 200 flies per sticky stake) were observed in 2021 in fields near the following communities (cumulative flies per stake in parentheses): Auburn (234), Buxton (882), Cavalier (828), Crystal (632), Drayton (420), Oakwood (274), Reynolds (436), St. Thomas (585), and Thompson (274), ND, as well as Ada (494), Argyle (214), Climax (397), Crookston (304), East Grand Forks (554), and Warren (297), MN. Moderately high levels of activity were also recorded near Bathgate (51), Caledonia (53), Forest River (133), Grand Forks (188), Hamilton (46), Hoople (180), Leroy (46), Merrifield (108), Minto (49), and Walhalla (161) in North Dakota, and near Alma (184), Angus (160), Borup (152), Donaldson (113), Euclid (109), Fisher (189), Kennedy (65), and Sabin (76), MN. Fly activity was either economically insignificant or undetectable in most other areas.

Figure 2 presents SBRM fly monitoring results from three representative sites (i.e., Ada and East Grand Forks, MN and St. Thomas, ND) during the 2021 growing season. Fly emergence began at a somewhat normal time (i.e., late May) of the season; however, the main Valley-wide peak in activity occurred between June 8 and 9, which was about four to five days earlier than the historical average. Significant secondary peaks in fly activity occurred near St. Thomas, ND, as well as near Ada, MN, but no secondary peak was observed near East Grand Forks. The occurrence of two peaks in one growing season is somewhat rare, but it occurs about every three to five years.

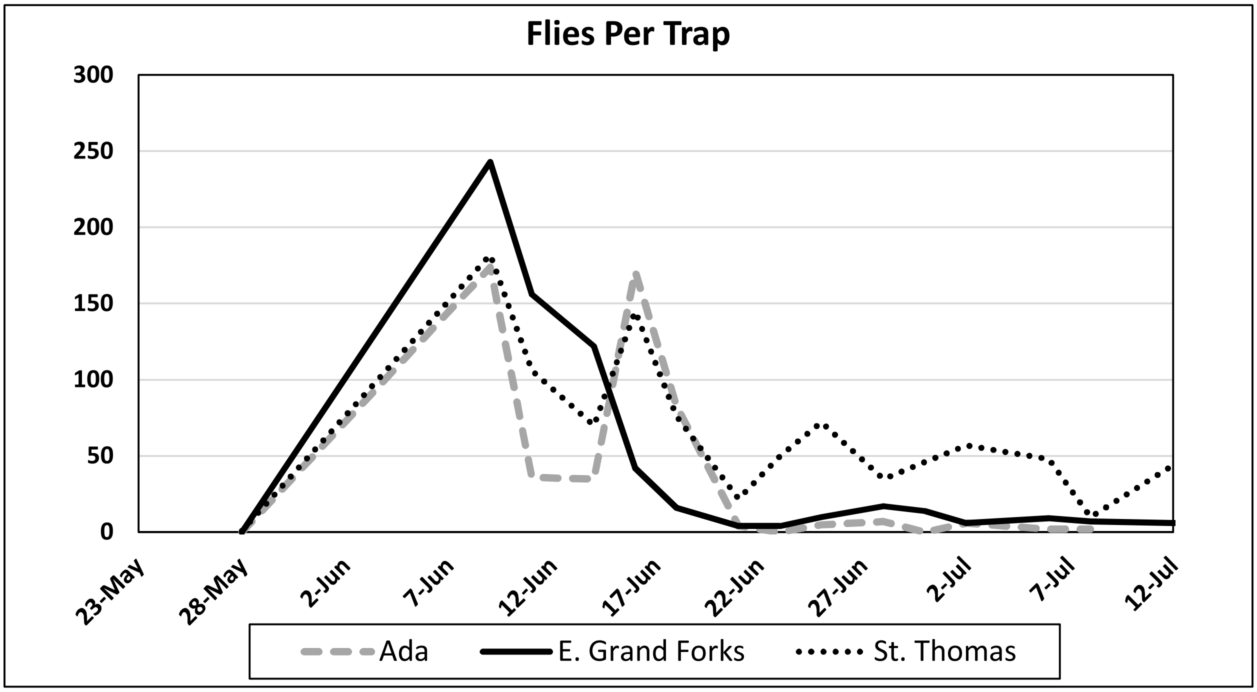


Fig. 2. Sugarbeet root maggot flies captured on sticky-stake traps at selected Red River Valley sites, 2020.

In late-August of 2021, after the larval feeding period had ended, 58 of the fly monitoring sites were rated for sugarbeet root maggot feeding injury in accordance with the 0-9 scale of Campbell et al. (2000) to assess whether fly outbreaks and larval infestations were managed effectively. The resulting data was subsequently overlaid with corresponding fly count data to develop the root maggot risk forecast map for the subsequent growing season (the SBRM risk forecast for next year is presented in the report that immediately follows this one).

Root maggot feeding injury, averaged across all RRV fields that exceeded the generalized economic threshold (43 cumulative flies per trap), was 1.65 on the 0 to 9 rating scale. That amounted to a 23% decrease over the same figure recorded in 2020. A list of RRV locations where the highest average root injury ratings were observed is presented in Table 1. Cumulative SBRM fly activity in those fields ranged from 70 flies/trap near Forest River, ND to 634 flies/trap near Crystal, ND.

Table 1. Sugarbeet root maggot fly activity and larval feeding injury in Red River Valley commercial sugarbeet fields where injury exceeded 2.5, 2021

Nearest City	Township	State	Flies/stake	Average Root Injury Rating[a]
St. Thomas	S. St. Thomas	ND	585	6.24
East Grand Forks	Sullivan	MN	458	4.40
Ada	Green Meadow	MN	358	3.00
Crystal	Elora	ND	404	2.73
Cavalier	Lodema	ND	828	2.50

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

The relatively high root injury ratings observed at a few of the locations listed in Table 1 are of concern, and growers in those areas should expect severe levels of SBRM fly activity in the 2022 growing season; however, the relatively small number of locations on this list suggest that control practices in much of the growing area were successful. This is supported by the fact that it is rare for SBRM feeding injury ratings in grower-managed fields to exceed 3.0 on the 0 to 9 scale.

Careful monitoring of fly activity in moderate- and high-risk areas (see Forecast Map [Fig. 1] in subsequent report) will be critical to preventing economic loss in 2022. 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.

Acknowledgments:

The authors extend sincere appreciation to the following American Crystal agriculturists for monitoring several additional fields for sugarbeet root maggot fly activity (in alphabetical order): Clay Altepeter, Andrew Clark, Todd Cymbaluk, Thomas Cymbaluk, Mike Doeden, Tyler Driscoll, Curtis Funk, Austin Holy, Bob Joerger, Tim Kenyon, Holly Kowalski, Kody Kyllo, Brock Larson, Kyle Lindberg, Chris Motteberg, Alysia Osowski, Travis Pederson, Nolan Rockstad, Aaron Sawatzky, Nick Shores, and Dan Vagle. Thanks are also due to the following NDSU summer aides for providing assistance with fly monitoring activities: Carter Blackwell, Gannon Rockstad, Brett Skarda, Karter Wasberg, and Victor Yang. We also thank the Sugarbeet Research and Education Board of Minnesota and North Dakota, and American Crystal Sugar Company for providing significant funding support for this project. This work was also partially supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Hatch project number ND02398.

References Cited:

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

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

SUGARBEET ROOT MAGGOT FORECAST FOR THE 2022 GROWING SEASON

Mark A. Boetel, Professor
Jacob J. Rikhus, Research Specialist

Department of Entomology, North Dakota State University, Fargo, ND

The 2022 sugarbeet root maggot (SBRM) risk map for the Red River Valley appears in the figure below. In 2021, SBRM fly activity was greater than that recorded in the four previous years. Root maggot infestations in 2021 were the highest recorded in the past 15 years, and root injury surveys suggest that some areas could have even higher infestations in 2022.

Areas at highest risk of damaging SBRM infestations include rural Auburn, Buxton, Cavalier, Crystal, Drayton, Grand Forks, Oakwood, Reynolds, St. Thomas, and Thompson, ND, and Ada, Argyle, Climax, Crookston, East Grand Forks, and Kennedy, MN. Moderate risk is expected in areas bordering high-risk zones, as well as fields near Bathgate, Caledonia, Forest River, Hamilton, Hoople, Leroy, Merrifield, and Minto, ND, and near Angus, Borup, Donaldson, Euclid, Fisher, Sabin, Stephen, and Warren, 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 2021 should be monitored closely in 2022. 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 decide if postemergence treatment is needed.

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

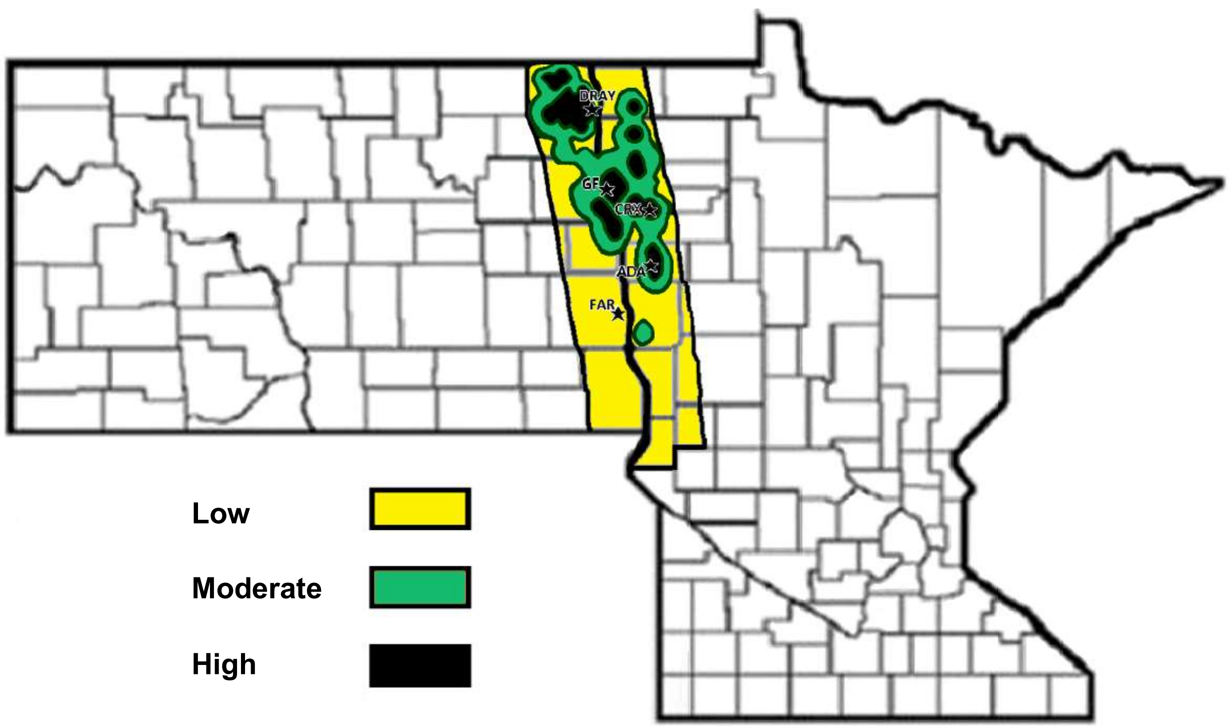


Fig. 1. Anticipated risk of SBRM fly activity and damaging larval infestations in the Red River Valley.

Acknowledgments:

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

COMPARISON OF YUMA 4E AND MUSTANG MAXX® FOR POSTEMERGENCE SUGARBEET ROOT MAGGOT CONTROL

Mark A. Boetel, Professor
Jacob J. Rikhus, Research Specialist

Department of Entomology, North Dakota State University, Fargo, ND

Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), continues to be a major economic pest of sugarbeet in the Red River Valley (RRV) growing area of North Dakota and Minnesota. Unfortunately, SBRM populations in the production area have mostly trended upward and expanded in geographic distribution for much of the past decade. Successful SBRM management in areas affected by high to severe SBRM infestations typically requires aggressive insecticide-based control programs that usually consist of either a granular insecticide or an insecticidal seed treatment at planting, followed by an additive postemergence insecticide application when the localized infestation level warrants it. The most commonly used approach for postemergence root maggot control in the RRV is a broadcast application of a sprayable liquid insecticide product.

The most recent challenge to effective SBRM management in the RRV was the U.S. Environmental Protection Agency's revocation of all food crop tolerances for all chlorpyrifos-containing insecticide products in August of 2021. The loss of this insecticide active ingredient will likely be a major impediment to U.S. sugarbeet growers' ability to effectively manage the SBRM. In anticipation of the loss or restrictions on uses for this important insecticide, research was undertaken to evaluate Mustang Maxx as a pyrethroid insecticide alternative to chlorpyrifos for postemergence SBRM control.

Materials and Methods:

This experiment was conducted on a commercial sugarbeet field site near St. Thomas, ND during the 2020 and 2021 growing seasons. Glyphosate-resistant seed was used both years (i.e., Betaseed 8524 in 2020 and Betaseed 8961 in 2021). Plots were planted on 18 and 10 May in 2020 and 2021, respectively. All plots were planted using a 6-row Monosem NG Plus 4 7x7 planter set to deliver seed at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. The outer "guard" row on each side of the plot served as an untreated buffer. Each plot was 35 feet long, and 35-foot tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with four replications of the treatments; however, environmental variability that impacted plots before harvest required exclusion of one replicate per year, thus resulting in three replications of yield data from each year.

<u>Planting-time insecticides</u>. All insecticide-treated plots received a planting-time application of Counter 20G at its maximum labeled rate of 8.9 lb product per acre. Counter 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 output was regulated by using a planter-mounted SmartBox™ computer-controlled insecticide delivery system that had been calibrated on the planter before all applications.

<u>Postemergence insecticide applications</u>. Dual insecticide program treatments received additive postemergence applications of either Yuma 4E (active ingredient: chlorpyrifos) or Mustang Maxx (active ingredient: zetacypermethrin). Treatments that included postemergence applications involved both single and double postemergence spray applications of both products. Yuma was applied at either 1 or 2 pints of product per acre, and Mustang Maxx was applied at the maximum single-application rate of 4 fl oz per acre. Average postemergence insecticide timing compared included four days ahead of peak SBRM fly activity ("Pre-peak"), one day pre-peak, and five days after peak fly activity ("Post-peak"). Liquid insecticide solutions were delivered with a tractor-mounted CO_2-propelled spray system equipped with TeeJet™ XR 110015VS nozzles calibrated to deliver applications in a finished output volume of 10 GPA.

<u>Root injury ratings</u>. Sugarbeet root maggot feeding injury was assessed in this experiment on July 28 and August 3 in 2020 and 2021, respectively. A random sample of ten beet roots (five from each of the outer two treated rows) was collected from each plot, hand-washed, and scored in accordance with the 0 to 9 root injury rating scale (0 =

no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest. Treatment performance was also compared on the basis of sugarbeet yield parameters. Plots were harvested on September 22 and 21, respectively, in 2020 and 2021. Foliage was removed from plots immediately before harvest by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were extracted from soil using a mechanical harvester, and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Data analysis. All data from root injury ratings and harvest samples were subjected to analysis of variance (ANOVA) according to the general linear models (GLM) procedure (SAS Institute, 2012). Treatment means were compared by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance. Initial analyses indicated that there were no significant treatment × year interactions for root injury ratings ($P = 0.0840$), recoverable sucrose yield ($P = 0.2023$), root yield ($P = 0.2917$), or percent sucrose content data ($P = 0.0718$). As such, two-year combined analyses were performed on all data from this experiment.

Results and Discussion:

Sugarbeet root maggot feeding injury ratings in the untreated check plots averaged 6.92 on the 0 to 9 scale of Campbell et al. (2000) (Table 1), suggesting that relatively high SBRM infestations were present for the both years of the experiment. All insecticide treatment combinations, including single-, dual-, and triple-insecticide component programs, resulted in significant reductions in sugarbeet root maggot feeding injury when compared to that sustained in the untreated check plots. Plots treated with Counter 20G at its highest labeled rate (8.9 lb product/ac), followed by two postemergence broadcast sprays of Yuma 4E (either 1 or 2 pts product/ac) resulted in the lowest overall root injury ratings in the experiment. However, plots protected by similar treatment combinations involving the same rate of Counter at planting, followed by either a single application of Yuma 4E at its maximum single-application rate (2 pts/ac) or a dual application of Mustang Maxx, were not significantly outperformed by those that received two applications (1 or 2 pts/ac) of Yuma. The two top-performing treatments that included dual postemergence applications of Yuma 4E did, however, perform significantly greater than those that received only a single postemergence insecticide application, irrespective of whether it was Mustang Maxx or Yuma 4E.

Table 1. *Larval feeding injury* in an assessment of Yuma 4E® and Mustang Maxx® for postemergence sugarbeet root maggot control, St. Thomas, ND, 2020-2021

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Yuma 4E + Yuma 4E	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	8.9 lb 1 pt 1 pt	1.8 0.5 0.5	2.92 d
Counter 20G + Yuma 4E + Yuma 4E	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	8.9 lb 2 pts 2 pts	1.8 1.0 1.0	3.05 d
Counter 20G + Yuma 4E	B 1 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	3.72 cd
Counter 20G + Mustang Maxx + Mustang Maxx	B 1 d Pre-peak Broadcast 2 d Post-peak Broadcast	8.9 lb 4 fl oz 4 fl oz	1.8 0.025 0.025	3.88 bcd
Counter 20G + Mustang Maxx	B 1 d Pre-peak Broadcast	8.9 lb 4 fl oz	1.8 0.025	4.16 bc
Counter 20G + Yuma 4E	B 3 d Pre-peak Broadcast	8.9 lb 1 pt	1.8 0.5	4.25 bc
Counter 20G	B	8.9 lb	1.8	4.81 b
Check	---	---	---	6.92 a
LSD (0.05)				1.010

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

Yield and associated gross economic return (i.e., excluding application and product costs) results from this trial are presented in Table 2. All treatments that included at least one postemergence insecticide spray provided significant increases in both recoverable sucrose yield and root tonnage. The single planting-time treatment consisting of Counter 20G at 8.9 lb/ac was the only treatment in the entire trial that did not provide a significant increase in recoverable sucrose or sugarbeet root yield. As observed with root injury rating data, excellent sucrose and root yields resulted from treatment combinations that included two postemergence applications of Yuma 4E (i.e., either 1 or 2 pts product/ac). Plots treated with those combinations produced significantly more root tonnage than all other treatments in the trial, and significantly greater recoverable sucrose yield per acre than all treatments, except the combination of Counter 20G plus a single application of Yuma at 2 pts/ac. Unfortunately, although trends suggested some numerical increases in sucrose and root tonnage from single postemergence application of Yuma 4E at the lower, 1-pt rate and both the single and double applications of Mustang Maxx none of those additive treatments resulted in a significant increase in either recoverable sucrose yield or root tonnage.

Table 2. *Yield parameters* from an assessment of Yuma 4E® and Mustang Maxx® for postemergence sugarbeet root maggot control, St. Thomas, ND, 2020-2021

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 + Yuma 4E + Yuma 4E	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	8.9 lb 2 pts 2 pts	1.8 1.0 1.0	9,244 a	29.2 a	17.0 a	1,395
Counter 20G + Yuma 4E + Yuma 4E	B 4 d Pre-peak Broadcast 6 d Post-peak Broadcast	8.9 lb 1 pt 1 pt	1.8 0.5 0.5	8,938 a	27.9 ab	17.1 a	1,364
Counter 20G + Yuma 4E	B 1 d Pre-peak Broadcast	8.9 lb 2 pts	1.8 1.0	8,261 ab	25.6 bc	17.2 a	1,269
Counter 20G + Mustang Maxx + Mustang Maxx	B 1 d Pre-peak Broadcast 2 d Post-peak Broadcast	8.9 lb 4 fl oz 4 fl oz	1.8 0.025 0.025	7,679 bc	23.6 cd	17.2 a	1,194
Counter 20G + Mustang Maxx	B 1 d Pre-peak Broadcast	7.5 lb 4 fl oz	1.5 0.025	7,592 bc	23.4 cd	17.1 a	1,176
Counter 20G + Yuma 4E	B 3 d Pre-peak Broadcast	8.9 lb 1 pt	1.8 0.5	7,548 bc	24.0 cd	16.8 a	1,132
Counter 20G	B	8.9 lb	1.8	6,797 cd	21.4 de	16.8 a	1,029
Check	---	---	---	6,084 d	19.4 e	16.3 a	901
LSD (0.05)				1,070.6	3.04	NS	

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

Although there were no significant differences among the top three treatments with regard to recoverable sucrose per acre or root yield, economic return results suggest that, under the high SBRM pressure that developed for both years of this study, substantial increases in gross revenue can be achieved through effective postemergence insecticide approaches. Even the lowest-yielding planting-time/postemergence treatment combination, consisting of Counter 20G at planting plus one application of Yuma 4E at 1 pt/ac, generated $103/ac in increased revenue when compared to Counter alone. Another interesting finding was that, when a total of two pints of Yuma 4E was used, splitting the total product amount applied into two separate applications of one pt each resulted in a revenue increase of $95 over the single, two-pint application.

The best-performing treatment, in considering protection from SBRM feeding injury, recoverable sucrose yield, root tonnage, and resulting gross revenue, was the combination of planting-time Counter 20G at its high labeled rate (8.9 lb/ac) plus two 2-pt/ac applications of Yuma 4E, one at 5 days SBRM fly activity and the second one at 5 days post-peak. This combination generated $946/ac more gross revenue than the untreated check, and at least $31/ac more greater revenue than any other insecticide treatment combination tested in this experiment. Also supportive of aggressive approaches to SBRM management was the finding that the top-performing program in this trial (Counter at planting followed by two 2-pt/ac applications of Yuma 4E) increased gross economic return over the Counter-only treatment by $366/ac.

The top-yielding, aggressive approach also generated $201/ac greater gross revenue than a similar treatment combination comprised of Counter at planting plus two applications of Mustang Maxx at its maximum labeled rate (4 fl oz/ac). This suggests that dual broadcast applications of a chlorpyrifos-containing sprayable liquid (e.g., Lorsban 4E, Yuma 4E, etc.), probably provide superior postemergence SBRM management to those involving dual applications of a pyrethroid-based insecticide such as Mustang Maxx. It should be noted, however, that single and dual postemergence broadcasts of Mustang Maxx provided respective revenue benefits of $147 and $165/ac when compared to the single, Counter 20G-based control programs.

Given that chlorpyrifos tolerances in sugarbeet have been revoked, it is highly likely that U.S. sugarbeet producers will face serious challenges with regard to SBRM management in the future. Producers in affected areas, such as much of the RRV sugarbeet growing area, who perennially experience the threat of economically damaging SBRM infestations, should strongly consider using a pyrethroid insecticide in lieu of the regulatory loss of chlorpyrifos-based products as sprayable liquid insecticide options. Another viable, although expensive, option would be to invest in equipment for applying postemergence applications of a granular organophosphate insecticide product. Results further suggest that even two applications of a pyrethroid insecticide may still be insufficient in maximizing yield and associated revenue under high SBRM infestation pressure. Another general conclusion that can be drawn is that the root protection, yield, and revenue benefits from additive postemergence insecticides demonstrate that they are cost-effective tools that easily pay for themselves in areas where moderately high to severe SBRM populations occur.

Acknowledgments:

The authors thank Wayne and Austin Lessard, and Darryl Collette for allowing us to conduct this research on their farms. Appreciation is also extended to the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing partial funding to support this project. We also thank Carter Blackwell, Zane Miller, Brett Skarda, Claire Stoltenow, Kenan Stoltenow, Gannon Rockstad, Karter Wasberg, and Victor Yang for assistance with plot maintenance, stand counting, root sample collection, and data entry. Gratitude is also extended to the American Crystal Quality Tare Laboratory (East Grand Forks, MN) for performing sucrose content and quality analyses on harvest samples. This work was also partially supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, under Hatch project number ND02398.

References Cited:

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

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

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

ROOT MAGGOT CONTROL AND PLANT SAFETY OF INSECTICIDE, AZOXYSTROBIN FUNGICIDE, AND STARTER FERTILIZER COMBINATIONS IN SUGARBEET

Mark A. Boetel, Associate Professor
Jacob J. Rikhus, Research Specialist

Department of Entomology, North Dakota State University, Fargo, ND

Introduction:

Combining crop management material (e.g., insecticide, fungicide, etc.) applications into one pass through the field, either at planting or after emergence of the crop, can be a significant cost-saving measure in most agricultural cropping systems. However, there is often uncertainty with regard to the impacts of such combinations on plant health or pest control efficacy.

Red River Valley sugarbeet producers often apply a planting-time insecticide to their crop for protection from losses associated with root-feeding insect pests, such as wireworms, springtails, white grubs, or the sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder). The latter is the most frequently problematic and most severe insect pest of sugarbeet in the growing region. Producers typically manage this pest through prophylactic insecticide application during sugarbeet planting, which consists of granular or sprayable liquid formulations, or insecticide-treated seed. In situations where high SBRM fly activity and associated larval feeding pressure are expected, most producers also supplement the at-plant insecticide with a postemergence-applied material, which can involve either granular or sprayable liquid formulations.

Fungicides are also frequently applied to manage soil-borne root diseases such as Rhizoctonia damping off, as well as Rhizoctonia crown and root rot, which are all caused by the pathogen *Rhizoctonia solani* Kühn. Similar to the insecticides used for SBRM management, fungicides targeting Rhizoctonia management in sugarbeet also can be delivered as planting-time and/or postemergence applications. Starter fertilizer applications are also commonly used by RRV sugarbeet producers. However, little is known about the crop safety of these combinations or if they either complement or impair product performance. If demonstrated to be safe for the crop and at least neutral in impact on control efficacy, consolidating product combinations into either tank-mixed combinations or concurrent (i.e., single-pass) applications would provide time savings and significant application-associated input costs.

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

1) Counter 20G insecticide, 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;

2) Yuma 4E 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 application of Quadris (i.e., azoxystrobin) fungicide, also delivered in a band.

Materials and Methods:

This experiment was conducted during the 2020 and 2021 growing seasons in commercial sugarbeet field sites near St. Thomas in rural Pembina County, ND. Plots were planted on May 19 in 2020 and May 12 in 2021. Betaseed 8524 was used for all treatments in 2020, and Betaseed 8961 was used in 2021. Both varieties were glyphosate-resistant, regular pellet-sized seed. A 6-row Monosem NG Plus 4 7x7 planter set to deliver seed at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length was used to plant the trial. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. The outer "guard" row on each side of the plot served as an untreated buffer. Each plot was 35 feet long, and 35-foot tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with four replications. Quadris was used as the postemergence fungicide, as it is the most common use of an azoxystrobin-based for postemergence root diseases in the Red River Valley growing area.

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

Planting-time liquid spray applications were delivered by using dribble in-furrow (DIF) placement. Dribble in-furrow applications were made by orienting a microtube (1/4” outside diam.) directly into the open seed furrow. Inline Teejet™ No. 18 orifice plates were used to stabilize and restrict spray solution output from the microtubes for a delivery rate of 5 gallons per acre (GPA).

Postemergence insecticide applications. Additive postemergence insecticides applied in this trial included Yuma 4E (a generic chlorpyrifos formulation, similar to Lorsban 4E) and Thimet 20G. In 2020, treatment combinations that included postemergence applications of both Thimet or Yuma were applied on June 17, which was just one to 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, an equipment failure and long periods of unfavorable weather prevented more timely applications of treatments that included it. In 2021, Thimet was applied on June 2 (7 days pre-peak) and Yuma was applied on June 3 (6 days pre-peak). The timing of Yuma applications in 2021 was also suboptimal for SBRM control, but similar weather conditions interfered with application timing.

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

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this experiment on July 27 in 2020, and on August 3 in 2021. Sampling consisted of randomly collecting ten beet roots per plot (five from each of the outer two treated rows), hand-washing them, and scoring them in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. Plots were harvested on September 23 in 2020 and on September 21 in 2021. Foliage was removed from plots immediately before harvest by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were extracted from soil using a mechanical harvester and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Data analysis: All data from root injury ratings and harvest samples were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2012). Treatment means were compared by using Fisher’s protected least significant difference (LSD) test at a 0.05 level of significance. Initial analyses indicated that there were no significant treatment × year interactions for root injury ratings (P = 0. 4507), recoverable sucrose yield (P = 0. 2609, or root yield (P = 0. 1619). Therefore, two-year combined analyses were performed on all data from this experiment.

Results and Discussion:

Sugarbeet root maggot feeding injury results from this two-year trial are shown in Table 1. This data should be interpreted with the aforementioned fact that an equipment failure and unfavorable weather conditions prevented the applications of Yuma 4E and Thimet 20G at preplanned timings in relation to peak SBRM fly activity. As such, the performance levels of treatments including those products could have been negatively affected.

The average SBRM feeding injury sustained in the true untreated check and the fertilizer-only check plots (8.19 and 7.58, respectively, on the 0 to 9 scale of Campbell et al. [2000]) indicated the presence of severe larval infestations for both years of 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 level of 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 moderate labeled rate (7.5 lb product/ac) plus a tank-mixed postemergence combination of Yuma 4E (2 pts/ac) plus Quadris fungicide; however, that entry was not statistically superior to any of the dual (i.e., planting-time plus postemergence) insecticide entries in the trial. Root protection from SBRM feeding injury was not significantly impaired by applying starter fertilizer at the same time as banded applications of Counter 20G at planting time. In fact, numerically (i.e., not statistically) lower levels of SBRM feeding injury were recorded in Counter 20G-treated plots when starter fertilizer was included than when the fertilizer was not used. There also were no significant reductions in SBRM control when Quadris was applied concurrently with Thimet 20G or when it was tank mixed with Yuma 4E, irrespective of the rate at which the insecticides were applied.

Table 1. *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, 2020-2021

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G + Yuma 4E + Quadris	B 10” Post B, 1 d Pre-peak	8.9 lb 2 pt 10 fl oz	1.8 1.0 0.17	3.62 f
Counter 20G + Thimet 20G + Quadris	B 4” Post B, 1 d Pre-peak 10” Post B, 1 d Pre-peak	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	4.07 ef
Counter 20G + Yuma 4E + Quadris	B 10” Post B, 1 d Pre-peak	8.9 lb 1 pt 10 fl oz	1.8 0.5 0.17	4.26 def
Counter 20G + Thimet 20G	B 4” Post B, 1 d Pre-peak	8.9 lb 7 lb	1.8 1.4	4.28 def
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	4.76 cde
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	4.99 bcd
Counter 20G	B	8.9 lb	1.8	5.42 bc
Counter 20G	B	7.5 lb	1.5	5.54 b
Fertilizer check	DIF	5 GPA		7.58 a
Untreated check	-----	----	-----	8.19 a
LSD (0.05)				0.771

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

Yield data from this experiment are presented in Table 2. Overall performance patterns indicated that treatment combinations including dual (planting-time plus postemergence) insecticide applications provided greater recoverable sucrose and root yields, and higher gross economic returns than the insecticide treatments that did not include a postemergence insecticide.

The treatment combination comprised of Counter 20G at its high labeled rate (8.9 lb product/ac) plus a postemergence tank mixture of Yuma 4E (high labeled rate of 2 pts product/ac) and Quadris fungicide at its recommended rate (10 fl oz product/ac) produced greatest recoverable sucrose yield, root tonnage, and gross revenue in this trial. Reducing the rate of Yuma 4E to 1 pint per acre resulted in plots producing comparable sucrose and root yields, but gross economic return was $44 higher when the Yuma component was applied at its full 2-pt labeled rate.

Table 2. Impacts of concurrently applied and tank-mixed combinations of azoxystrobin fungicide and sugarbeet root maggot-targeted insecticides on *yield parameters*, St. Thomas, ND, 2020-2021						
Treatment/form.[a]	**Placement[b]**	**Rate (product/ac)**	**Rate (lb a.i./ac)**	**Sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Gross return ($/ac)**
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 2 pt 10 fl oz	1.8 1.0 0.17	8,409 a	29.0 a	1,140
Counter 20G + Yuma 4E + Quadris	B 10" Post B, 1 d Pre-peak	8.9 lb 1 pt 10 fl oz	1.8 0.5 0.17	7,800 ab	26.1 b	1,096
Counter 20G + Thimet 20G + Quadris	B 4" Post B, 1 d Pre-peak 10" Post B, 1 d Pre-peak	8.9 lb 7 lb 10 fl oz	1.8 1.4 0.17	7,584 ab	24.9 b	1,092
Counter 20G + Thimet 20G	B 4" Post B, 1 d Pre-peak	8.9 lb 7 lb	1.8 1.4	7,455 b	24.7 b	1,065
Counter 20G	B	8.9 lb	1.8	6,241 c	21.1 c	866
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	6,203 c	21.2 c	850
Counter 20G + 10-34-0	B DIF	8.9 lb 5 GPA	1.8	6,175 c	20.8 c	861
Counter 20G	B	7.5 lb	1.5	5,642 c	19.4 c	766
Fertilizer check	DIF	5 GPA		4,493 d	15.7 d	600
Check	-----	----	-----	4,058 d	14.9 d	499
LSD (0.05)				909.3	4.10	

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

In plots that received the planting-time combination of a banded application of Counter 20G at 7.5 lb product per acre plus a concurrently applied (i.e., dribbled in-furrow) application of 10-34-0 starter fertilizer, the inclusion of the fertilizer resulted in numerical, but not statistically significant, increases in both recoverable sucrose yield and root tonnage per acre. However, when Counter was applied at its high labeled rate (8.9 lb product/ac), numerical, non-significant reductions in recoverable sucrose yield, root tonnage, and gross revenue were observed when 10-34-0 starter fertilizer was applied in furrow ahead of the insecticide bands at planting time.

The overall findings of this experiment suggest that applying 10-34-0 starter fertilizer dribble-in-furrow concurrently with a planting-time 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. Similarly, combining azoxystrobin-based fungicide applications with SBRM-targeted insecticide applications, through either tank mixing (i.e., Yuma 4E + Quadris) or by using concurrent delivery systems (i.e., Quadris banded concurrently, but delivered ahead of the deposition Thimet granules), is not likely to result in reduced root maggot control or negative impacts on sugarbeet yield or quality.

It should be noted that this trial was conducted in environments in which high SBRM feeding pressure developed. The net impacts of the treatment combinations on plant health under lower SBRM pressure, or in its absence need to be studied under both pest-free and SBRM-infested scenarios to more fully characterize the safety and SBRM control efficacy of these treatment combinations.

Acknowledgments:

Appreciation is extended to Wayne and Austin Lessard, and Darryl Collette for allowing us to conduct this research on their farms. The authors also thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing partial funding to support this project. We also appreciate the contributions of Carter Blackwell, Zane Miller, Brett Skarda, Claire Stoltenow, Kenan Stoltenow, Gannon Rockstad, Karter Wasberg, and Victor Yang for assistance with plot maintenance, stand counting, root sample collection, and data entry. Thanks are also extended to the American Crystal Quality Tare Laboratory (East Grand Forks, MN) for performing sucrose content and quality analyses on harvest samples. This work was also partially supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, under Hatch project number ND02398.

References Cited:

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

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

EVALUATION OF MIDAC FC® AND BIFENDER FC® FOR SUGARBEET ROOT MAGGOT CONTROL

Mark A. Boetel, Professor
Jacob J. Rikhus, Research Specialist

Department of Entomology, North Dakota State University, Fargo, ND

Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder), is a key insect pest of sugarbeet in the Red River Valley (RRV) growing area. Red River Valley sugarbeet producers typically manage the SBRM by using a two-pronged approach involving 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.

For well over four decades, chemical control of the SBRM has involved using insecticides from the same mode of action, acetylcholinesterase (ACHE) inhibition because a limited number of insecticide products have been commercially available for use in the crop for several decades. This long-term, repeated use of ACHE inhibitor insecticides has exerted a considerable amount of selection pressure for the development of ACHE insecticide resistance development 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 2019, EPA approved Midac FC for registered use in sugarbeet and potato. Although the current EPA-issued Midac FC label does not specifically list sugarbeet root maggot as a target pest, Vive Crop Protection has issued a Section 2(ee) recommendation for planting-time applications of Midac for SBRM control. The 2(ee) is a legal designation, offered to end-users by the registrant, as permitted by EPA through statutory authority under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1910. The FIFRA 2(ee) designation allows a user to apply "*a pesticide against any target pest not specified on the labeling if the application is to the crop, animal, or site specified on the labeling, unless the Administrator has required that the labeling specifically state that the pesticide may be used only for the pests specified on the labeling after the Administrator has determined that the use of the pesticide against other pests would cause an unreasonable adverse effect on the environment*." This provides legal permission for producers and other applicators to use Midac FC for sugarbeet root maggot management in sugarbeet. However, they must be in physical possession of the published 2(ee) recommendation/product bulletin at the time the product is being applied.

The active ingredient in Midac FC imidacloprid, 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 neonicotinoid products have been used as insecticidal seed treatments for insect management in sugarbeet since 2008. One purported benefit of Midac FC is its apparent compatibility for tank mixing with starter fertilizer formulations. Inclusion of starter fertilizer with sugarbeet planting is commonly practiced by producers in the Red River Valley growing area, but little is known about its potential impacts, either positive or negative, on agronomic responses such as insecticide performance, plant safety, and resulting crop yield.

The key objective of this experiment was to evaluate the efficacy of Midac FC and Bifender 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 enhancing single-pass insect 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 2021 growing season. Betaseed 8961 glyphosate-resistant seed was used for all treatments in the trial, and all plots were planted on May 13, 2021 by using a 6-row Monosem NG Plus 4 7x7 planter set to deliver seed at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide, with the four centermost rows treated. Insecticide was excluded from each of the outside rows (i.e., rows 1 and 6) of the planter, and those "guard rows" served as untreated buffers. Each plot was 35 feet long, and 35-foot alleys between replicates were maintained weed-free by using periodic cultivation throughout the growing season. The experiment was arranged in a randomized complete block design with four replications of the treatments.

Midac FC and VCP034 (an experimental insecticide) were 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. Bifender FC was applied by using both DIF and T-band placement. T-band placement was achieved by orienting the output fan of a conventional TeeJet™ 450067E nozzle directly perpendicular to each planter row, and adjusting nozzle height to achieve a 3-inch band over the open seed furrow. Most at-plant treatments included 10-34-0 fertilizer (i.e., 10, 34, and 0% nitrogen, phosphorus, and potassium, respectively), which was diluted to a 3:2 gallon ratio of fertilizer to water. Water used for these solutions was adjusted to pH 6.0 several 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. The 7.5-lb rate of Counter and a control were also included 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 3, 22, and 29 June, 2021 (i.e., 21, 40, and 47 days after planting [DAP]), respectively. Plant stand assessments involved counting all living plants within each 35-ft-long row. Raw stand counts were then converted to plants per 100 linear row feet for the analysis.

Root injury ratings: Sugarbeet root maggot feeding injury ratings were conducted on August 4. Sampling consisted of randomly collecting ten beet roots per plot (five from each of the outer two treated rows), hand-washing them, and scoring them in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Plots were harvested on September 22. Immediately (i.e., within one hour) before harvest, all foliage was removed from plots by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were then extracted from soil using a mechanical harvester and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

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

Results and Discussion:

Table 1 includes plant stand counts from three dates. Treatments are listed in descending order of surviving plant stand at the final count. Thus, careful attention is required to assess stand count comparisons from the first two count dates. The highest plant densities at the first stand count (i.e., 21 DAP) were observed in the true untreated control plots; however, other treatments, which were not statistically different in surviving stand at 21 DAP included both at-plant-only (i.e., no starter fertilizer) applications of Counter 20G, and the 3" T-band of Bifender FC. All other treatments had significantly lower surviving plant stands than the true untreated check. This suggests that those treatments, which included the DIF application of Bifender, all Midac-based treatments, both Counter-based treatments that included a starter fertilizer, and the treatment of Poncho Beta plus fertilizer, had statistically significant negative impacts on stand establishment. The treatment consisting of Poncho Beta and starter fertilizer also had significantly lower plant stands at 21 DAP than the fertilizer-only check. Additionally, plots that received the 10-34-0 starter fertilizer-only control had statistically fewer plants per 100 ft than the true untreated check, suggesting that the fertilizer was likely an important factor in the observation of reduced stands in several these treatments.

Table 1. *Plant stand counts* from an evaluation of Midac® and Bifender® insecticides for sugarbeet root maggot control, St. Thomas, ND, 2021

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Stand count[c] (plants / 100 ft)		
				21 DAP[c]	40 DAP[c]	47 DAP[c]
Counter 20G	B	7.5 lb	1.5	200.4 ab	183.0 abc	206.3 a
Counter 20G	B	8.9 lb	1.8	210.7 a	197.9 a	197.9 ab
Midac FC + 10-34-0 + Bifender FC	DIF 1 d Pre-peak Broadcast	13.6 fl oz 5 GPA 7.3 fl oz	0.18 0.1	180.4 cd	188.6 abc	192.7 abc
Bifender FC + 10-34-0	3" TB	7.3 fl oz 5 GPA	0.1	195.5 abc	190.5 ab	181.3 bcd
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	178.4 cd	181.3 abc	173.4 cd
VCP034 + 10-34-0	DIF	5.76 fl oz 5 GPA		188.6 bcd	178.8 abc	165.7 de
Poncho Beta + Midac FC + 10-34-0	Seed DIF	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	157.3 e	167.3 bc	149.6 ef
Bifender FC + 10-34-0	DIF	7.3 fl oz 5 GPA	0.1	180.9 cd	173.0 abc	145.7 efg
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	158.6 e	164.1 c	142.5 fg
Poncho Beta + 10-34-0	Seed DIF	 5 GPA	68 g a.i./ unit seed	136.8 f	132.0 d	134.8 fg
Check	---	---	---	212.3 a	177.3 abc	125.9 gh
10-34-0 fertilizer check	DIF	5 GPA	---	173.8 de	173.6 abc	104.5 h
LSD (0.05)				17.23	25.02	22.90

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
[c]Surviving plant stands were counted on 3, 22, and 29 June, 2021 (i.e., 21, 40, and 47 days after planting [DAP], respectively).

These early plant stand counts suggest a few concerns. The first of which is that planting Poncho Beta-treated seed and including 10-34-0 starter fertilizer at planting has at least the potential to negatively impact seedling emergence and/or survival. However, further study should be conducted to confirm or rule out this concern. Secondly, the results of this first stand count indicate that banding Counter 20G at its moderate rate (7.5 lb product/ac) at planting and combining the application with a concurrent (i.e., separate delivery system) application of 10-34-0 starter fertilizer could also delay or reduce sugarbeet seedling emergence.

The highest average surviving plant stand in the trial at 40 DAP was observed in plots treated with Counter 20G at 8.9 lb product per acre (no starter fertilizer); however, the plant stand recorded for that treatment was not statistically greater than the following treatments: 1) Counter 20G at 7.5 lb/ac, no fertilizer; 2) Midac FC + 10-34-0 starter fertilizer + Bifender FC postemergence; 3) Bifender FC plus 10-34-0 [3" T-band or DIF]; 4) Midac + 10-34-0; 5) VCP034 + 10-34-0; 6) untreated check; and 7) the fertilizer-only check. The true untreated check and the fertilizer control did not differ significantly with respect to surviving stand at 40 DAP. The lowest overall plant densities at 40 DAP were recorded in plots planted with Poncho Beta-treated seed when 10-34-0 starter fertilizer was applied DIF at planting. Another concerning result was that plant stands were significantly lower in plots treated with Counter 20G at 7.5 lb/ac plus a concurrent application of 10-34-0 starter fertilizer when compared to similar plots that received Counter 20G at 7.5 lb/ac without starter fertilizer.

The third stand count (i.e., 47 DAP) was carried out on June 29, which should have been after most SBRM larval feeding activity had occurred. As such, this data should be interpreted for treatment impacts on both crop safety and efficacy at protecting plants from mortality resulting from SBRM feeding injury. At this last (47 DAP) count, excellent stands were achieved by using the following treatments, which were not significantly different from each other in respect to surviving plant densities: 1) Counter 20G banded at 7.5 lb product/ac (no fertilizer);

2) Counter 20G banded at 8.9 lb product/ac (no fertilizer); and 3) Midac FC + 10-34-0, applied DIF + Bifender FC applied postemergence. Other treatments that resulted in surviving plant stands at 47 DAP that were significantly greater than the untreated check and the fertilizer-only check included the following: 1) Midac FC + 10-34-0, applied DIF; 2) VCP034 + 10-34-0, applied DIF; and 3) Poncho Beta seed + Midac FC + 10-34-0, applied DIF.

Unfortunately, stand counts in the following treatments were not statistically different from the untreated check at 47DAP, the final stand assessment: 1) Bifender FC at 7.3 fl oz/ac + 10-34-0 starter fertilizer, applied DIF; 2) Counter 20G banded at 7.5 lb product/ac + a DIF application of 10-34-0; and 3) Poncho Beta-treated seed + a DIF application of 10-34-0. Also disappointing was that plots treated with Counter 20G at its moderate labeled rate (7.5 lb/ac) had significantly lower plant densities per 100 ft at the last stand count when a concurrent application of starter fertilizer was included. The addition of starter fertilizer resulted in a 31% stand reduction in that comparison.

Overall, this stand count data suggests that 10-34-0 starter fertilizer itself has potential to reduce or delay sugarbeet seedling emergence, at least under the light-textured soil conditions that characterized this field location. It should also be noted that extremely hot and dry conditions persisted for much of the first few weeks of the 2021 growing season, which could have exacerbated the potential for phytotoxic impacts from the fertilizer on young sugarbeet seedlings.

Results from sugarbeet root maggot feeding injury ratings in this experiment are presented in Table 2. Average root injury ratings in the untreated check (8.33) and fertilizer-only check (8.05) indicated that a very high SBRM infestation was present for the study. All insecticide treatments provided significant reductions in SBRM feeding injury when compared to that recorded for the untreated check plots, but the lowest root injury ratings in the trial were recorded in plots that received a planting-time banded application of Counter 20G at the lower, 7.5-lb rate when starter fertilizer was excluded.

Table 2. *Larval feeding injury ratings* from an evaluation of Midac® and Bifender® insecticides for sugarbeet root maggot control, St. Thomas, ND, 2021

Treatment/form.[a]	Placement[b]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G	B	7.5 lb	1.5	5.13 f
Counter 20G	B	8.9 lb	1.8	5.25 ef
Poncho Beta + Midac FC + 10-34-0	Seed DIF	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	5.30 ef
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	5.48 def
Midac FC + 10-34-0 + Bifender FC	DIF 1 d Pre-peak Broadcast	13.6 fl oz 5 GPA 7.3 fl oz	0.18 0.1	5.55 def
Poncho Beta + 10-34-0	Seed DIF	 5 GPA	68 g a.i./ unit seed	5.88 de
Bifender FC + 10-34-0	3" TB	7.3 fl oz 5 GPA	0.1	6.18 cd
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	6.68 bc
VCP034 + 10-34-0	DIF	5.76 fl oz 5 GPA		6.75 bc
Bifender FC + 10-34-0	DIF	7.3 fl oz 5 GPA	0.1	7.13 b
10-34-0 fertilizer check	DIF	5 GPA	---	8.05 a
Check	---	---	---	8.33 a
LSD (0.05)				0.745

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

Other treatments that provided good levels of protection from SBRM feeding injury included the following (listed in descending order of performance): 1) Counter 20G banded at 8.9 lb product/ac (no fertilizer); 2) Poncho Beta-treated seed + a tank mixture of Midac FC + 10-34-0 starter fertilizer, applied DIF; 3) Counter 20G banded at 7.5 lb product/ac + a concurrent application of 10-34-0; and 4) Midac FC + 10-34-0 starter fertilizer + postemergence Bifender FC (1d before peak fly activity).

Relatively poor performance in relation to root protection from SBRM feeding injury was observed with Bifender FC, Midac FC, and VCP034; however, Bifender FC performed significantly better (i.e., lower SBRM root injury) when applied as a 3" T-band as compared to the DIF application. Also, despite the findings that stand counts appearing to be negatively impacted by including 10-34-0 starter fertilizer, the results from root ratings suggest that combining at-plant applications of Counter 20G, Poncho Beta seed treatment, or Midac FC with starter fertilizer are not likely to reduce efficacy of the insecticides at protecting sugarbeet roots from SBRM feeding injury.

Yield data from this experiment are shown in Table 3. The top-yielding treatment in the trial, with regard to both recoverable sucrose yield and root tonnage, was the combination of Poncho Beta-treated seed planted with a DIF-placed tank mixture of Midac FC plus 10-34-0 starter fertilizer. Combining these two pest management tools (i.e., Poncho Beta-treated seed and Midac FC) increased gross economic return by $104/ac over Poncho Beta alone and by $230/ac over Midac alone, which suggests that this combination should be considered for use in fields where there is substantial risk of high SBRM infestations. Other treatments that produced similar recoverable sucrose yield and root tonnage values that were not statistically different from the top treatment included the following: 1) Counter 20G banded at 8.9 lb/ac (no fertilizer); 2) Poncho Beta + 10-34-0 starter fertilizer; 3) Counter 20G banded at 8.9 lb/ac (no fertilizer); and 4) the T-banded application of Bifender tank mixed with starter fertilizer.

Table 3. ***Yield parameters*** **from an evaluation of Midac® and Bifender® insecticides for sugarbeet root maggot control, St. Thomas, ND, 2021**

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)
Poncho Beta + Midac FC + 10-34-0	Seed DIF	 13.6 fl oz 5 GPA	68 g a.i./ unit seed 0.18	5,616 a	20.1 a	15.31 ab	822
Counter 20G	B	8.9 lb	1.8	5,276 ab	19.0 ab	15.25 ab	769
Poncho Beta + 10-34-0	Seed DIF	 5 GPA	68 g a.i./ unit seed	5,183 abc	19.4 a	14.81 b-e	718
Counter 20G	B	7.5 lb	1.5	5,096 a-d	18.1 abc	15.42 a	751
Bifender FC + 10-34-0	3" TB	7.3 fl oz 5 GPA	0.1	4,965 a-d	18.3 abc	14.93 abc	700
Counter 20G + 10-34-0	B DIF	7.5 lb 5 GPA	1.5	4,732 b-e	17.4 abc	15.02 abc	670
Midac FC + 10-34-0 + Bifender FC	DIF 1 d Pre-peak Broadcast	13.6 fl oz 5 GPA 7.3 fl oz	0.18 0.1	4,407 cde	16.4 bcd	14.90 a-d	616
Midac FC + 10-34-0	DIF	13.6 fl oz 5 GPA	0.18	4,319 def	16.3 bcd	14.62 c-f	592
VCP034 + 10-34-0	DIF	5.76 fl oz 5 GPA		4,088 ef	15.9 cd	14.29 ef	537
Check	---	---	---	3,555 fg	13.7 de	14.35 def	469
Bifender FC + 10-34-0	DIF	7.3 fl oz 5 GPA	0.1	3,223 g	12.6 e	14.19 f	416
10-34-0 fertilizer check	DIF	5 GPA		3,025 g	11.7 e	14.25 ef	398
LSD (0.05)				784.0	2.75	0.563	

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

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

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

Although stand counts demonstrated a negative impact from applying 10-34-0 starter fertilizer concurrently with Counter 20G, the fertilizer, and perhaps larger beet roots due to reduced plant populations in fertilizer-treated Counter plots, appeared to minimize negative impacts on resultant yield parameters. However, despite the absence of a significant difference between Counter 20G alone and Counter 20G plus starter fertilizer, Counter-treated plots that received the concurrent application of starter fertilizer generated \$81/ac in gross revenue when compared to those where the fertilizer was excluded.

Similar to the results from root injury ratings in this trial, yield comparisons indicated that marginal to relatively poor performance was achieved by DIF applications of Midac FC, VCP034, and Bifender FC. However, one very positive and definitive result from this trial was that placement (i.e., 3" T-band vs. DIF) had a significant impact on performance of Bifender FC. The T-banded placement of Bifender was superior to DIF in regard to surviving plant stands, root protection from SBRM feeding injury, as well as recoverable sucrose yield and root tonnage. Additionally, plots treated with the T-banded application of Bifender resulted in \$284 more economic return than those that received the product via DIF placement. Although this is a very encouraging finding, capitalizing on it would require producers to modify their sugarbeet planters by equipping them with conventional nozzles instead of the commonly used dribble-in-furrow delivery systems.

Overall results of this trial suggest that, for growers intending on applying Counter 20G at planting and also including a concurrent application of 10-34-0 starter fertilizer, it is advisable to at least dilute the fertilizer to the 3:2 gallon (i.e., 3 gallons of fertilizer to 2 gallons of water) ratio used in this study, or even further dilute it, if choosing to use the full 8.9-lb rate of Counter. Results also suggest that combining Poncho Beta-treated seed with an application of Midac FC plus 10-34-0 starter fertilizer can improve SBRM control and resulting yield and gross revenue over that of either Poncho Beta or Midac FC alone.

It should be noted that data from previous NDSU research suggests that Midac FC performs at a comparable level to that of the moderate rate of Counter 20G (i.e., 7.5 lb product/ac). Thus, if planting-time insecticide protection is limited to Midac FC, the grower should expect the need to add a postemergence rescue insecticide application to augment SBRM control, especially in areas of moderate to high risk of economically damaging root maggot populations.

Finally, it should be noted that most of the treatments tested in this trial need further testing to determine the validity and repeatability of these results. This is especially so with regard to the safety of combining Counter 20G applications with concurrent starter fertilizer applications.

Acknowledgments:

The authors greatly appreciate Darryl Collette for allowing us to conduct this research on his farm. Sincere gratitude is extended to the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing significant funding to support this project. We also appreciate Carter Blackwell, Gannon Rockstad, Brett Skarda, Karter Wasberg, and Victor Yang for assistance with plot maintenance, stand counting, root sample collection, and data entry. Thanks are also extended to the American Crystal Quality Tare Laboratory (East Grand Forks, MN) for performing sucrose content and quality analyses on harvest samples. This work was also partially supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, under Hatch project number ND02398.

References Cited:

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

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

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

SCREENING EXPERIMENTAL INSECTICIDES FOR SUGARBEET ROOT MAGGOT CONTROL

Mark A. Boetel, Professor
Jacob J. Rikhus, Research Specialist

Department of Entomology, North Dakota State University, Fargo, ND

Introduction:

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* (Röder) continues to rank as the most economically damaging insect pest of sugarbeet in the Red River Valley (RRV) production area. Unfortunately, growers have a very limited number of insecticide tools currently registered by the U.S. Environmental Protection Agency (EPA) for managing this pest. Another major, long-standing concern has been that, of the small number of insecticide options available for insect management in sugarbeet, most have involved the same insecticide mode of action (i.e., acetylcholinesterase [ACHE] inhibition). As a result, this insecticide group has been heavily relied upon for SBRM management for nearly five decades.

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

Materials and Methods:

This experiment was carried out on a grower-owned field site near St. Thomas (Pembina County), ND during the 2021 growing season. The trial was planted on May 12, and all plots were planted with glyphosate-resistant seed (i.e., Betaseed 8961) by using a 6-row Monosem NG Plus 4 7x7 planter set to plant at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Plots were six rows (22-inch spacing) wide with the four centermost rows treated. The outer "guard" rows (i.e., rows one and six on the planter) on each side of the plot served as untreated buffers. Each plot was 35 feet long, and 35-foot tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a randomized complete block design with four replications of the treatments.

<u>Planting-time insecticide applications</u>. Counter 20G, applied at moderate and maximum labeled rates (i.e., 7.5 and 8.9 lb product/ac) was used for comparative purposes as a planting-time standard chemical insecticide in the experiment. Counter was applied by using band (B) placement (Boetel et al. 2006), which consisted of 5-inch swaths of granules delivered through Gandy™ row banders. The granular application rate was regulated by using a planter-mounted SmartBox™ computer-controlled insecticide delivery system calibrated on the planter immediately before all applications.

Planting-time liquid insecticides screened in this trial included the following: 1) Asana XL (active ingredient: esfenvalerate, a pyrethroid insecticide); and 2) a tank-mixed combination of Asana XL plus Exponent (pyperonyl butoxide [PBO], an insecticide synergist). At-plant liquid treatments were delivered in 3-inch T-bands over the open seed furrow by using a planter-mounted, CO_2-propelled spray system equipped with TeeJet™ 400067E nozzles. The planting-time liquid insecticide delivery system was calibrated to apply a finished spray volume output of 5 GPA.

<u>Postemergence insecticide applications</u>. Postemergence insecticide treatments evaluated in this experiment included the following sprayable liquid products: 1) Dibrom Emulsive (a conventional organophosphate insecticide); 2) Ecozin Plus 1.2%ME (azadirachtin, a neem tree-derived insect antifeedant and growth disruptor); 3) Endigo ZCX (a combination insecticide product containing lambda-cyhalothrin [a pyrethroid] and thiamethoxam [a neonicotinoid]; 4) Evergreen Crop Protection 60-6EC (pyrethrum + a synergist); 5) Vydate C-LV (a carbamate insecticide); and 6) Yuma 4E, a sprayable liquid formulation of chlorpyrifos, applied at 1 and 2 pts product per acre. Yuma 4E was included as a

postemergence chemical insecticide standard because chlorpyrifos-based products have been the most commonly used postemergence liquid insecticides used by RRV growers for SBRM for several years. All postemergence sprays were applied 2 d before peak SBRM fly activity from a tractor-mounted, CO_2-propelled spray system equipped with an 11-ft boom that was calibrated to deliver a finished spray volume output of 10 GPA through TeeJet™ XR 110015VS nozzles. All insecticide treatments, irrespective of whether an at-plant or postemergence insecticide, were single, stand-alone applications. In other words, there was no postemergence insecticide included in plots assigned to receive an at-plant insecticide treatment, and vice versa.

Root injury ratings: Sugarbeet root maggot feeding injury was assessed in this trial on August 4, 2021. Rating procedures involved randomly selecting ten beet roots per plot (five from each of the outer two treated rows), hand-washing them, and rating them in accordance with the 0 to 9 root injury rating scale (0 = no scarring, and 9 = over ¾ of the root surface blackened by scarring or dead beet) of Campbell et al. (2000).

Harvest: Treatment performance was also compared according to sugarbeet quality and yield by harvesting all plots on September 22. Foliage was removed from plots immediately before harvest by using a commercial-grade mechanical defoliator. All beets from the center two rows of each plot were extracted from the soil using a mechanical harvester, and weighed in the field using a digital scale. A random subsample of 12-18 roots was collected from each plot and for subsequent sucrose content and quality analyses.

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

Results and Discussion:

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

The combined results for sugarbeet root maggot feeding injury in this experiment appear in Table 1. The average level of SBRM larval feeding injury recorded for the untreated check was 8.83 on the 0 to 9 scale of Campbell et al. (2000), which clearly demonstrated that a severe SBRM infestation was present for the experiment.

Table 1. *Larval feeding injury* in an evaluation of experimental at-plant and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2021

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Root injury (0-9)
Counter 20G	B	7.5 lb	1.5	6.87 d
Counter 20G	B	8.9 lb	1.8	7.00 d
Asana XL + Exponent	3" TB	9.6 fl oz 8 fl oz		8.03 c
Endigo ZCX	2 d Pre-peak Broadcast	4.5 fl oz	0.031	8.03 c
Yuma 4E	2 d Pre-peak Broadcast	2 pt	1.0	8.20 bc
Evergreen Crop Protection	2 d Pre-peak Broadcast	16 fl oz		8.33 abc
Vydate C-LV	2 d Pre-peak Broadcast	34 fl oz	1.0	8.43 abc
Ecozin Plus	2 d Pre-peak Broadcast	56 fl oz		8.47 abc
Dibrom	2 d Pre-peak Broadcast	1 pt	1.65	8.60 abc
Yuma 4E	2 d Pre-peak Broadcast	1 pt	0.5	8.63 abc
Asana XL	3" TB	9.6 fl oz		8.77 ab
Check	---	---	---	8.83 a
LSD (0.05)				0.609

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; 3" TB = 3-inch band over open seed furrow at planting

It is somewhat rare to observe SBRM root injury ratings that approach a 9.0 on the zero to 9 scale in field research trials that rely on natural pest infestations. The analysis showed that both rates of Counter 20G (i.e., 7.5 lb and

8.9 lb product per acre) provided significantly greater protection (i.e., lower SBRM feeding injury ratings) than any other treatment in the experiment. Other insecticides that provided significant levels of protection from larval feeding injury in comparison to the injury recorded for the untreated check included the following: 1) Asana XL, tank mixed with Exponent and applied as a 3” T-band at planting; 2) Endigo ZCX, applied as a postemergence broadcast; and 3) Yuma 4E postemergence broadcast-applied at its high (2 pts/ac) rate. Interestingly, the average SBRM feeding injury recorded for the combination treatment of Asana XL plus Exponent synergist was significantly lower (i.e., better root protection) than when Asana was applied without the synergist.

Yield data from this trial, shown below in Table 2, corresponded well with root injury rating results. For example, the two Counter treatments resulted in significantly greater recoverable sucrose yields than all other insecticide treatments in the experiment. Other entries that provided significant increases in both recoverable sucrose yield and root tonnage when compared to the untreated check included the following (listed in descending order of recoverable sucrose yield): 1) Asana XL plus Exponent, applied as a 3” T-band at planting; 2) Yuma 4E, applied as a postemergence broadcast at 2 pts/ac; and 3) Ecozin Plus, applied postemergence broadcast. All of these treatments, I except Yuma 4E, resulted in significantly greater root tonnage yields than the untreated check. Root yield increases from the treatments that differed statistically in comparison to the untreated check ranged from 2.6 tons/ac for plots treated with Ecozin Plus to well over 5 tons/ac for the two planting-time Counter 20G treatments. It also bears noting that Dibrom, Evergreen Crop Protection, Asana XL alone (i.e., without Exponent), Yuma 4E (1 pt/ac), Vydate C-LV, and Endigo ZCX failed to provide significant increases in either recoverable sucrose yield or root tonnage over that recorded for the untreated check.

Table 2. ***Yield parameters*** **from an evaluation of experimental at-plant and postemergence insecticides for sugarbeet root maggot control, St. Thomas, ND, 2021**

Treatment/form.	Placement[a]	Rate (product/ac)	Rate (lb a.i./ac)	Sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose (%)	Gross return ($/ac)
Counter 20G	B	8.9 lb	1.8	4,615 a	16.6 ab	15.42 a	670
Counter 20G	B	7.5 lb	1.5	4,595 a	17.3 a	14.83 bc	628
Asana XL + Exponent	3” TB	9.6 fl oz 8 fl oz		3,747 b	14.1 bc	14.89 abc	515
Yuma 4E	2 d Pre-peak Broadcast	2 pt	1.0	3,611 bc	13.3 cd	15.22 ab	511
Ecozin Plus	2 d Pre-peak Broadcast	56 fl oz		3,546 bcd	14.0 bc	14.24 def	452
Endigo ZCX	2 d Pre-peak Broadcast	4.5 fl oz	0.031	3,388 b-e	12.9 cd	14.68 b-e	456
Vydate C-LV	2 d Pre-peak Broadcast	34 fl oz	1.0	3,364 b-e	12.7 cd	14.75 bcd	457
Yuma 4E	2 d Pre-peak Broadcast	1 pt	0.5	3,061 b-e	11.6 cd	14.79 bcd	417
Check	---	---	---	2,960 cde	11.4 cd	14.61 cde	391
Asana XL	3” TB	9.6 fl oz		2,908 cde	11.6 cd	14.11 ef	368
Evergreen Crop Protection	2 d Pre-peak Broadcast	16 fl oz		2,817 de	11.5 cd	13.91 f	342
Dibrom	2 d Pre-peak Broadcast	1 pt	1.65	2,754 e	11.2 d	13.89 f	335
LSD (0.05)				739.8	2.68	0.576	

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; 3” TB = 3-inch band over open seed furrow at planting

Plots protected by single, planting-time band applications of Counter 20G provided gross revenue increases ranging from $237 (7.5 lb product/ac) to $391/ac (8.9-lb rate) when compared to the untreated check. Also, the combination of Asana XL and Exponent, applied as a T-band at planting, generated $515/ac in total gross revenue, which was an increase of $147/ac over that achieved by Asana XL without the synergist. Another interesting result with regard to revenue was that the maximum rate of Yuma 4E (2 pts product/ac) generated a total of $511/ac in gross revenue, which was $94 more in economic return than when Yuma was applied at 1 pt/ac.

As mentioned above, it is important to remember that all insecticide treatments in this trial were single-applications (i.e., either at-plant or postemergence). Although this practice is not recommended in high-risk SBRM infestation areas, it was employed this trial to isolate the performance of each individual insecticide treatment. As such, all insecticide-treated plots were anticipated to sustain more SBRM feeding injury and incur greater yield loss than would typical occur in a commercial sugarbeet production system. However, the results were somewhat encouraging. Most notable was the fact that Exponent, the insecticide synergist, provided consistent benefits in relation to protection from SBRM feeding injury, recoverable sucrose yield, and root tonnage.

NOTE: it is critical that producers and crop management advisors understand that, although piperonyl butoxide (PBO) synergist products are not actual insecticides, they are EPA-regulated and labeled in the same manner as insecticide products. Therefore, users must comply with PBO product labeling and confirm that a material is labeled for the following 1) tank mixing with the insecticide to be used; and 2) the crop to which it will be applied. Another important thing to realize is that most PBO products are labeled for enhancing the performance of pyrethroid insecticides, so using one to improve the activity of an insecticide belonging to another class would likely result in unsatisfactory performance. The application could also, depending on the product's label, be illegal.

The performance of Ecozin Plus and, to a lesser extent, Endigo ZCX, were also encouraging. Further testing should be carried out on these and other experimental materials to identify viable alternatives to the currently used insecticides. The use of alternative insecticide active ingredients in place of the long-used ACHE inhibitors could help prevent or delay the development of resistance to those insecticides in SBRM populations. Products formulated with active ingredients belonging to these alternative modes of action could also provide viable tools for growers to sustainably and profitably produce sugarbeet in areas affected by this pest if the currently available conventional insecticides become unavailable in the future due to regulatory action or voluntary cancellations by manufacturers. The recent EPA revocation of all food crop tolerances for insecticides containing chlorpyrifos (e.g., Lorsban, Yuma, etc.) illustrates and underscores the importance of this research, and provides strong impetus for the identification of viable alternatives for SBRM management in the future.

References Cited:

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

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

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

Acknowledgments:

We wish to thank Darryl Collette for allowing us to conduct this research on his farm. We also appreciate the contributions of Carter Blackwell, Gannon Rockstad, Brett Skarda, Karter Wasberg, and Victor Yang for their assistance with plot maintenance, sample collection, and data entry. Sincere appreciation is extended to the Sugarbeet Research and Education Board of Minnesota and North Dakota for providing partial funding support for this research. This work was also partially supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, under Hatch project number ND02398.

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

Location:	St. Thomas (Pembina County), ND – Darryl Collette 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 = 3.0% pH = 8.2	
Soil texture:	38.8% sand 43.5% silt 17.7% clay	
Previous crop:	Potatoes (2020)	
Soil preparation:	Field cultivator (1x)	
Planting depth:	1.25"	
Planting date:	May 10-13	
Herbicides applied:	June 17	Cornerstone 5 Plus (24 fl oz/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)
	July 1	Cornerstone 5 Plus (22 fl oz/ac) + Class Act NG (2.5% v/v) + Interlock (6 fl oz/ac)
Rainfall (after seedbed preparation)**:**	May 14	0.01"
	May 20	0.30"
	May 22	0.29"
	May 29	0.01"
	May 30	0.01"
	Total/May	**0.62"**
	June 8	0.02"
	June 9	0.75"
	June 11	0.42"
	June 18	0.09"
	June 20	0.09"
	June 22	0.14"
	June 25	0.11"
	June 27	0.37"
	Total/June	**1.99"**
	July 3	0.64"
	July 14	0.08"
	July 19	0.72"
	Total/July	**1.44"**
	August 4	0.04”
	August 9	0.05”
	August 20	1.08”
	August 22	0.06”
	August 24	0.06”
	August 26	0.04”

August 27	0.47”
August 28	0.14”
Total/August	**1.94"**
September 2	0.15”
September 4	0.03”
September 11	0.01”
September 13	0.19”
September 20	0.16”
September 21	0.02”
Total/September	**0.56"**

Damage ratings: August 3-5
Harvest: September 21-22
Yield sample size: 2 center rows x 35 ft length (70 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 2021

Peter C. Hakk[1], Mohamed F.R. Khan[2], Ashok K. Chanda[3], Tom J. Peters[2] and Mark A. Boetel[4]
[1]Sugarbeet Research Specialist, [2]Extension Sugarbeet Specialists
North Dakota State University & University of Minnesota, Fargo, ND, [3]Extension Sugarbeet Pathologist, Universityof Minnesota Northwest Research and Outreach Center, Crookston, MN and
[4]Professor, Dept. of Entomology, North Dakota State University

The seventh annual fungicide practices live polling questionnaire was conducted using Turning Point Technology at the 2022 Winter Sugarbeet Growers' Seminars held during January and February 2022. Responses are based on production practices from the 2021 growing season. The survey focuses on responses from growers in attendance at the Fargo, Grafton, Grand Forks, Wahpeton, ND and Willmar, MN Grower Seminars both in person and online. 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 2021 was calculated from Table 5 at between 1,000 and 1,499 acres.

Survey respondents were asked about soilborne disease and control practices. Fifty-nine percent said their fields were affected by Rhizoctonia, 10% said Aphanomyces was the biggest issue, Seven percent said they had issues with multiple disease including Rhizoctonia, Aphanomyces, Fusarium and Rhizomania, 21% said they had no soilborne disease issues and four percent listed Fusarium as their biggest issue (Table 8). Additionally, participants were asked about the prevalence of Rhizoctonia in sugarbeet with which preceding crops. Thirty four percent of respondents said they saw more rhizoctonia when soybeans preceded their sugarbeet crop. Nineteen percent reported more Rhizoctonia following edible beans and small grains, 18% saw more Rhizoctonia following any crop, five percent said other crop, 4% said field corn and 1% stated sweet corn 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, 67% respondents said yes they did use a specialty variety for Rhizoctonia while 33% said no (Table 10).

Participants were asked what methods were used to control Rhizoctonia and 45% said they used a seed treatment only, 20% used a seed treatment and a POST fungicide and another 20% used a seed treatment plus an in-furrow fungicide while 15% also said they used a seed treatment, in-furrow fungicide and a POST fungicide (Table 11). Sixty three percent of respondents used a Kabina seed treatment while 16% used Vibrance, 10% used Metlock Suite + Kabina, 9% used Systiva, and 1% used Metlock Suite and Vibrance (Table 12). Of the respondents who applied an in-furrow fungicide, 58% used Azteroid, 8% used Quadris or generic and 1% used other; 32% 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 eight percent used Quadris or generic, 8% used Azteroid, 4% used Proline and 2% used Priaxor (Table 14). Participants were then asked to grade the effectiveness of the POST fungicides that were used. Forty two percent were unsure of their results, 35% said they had good results, 12% reported fair results, 9% said the fungicides performed excellently and 2% said they performed poorly (Table 15). Respondents were also asked how they applied POST fungicide and 51% stated they used a band application and 49% used a broadcast application (Table 16). Sixty three percent of growers reported that they used an in-furrow starter fertilizer while 37% did not (Table 17).

Participants were also asked about use of waste lime to control Aphanomyces. Fifty five percent of participants did not use waste lime in their fields while 31% used between 6 and 10 tons/acre while 14% used less than 5 tons/acre (Table 18). Respondents were also asked about their soil pH. Forty six percent said it was between 8.0 and 8.5, 41% said between 7.5 and 8.0, 11% between 7.0 and 7.5 and 2% said between 6.0 and 6.5 (Table 19). The growers were asked how effective their waste lime application was. Forty eight percent of respondents did not apply lime, 19% said they had good results and another 19% were unsure of their results, 11% said excellent and 3% reported fair results (Table 20). One of the survey questions also asked if growers had used a specialty variety for Aphanomyces in 2021. Fifty eight percent of respondents said yes and 42% said no (Table 21).

Survey respondents were asked about how many acres were planted to CR+ in 2021. Seventy one percent said they planted no CR+ acres, 17% planted between 1% and 20%, 6% reported planting between 21% and 50% while 2% planted between 51% and 60% of their acres to CR+ varieties (Table 22). Growers were then asked to rate the effectiveness of CR+ varieties in controlling CLS. Sixty eight percent of growers did not use CR+ varieties, 16% said their CLS control was excellent, 10% reported good CLS control while another 5% were unsure (Table 23).

Survey participants were then asked a series of questions regarding their CLS fungicide practices on sugarbeet in 2021. Thirty three percent said that they used 5 sprays to control CLS, 20% used four applications, 18% used sixapplications, 17% used three applications, 5% used seven applications, 3% used two applications, 2% used one application and another 2% applied no CLS applications (Table 24). Respondents were then asked about the effectiveness of their CLS sprays. Sixty two percent said they had good results, 15% said they had fair results, 14% reported excellent results while 8% reported poor results (Table 25).

Respondents were asked about when their CLS application started and ended. Thirty nine percent of participants said that they began their applications between July 1 and 10, 38% said they started before July 1, 14% said it was between July 11 and 20, 9% said between July 21 and July 31 and 1% said between August 1 and 10 (Table 26). Forty seven percent of respondents said that their last CLS spray was between September 1 and 10, 22% said between September 11 and 20, 19% said between August 21 and 31, 7% said between August 11 and 20, 4% said after September 20, and 1% they made zero or one CLS application (Table 27). Growers were also asked if they used fungicide mixtures for all of their CLS applications. Seventy three percent said yes while 27% said no (Table 28).

Sixty three percent of survey respondents made 100% of their CLS applications by ground application. Thirteen percent made 61-80% of their application from the ground, another 10% made between 81 and 99% from the ground. Eight percent made between 0% percent of their CLS applications from the ground, five percent had between 1% and 20% of their application made by ground rig while two percent had between 21 and 40% of their applications made on the ground (Table 29).

Of the total fungicide applications for CLS, 33% did not use an aerial applicator, 30% used an aerial applicator for100% of their applications, 23% used an aerial applicator for 1-20% of their fungicide applications, 6% said they used an aerial applicator for 61-80% of applications, 4% fell in the 81-99% range and 3%in the 21-40% range (Table 30).

Regarding water usage in gallons per acre as applied by tractor, 55% of respondents used 16-20 gallons per acre, 28% used 11-15 gallons per acre, 14% used more than 20 gallons per acre, 2% used 6-10 gallons per acre and 1%used 1-5 gallons per acre (Table 31).

Table 1. 2022 Fargo Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Barnes	-	-
Becker	-	-
Cass	2	29
Clay	1	14
Mahnomen	2	29
Ransom	-	-
Richland	1	14
Steele	-	-
Trail	1	14
Otter Tail	-	-
Total	7	100

Table 2. 2022 Grafton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Cavalier	-	-
Grand Forks	1	6
Kittson	1	6
Marshall	2	13
Nelson	-	-
Pembina	4	25
Polk	-	-
Ramsey	-	-
Walsh	6	38
Other	2	13
Total	16	101

Table 3. 2022 Grand Forks Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Grand Forks	7	18
Mahnomen	1	3
Marshall	2	5
Nelson	-	-
Pennington/Red Lake	-	-
Polk	17	44
Steele	-	-
Traill	1	3
Walsh	2	5
Other	9	23
Total	39	101

Table 4. 2022 Wahpeton Grower Seminar – Number of survey respondents by county growing sugarbeet in 2021.

County	Number of Responses	Percent of Responses
Cass	-	-
Clay	7	11
Grant	6	9
Otter Tail	-	-
Ransom	-	-
Richland	16	25
Roberts	-	-
Stevens	-	-
Traverse	3	5
Wilkin	33	51
Total	65	101

Table 5. Total sugarbeet acreage operated by respondents in 2021.

		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	12	17	-	-	17	17	8	-	17	17	8
Grafton	16	13	6	-	13	19	6	19	13	6	6
Grand Forks	38	13	8	3	11	16	11	11	8	3	18
Wahpeton	65	-	11	-	34	-	17	-	39	-	-
Willmar	37	24	5	11	3	16	14	3	16	5	3
Total	168	11	8	3	18	10	13	5	23	4	6

Table 6. What crop preceded most of your sugarbeet acreage in 2021?

Location	Respondents	Field Corn	Sweet Corn	Dry Bean	Peas	Potato	Soybean	Wheat	Other
		% of respondents							
Fargo	14	-	-	-	-	-	7	86	7
Grafton	15	-	-	20	-	7	7	67	-
Grand Forks	39	3	-	-	-	-	-	95	3
Wahpeton	65	14	-	-	-	-	20	66	-
Willmar	40	70	20	-	-	-	8	3	-
Total	173	22	5	2	-	1	10	60	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	14	-	57	14	7	-	14	-	-	7
Grafton	17	6	59	18	-	-	-	-	12	6
Grand Forks	39	-	36	28	-	-	8	-	3	26
Wahpeton	63	-	21	24	-	2	13	-	-	41
Willmar	40	-	15	25	-	5	13	-	-	43
Total	173	1	29	24	1	2	10	-	2	32

Table 8. What soil-borne diseases affected your sugarbeet production in 2021?

		Root disease					
Location	Respondents	Rhizoctonia	Aphanomyces	Fusarium	Rhizomania	All	None
		% of respondents					
Fargo	14	50	7	21	-	14	7
Grafton	11	64	18	-	-	-	18
Grand Forks	44	61	9	1	-	7	23
Willmar	33	58	9	3	-	6	24
Total	102	59	10	4	-	7	21

Table 9. With which of the preceding crops did you see the most rhizoctonia in 2021?

Location	Respondents	Edible Beans	Field Corn	Sweet Corn	Potatoes	Small Grains	Soybeans	Any Crop	Other
		-----% of respondents-----							
Fargo	9	22	-	-	-	-	56	22	-
Grafton	10	70	-	-	-	10	10	10	-
Grand Forks	44	14	2	-	-	36	27	9	11
Willmar	28	7	11	4	-	-	46	32	-
Total	91	19	4	1	-	19	34	18	5

Table 10. Did you use a specialty variety to control Rhizoctonia in 2021?

Location	Respondents	Yes	No
		-----% respondents-----	
Fargo	14	93	7
Grafton	11	55	45
Grand Forks	45	62	38
Total	70	67	33

Table 11. What methods were used to control *Rhizoctonia solani* in 2021?

Location	Respondents	Seed Treatment Only	Seed Treatment + In-Furrow	Seed Treatment + POST	Seed Treatment + In-Furrow + POST	Seed Treatment + In-Furrow + 2xs POST
			-----% respondents-----			
Fargo	14	29	21	43	7	-
Grafton	13	38	-	23	38	-
Grand Forks	45	20	36	20	24	-
Wahpeton	54	81	9	7	1	-
Willmar	32	28	22	31	19	-
Total	158	45	20	20	15	-

Table 12. Which seed treatment did you use to control Rhizoctonia solani in 2021?

		Seed treatment				
Location	Respondents	Kabina	Metlock Suite + Kabina	Vibrance	Systiva	Metlock Suite + Vibrance
		-----% of respondents-----				
Fargo	13	46	8	8	38	-
Grafton	9	89	11	-	-	-
Grand Forks	45	62	1	22	2	2
Total	67	63	10	16	9	1

Table 13. Which fungicide did you apply in-furrow to control R. solani in 2021?

		In-furrow fungicide use			
Location	Respondents	Azteroid	Quadris or generic	Other	None
		-----% of respondents-----			
Fargo	15	47	13	-	40
Grafton	12	50	8	-	42
Grand Forks	45	64	7	2	27
Total	72	58	8	1	32

Table 14. Which POST fungicide did you use to control R. solani in 2021?

Location	Respondents	POST fungicide					
		Azteroid	Quadris or generic	Proline	Priaxor	Other	None
		-------------------------------% of respondents----------------------------					
Fargo	12	-	54	8	-	-	33
Grafton	11	-	64	-	-	-	36
Grand Forks	45	9	40	4	4	-	42
Willmar	31	13	52	3	-	-	32
Total	99	8	48	4	2	-	37

Table 15. How effective were your POST fungicides at controlling Rhizoctonia solani in 2021?

Location	Respondents	Effectiveness of fungicides				
		Excellent	Good	Fair	Poor	Unsure
		-------------------------------% of respondents----------------------------				
Fargo	10	10	40	20	-	30
Grafton	8	25	38	-	-	38
Grand Forks	45	9	36	11	2	42
Willmar	28	4	32	14	4	46
Total	91	9	35	12	2	42

Table 16. How did you apply POST fungicides to control Rhizoctonia in 2021?

Location	Respondents	Band	Broadcast
		---------------------% respondents---------------------	
Fargo	8	63	38
Grafton	7	57	43
Grand Forks	24	46	54
Total	39	51	49

Table 17. Did you apply any in-furrow starter fertilizer in 2021?

Location	Respondents	Variety type	
		Yes	No
		---------------------% respondents---------------------	
Fargo	8	88	13
Grafton	4	100	-
Grand Forks	45	93	7
Wahpeton	60	35	65
Total	117	63	37

Table 18. What rate of precipitated calcium carbonate (waste lime) did you use in 2021?

Location	Respondents	Lime use rate		
		None	>5 T/A	6-10 T/A
		-------------------------------% of respondents----------------------------		
Fargo	10	20	-	80
Grafton	9	89	-	11
Grand Forks	43	58	2	40
Willmar	31	52	39	10
Total	93	55	14	31

Table 19. What is your soil pH?

Location	Respondents	Soil pH 6.0-6.5	6.5-7.0	7.0-7.5	7.5-8.0	8.0-8.5	8.5-9.0
		-------------------------------% of respondents----------------------------					
Fargo	11	-	-	18	36	45	-
Grafton	9	-	-	-	78	22	-
Grand Forks	43	2	-	12	35	51	-
Total	63	2	-	11	41	46	-

Table 20. How effective was waste lime at controlling aphanomyces in 2021?

Location	Respondents	Waste lime effectiveness Excellent	Good	Fair	Poor	Unsure	No Lime
		-------------------------------% of respondents----------------------------					
Fargo	12	42	25	-	-	17	17
Grafton	8	12	25	-	-	13	63
Grand Forks	43	12	19	2	-	12	56
Willmar	32	-	16	6	-	31	47
Total	95	11	19	3	-	19	48

Table 21. Did you use a specialty variety to control Aphanomyces in 2021?

Location	Respondents	Yes	No
		---------------------% respondents---------------------	
Fargo	9	78	22
Grafton	8	38	63
Grand Forks	43	58	42
Total	60	58	42

Table 22. What percentage of your acres were planted to CR+ varieties in 2021?

Location	Respondents	0%	1%-20%	21%-50%	51%-60%	61%-70%	70%+
		-------------------------------% of respondents----------------------------					
Fargo	14	79	7	7	7	-	-
Grafton	7	100	-	-	-	-	-
Grand Forks	43	91	2	2	2	-	2
Willmar	30	33	47	13	-	-	7
Total	94	71	17	6	2	-	3

Table 23. How effective was CLS control on CR+ varieties in 2021?

Location	Respondents	CR+ effectiveness Excellent	Good	Fair	Poor	Unsure	Did not use
		-------------------------------% of respondents----------------------------					
Fargo	12	33	-	-	-	-	67
Grafton	8	-	-	-	-	-	100
Grand Forks	43	-	5	-	-	5	91
Willmar	29	38	24	-	-	10	28
Total	92	16	10	-	-	5	68

Table 24. How many fungicide application did you make to control CLS in 2021?

Location	Respondents	Number of applications								
		0	1	2	3	4	5	6	7	>7
		-----------------------------% of respondents-------------------------								
Fargo	14	-	7	-	14	29	36	14	-	-
Grafton	10	-	10	30	10	30	20	-	-	-
Grand Forks	42	7	2	2	40	36	12	-	-	-
Wahpeton	58	-	-	-	10	10	48	24	7	-
Willmar	32	-	-	3	3	9	34	38	13	-
Total	156	2	2	3	17	20	33	18	5	-

Table 25. How effective were your fungicide applications on CLS in 2021?

Location	Respondents	Effectiveness of CLS sprays					
		Excellent	Good	Fair	Poor	Unsure	No applications
		-----------------------------% of respondents-------------------------					
Fargo	15	13	40	13	33	-	-
Grafton	13	8	54	31	8	-	-
Grand Forks	43	16	72	12	-	-	-
Total	71	14	62	15	8	-	-

Table 26. 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	12	17	75	8	-	-	-
Grafton	9	-	33	22	44	-	-
Grand Forks	43	5	42	37	14	2	-
Wahpeton	53	57	36	4	4	-	-
Willmar	31	71	26	-	3	-	-
Total	148	38	39	14	9	1	-

Table 27. What date was your last CLS application in 2021?

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	10	-	-	-	10	70	20	-	-
Grafton	11	-	-	-	9	45	27	9	9
Grand Forks	42	-	-	7	29	45	14	5	-
Willmar	28	-	-	11	11	43	32	4	-
Total	91	-	-	7	19	47	22	4	1

Table 28. Did you use fungicide mixtures for all of your CLS applications?

Location	Respondents	Yes	No
		---------------------% respondents---------------------	
Fargo	13	69	31
Grafton	9	33	67
Grand Forks	42	83	17
Total	64	73	27

Table 29. 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	13	8	8	8	-	-	15	62
Grafton	8	-	-	-	-	38	13	50
Grand Forks	42	10	5	-	-	12	7	67
Total	63	8	5	2	-	13	10	63

Table 30. 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	13	62	15	-	-	8	8	8
Grafton	8	63	38	-	-	-	-	-
Grand Forks	42	10	5	-	-	12	7	67
Willmar	33	45	45	9	-	-	-	-
Total	96	33	23	3	-	6	4	30

Table 31. 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	14	-	-	79	14	7
Grafton	13	-	23	46	23	8
Grand Forks	44	2	2	36	55	5
Wahpeton	56	-	-	16	75	9
Willmar	35	2	-	9	51	40
Total	162	1	2	28	55	14

SURVEY OF FUNGICIDE USE IN SUGARBEET IN MONTANA AND WESTERN NORTH DAKOTA IN 2021

Peter C. Hakk[1], Mohamed F.R. Khan[2], Ashok K. Chanda[3], Tom J. Peters[2] and Mark A. Boetel[4]
[1]Sugarbeet Research Specialist, [2]Extension Sugarbeet Specialists
North Dakota State University & University of Minnesota, Fargo, ND, [3]Extension Sugarbeet Pathologist, Universityof Minnesota Northwest Research and Outreach Center, Crookston, MN and
[4]Professor, Dept. of Entomology, North Dakota State University

Sugarbeet growers were asked to report production practices in a mailer sent out to growers in the Western North Dakota and Montana sugarbeet growing area. Survey responses are based on the 2021 growing year. Respondents indicated the county in which the majority of their sugarbeets were produced (Table 1). The average sugarbeet acreage per respondent grown in 2021 was calculated from Table 2 at between 200 and 299 acres. Respondents were also asked about their most serious production problem. Sixty eight percent of growers said weeds were the biggest concern, 16% said emergence, 11% said Cercospora Leaf Spot and five percent said Fusarium (Table 3).

Survey respondents were asked about soilborne disease and control practices. Sixty seven percent said that had no soilborne disease issues, 14% each said that they were most affected by rhizoctonia and fusarium while five percent said that they were affected by multiple soilborne diseases (Table 4). Additionally, participants were asked which fungicide they used to control rhizoctonia in-furrow. Eighty one percent did not use an in-furrow fungicide, 14% used Azteroid while 5% used Quadris or a generic product (Table 5). Growers were then asked which fungicide they used POST to control rhizoctonia. Seventy six percent did not use a POST fungicide while 24% used Quadris or a generic product (Table 6).

Survey participants were then asked a series of questions regarding their CLS fungicide practices on sugarbeet in 2021. Fifty seven percent said that they used two sprays to control Cercospora leaf Spot, 24% used one spray while 19% did not spray any fungicides to control CLS (Table 7). Fifty six percent of growers start their Cerocospora Leaf Spot sprays between August 1 and 10, 17% started between July 21 and 31 and after August 10 while six percent each started their CLS sprays before July 1 and between July 1 and 10 (Table 8). Growers were asked when they finished their CLS applications. Thirty eight percent made only one or zero applications, 19% finished their CLS sprays between August 1 and 10, 10% each finished their CLS sprays before August 1, between August 11 and 20 and between September 11 and 20 while five percent of growers finished their CLS sprays between September 1 and 10 (Table 9).

Sixty three percent of survey respondents made zero percent of their CLS applications by ground application. Eleven percent each made 41-60% and 100% of their application from the ground and another six percent made between 21 and 40% and 61% and 80% from the ground (Table 10). Sixty seven percent of growers used an aerial applicator for 100% of their applications, 11% each used an aerial applicator for 0% and 41%-60% of their CLS applications while another six percent used and aerial applicator for between 21% and 40% and 61% and 80% of their sprays for Cercospora Leaf Spot (Table 11).

Table 1. 2021 Western North Dakota and Montana Growers Survey – Number of survey respondents by county.

County	Number of Responses	Percent of Responses
Dawson	4	19
McKenzie	6	29
Prairie	1	5
Richland	9	43
Roosevelt	1	5
Total	21	101

Table 2. Total sugarbeet acreage operated by respondents in 2021.

		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--------------									
Dawson	4	25	0	25	50	0	0	0	0	0	0
McKenzie	6	0	0	33	17	17	17	0	17	0	0
Prairie	1	0	100	0	0	0	0	0	0	0	0
Richland	9	0	33	33	11	0	11	0	11	0	0
Roosevelt	1	0	0	100	0	0	0	0	0	0	0
Total	21	5	19	33	19	5	10	0	10	0	0

Table 3. What was your most serious production problem?

Location	Respondents	Aph	CLS	Emergence	Fusarium	Herbicide Injury	Rhizoc	Rhizomania	Root Maggot	Weeds
		--------------% of respondents--------------								
Dawson	3	0	0	67	0	0	0	0	0	33
McKenzie	6	0	17	0	0	0	0	0	0	83
Prairie	1	0	0	0	0	0	0	0	0	100
Richland	8	0	13	13	13	0	0	0	0	63
Roosevelt	1	0	0	0	0	0	0	0	0	100
Total	19	0	11	16	5	0	0	0	0	68

Table 4. What soil-borne diseases affected your sugarbeet production in 2021?

		Root disease					
Location	Respondents	Rhizoctonia	Aphanomyces	Fusarium	Rhizomania	All	None
		--------------% of respondents--------------					
Dawson	4	0	0	0	0	0	100
McKenzie	6	0	0	33	0	17	50
Prairie	1	0	0	0	0	0	100
Richland	9	33	0	11	0	0	56
Roosevelt	1	0	0	0	0	0	100
Total	21	14	0	14	0	5	67

Table 5. Which fungicide did you apply in-furrow to control R. solani in 2021?

		In-furrow fungicide use			
Location	Respondents	Azteroid	Quadris or generic	Other	None
		--------------% of respondents--------------			
Dawson	4	50	0	0	50
McKenzie	6	0	0	0	100
Prairie	1	0	0	0	100
Richland	9	11	11	0	78
Roosevelt	1	0	0	0	100
Total	21	14	5	0	81

Table 6. Which POST fungicide did you use to control R. solani in 2021?

		POST fungicide					
Location	Respondents	Azteroid	Quadris or generic	Proline	Priaxor	Other	None
		--------------------------------% of respondents----------------------------					
Dawson	4	0	25	0	0	0	75
McKenzie	6	0	33	0	0	0	67
Prairie	1	0	0	0	0	0	100
Richland	9	0	22	0	0	0	78
Roosevelt	1	0	0	0	0	0	100
Total	21	0	24	0	0	0	76

Table 7. How many fungicide application did you make to control CLS in 2021?

		Number of applications								
Location	Respondents	0	1	2	3	4	5	6	7	>7
		-----------------------------% of respondents-------------------------								
Dawson	4	0	0	100	0	0	0	0	0	0
McKenzie	6	0	33	67	0	0	0	0	0	0
Prairie	1	100	0	0	0	0	0	0	0	0
Richland	9	33	33	33	0	0	0	0	0	0
Roosevelt	1	0	0	100	0	0	0	0	0	0
Total	21	19	24	57	0	0	0	0	0	0

Table 8. What date was your first CLS application?

		Date of first CLS application					
Location	Respondents	Before July 1	July 1-10	July 11-20	July 21-31	August 1-10	After August 10
		-----------------------------% of respondents-----------------------------					
Dawson	4	0	0	0	25	50	25
McKenzie	6	0	0	0	0	83	17
Prairie	0	0	0	0	0	0	0
Richland	7	14	14	0	14	43	14
Roosevelt	1	0	0	0	100	0	0
Total	18	6	6	0	17	56	17

Table 9. What date was your last CLS application in 2021?

		Date of last CLS application							
Location	Respondents	Before August 1	August 1-10	August 11-20	August 21-31	Sept 1-10	Sept 11-20	Later than Sept 20	Made zero or 1 CLS applications
		-----------------------------% of respondents-----------------------------							
Dawson	4	0	0	25	25	25	25	0	0
McKenzie	6	0	33	17	17	0	0	0	33
Prairie	1	0	0	0	0	0	0	0	100
Richland	9	11	22	0	0	0	11	0	56
Roosevelt	1	100	0	0	0	0	0	0	0
Total	21	10	19	10	10	5	10	0	38

Table 10. 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	---------------------------			
Dawson	4	25	0	25	0	0	0	50
McKenzie	6	67	0	0	17	17	0	0
Prairie	0	0	0	0	0	0	0	0
Richland	7	86	0	0	14	0	0	0
Roosevelt	1	100	0	0	0	0	0	0
Total	18	67	0	6	11	6	0	11

Table 11. 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	---------------------------			
Dawson	4	50	0	0	0	25	0	25
McKenzie	6	0	0	17	17	0	0	67
Prairie	0	0	0	0	0	0	0	0
Richland	7	0	0	0	14	0	0	86
Roosevelt	1	0	0	0	0	0	0	100
Total	18	11	0	6	11	6	0	67

Development of CRISPR-based next-generation diagnostic method to evaluate *Beet necrotic yellow vein virus* causing rhizomania in sugarbeet

Vanitha Ramachandran*, John Weiland, and Melvin Bolton
USDA-ARS, Sugarbeet & Potato Research Unit, Edward T.Schafer Agricultural Research Center, Fargo, ND

Rhizomania is an important disease of sugar beet caused by *Beet necrotic yellow vein virus* (BNYVV) affects sugarbeet production and growers' economy. 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 within the last 15 years. Rhizomania disease management measures principally rely on resistance genes bred into commercial varieties specifically developed against BNYVV (Rush et al., 2006). Accurate and sensitive detection of BNYVV in plants and infected fields soils are crucial in appropriating management strategies that include varietal selection, non-host crop rotations, and evaluating resistance levels of sugarbeet breeding lines. Firstly, it can identify infected soil to adopt disease management strategies. Secondly, it can distinguish the truly resistant sugarbeet breeding lines from those of partially resistant lines. Enzyme-linked immunosorbent assay (ELISA), a protein-based detection technology has been used for many years for field soil evaluations because of the ease of implementation and availability of reagents commercially (Torrance et al., 1988).

In this study, we developed a new molecular diagnostic method based on CRISPR-Cas12a system termed DETECTR (DNA Endonuclease Targeted CRISPR Trans Reporter) technology (Chen et al., 2018) for detecting BNYVV in the roots of sugarbeet. Template DNA amplification of viral fragments under isothermal conditions is crucial for developing CRISPR-Cas12a based diagnostics method. We have developed an inexpensive isothermal one-step reverse-transcription (RT) recombinase polymerase amplification (RPA) method and confirmed the sequence identity of the RT-RPA amplicon representing the BNYVV sequence. Further, the CRISPR-based BNYVV detection method was evaluated, and the sensitivity determined in the roots of sugarbeet baited for rhizomania using field soils.

Materials and Methods

Soil samples were obtained from the sugarbeet production areas of North Dakota and Minnesota courtesy of agriculturists from the Southern Minnesota Beet Sugar Cooperative (Renville, MN). Sugarbeet seeds, susceptible variety used obtained from SESVanderhave (Fargo). For healthy control, susceptible sugarbeet seeds were planted into Sunshine Mix with sand of 1:1 ratio (Sungro Horticulture, MA). Slow-release fertilizer (Sungro Horticulture, MA) was added following the manufacturer's instructions. 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 a root sample consisting of 2-3 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 at -80°C until used for RNA extraction.

One hundred mg of cleaned root tissue was ground using a pulverizer (SPEX, Fisher Scientific, MA), and then total RNA was extracted using RNeasy Plant mini kit (Qiagen, MD), with final RNA concentration determined using a Nanodrop (Thermo Fisher Scientific, MA). Equal concentration of total RNA from healthy and rhizomania infected roots were used for setting up RT-RPA reactions. Reverse transcription-recombinase polymerase amplification (RT-RPA) reactions were performed using TwistAmp liquid basic kit (TwistDx, Cambridge, UK). Primers were designed and synthesized from Integrated DNA Technologies (IDT, IA) for amplifying a 465 bp fragment of BNYVV RNA-1 (Weiland et al., 2020). RT-RPA reactions were setup using total RNA (100 ng) from rhizomania baited roots and healthy roots separately in a 50 µL reaction containing forward (VR-1) and reverse (VR-2) primers (Table. 1), each 2.5 µL (10 µM), 2X reaction buffer 25 µL, dNTPs 4 µL (10 mM), 10X basic E-mix 5 µL, 20X core reaction mix 2.5 µL (TwistDx, Cambridge), and 2 µL of M-MuLV Reverse Transcriptase (NEB, MA), and MgOAc 2.5 µL and remaining volume adjusted with nuclease-free water. After gently mixing and collecting the contents of the tubes with a brief spin, the reactions were incubated at 42°C for 60 minutes. To visualize the RT-RPA products, an aliquot of the RPA reaction was transferred to a new tube and to that EDTA was added to a final concentration of 20 mM and held at room temperature for 5 minutes. After a brief spin the contents were loaded onto the agarose gel containing SyberSafe stain (Invitrogen, MA). Following electrophoresis, DNA products were visualized using Chemdoc (Bio-Rad, CA). Gel-elution of the RT-RPA product was carried out using a Gel-extraction kit (Qiagen, MD) and subjected to Sanger sequencing (MCLAB, CA).

For CRISPR-based reporter assay, ribonucleoprotein complex was pre-assembled using Cas12a (30 nM), guide RNA (40 nM), and ssDNA reporter with fluorophores 5' 6-Carboxyfluorescein and 3' Black Hole Quencher-1 (30 nM) in 1X concentration of Cas12a cognate buffer at 25°C for 10 min. For BNYVV detection from sugarbeet root samples, first RT-RPA was conducted using 100 ng of total RNA extracted from sugarbeet root tissue in a volume of 50 µL using the primers VR-1 and VR-2. The reactions were incubated at 37°C for 60 min and output fluorescence signal was measured at 485 nm excitation and 535 nm emission in a Tecan Spark Ultra plate reader (TECAN, Switzerland). The RT-RPA reactions were diluted up to 10^{-5}, and from each dilution 5 µL was used for the CRISPR-assay. For CRISPR assay background noise alleviation the no template control (NTC) reaction was included in the assay, which was subtracted from test samples prior to plotting the graphs.

Results and Discussion

Rhizomania disease baiting in sugarbeet roots was accomplished by growing plants using rhizomania infested soil. The presence of rhizomania in the soil investigated in this study was confirmed by ELISA testing for BNYVV presence in a soil-baiting assay. Under greenhouse conditions, sugarbeet grown in pot containing soil obtained from field showed yellowish foliar phenotype, while healthy plants grown in potting mix (no field soil) the leaves remained noticeably more-green (Fig. 1A). The representative root phenotypes of rhizomania infected verses healthy sugarbeet plantlets are shown in Figure 1B. Healthy plants' root is large with dense rootlets, whereas rhizomania diseased root is thinner with less-dense rootlets (Fig. 1B).

We developed RT-RPA-based isothermal amplification of BNYVV targeting RNA-1. To accomplish RT-RPA of BNYVV, we designed primers that amplified a 465 bp fragment of BNYVV RNA-1 in a single tube using reagents from TwistAmp liquid basic kit along with M-MuLV reverse transcriptase from total RNA extracted from sugarbeet root samples. The RT-RPA products were visualized on the gel after treating it with 20 mM EDTA to a final concentration upon loading even 5 and 10 µL out of total 50 µL reaction volume (Fig. 1C and D). The RT-RPA analysis of total RNA isolated from sugarbeet roots baited for rhizomania from infected field soil revealed the production of an amplification product of 456 bp fragment as expected (Fig. 1C and D). No such amplification product was obtained in the root samples from healthy sugarbeet controls. Absence of amplified product with no template control (NTC) revealed the specificity of reagents used in the RPA assays. Next, to confirm the sequence authenticity, the RT-RPA amplified fragment was gel-purified, and Sanger sequencing analysis revealed the amplicon indeed carrying BNYVV RNA-1 sequence as expected. Taken together, we have developed an isothermal one-step RT-RPA assay to amplify BNYVV from sugarbeet roots baited for rhizomania from field soil, optimized conditions to visualize the RT-RPA products on gel and confirmed the identity of underlying sequence useful for downstream molecular analysis.

Next, we investigated application of the developed CRISPR-Cas12a based virus diagnostic assay for detecting BNYVV in the roots, the most highly impacted organ due to rhizomania. Rhizomania infected roots were obtained by baiting for the disease from field soil, and as a control healthy roots grown on non-field soil. Firstly, RT-RPA was performed at isothermal conditions using total RNA isolated from rhizomania baited roots, and healthy roots along with a no template control. To determine sensitivity of the CRISPR-Cas12a based assay, these RT-RPA reactions were serially diluted ten-folds and used 5 µL from dilutions in the CRISPR-Cas12a reaction that contains fluorescently labelled ssDNA reporter. After incubating at 37°C, and the results revealed dramatic strong fluorescence signal in the reactions that had RT-RPA template from rhizomania infected roots compared to the signal obtained for reactions with healthy root samples (Fig. 2). Signal observed with no template control was considered background, and this value was subtracted from the signals that were obtained for rhizomania containing roots and healthy roots samples to alleviate background noise accompanying with the reagents. A linear correlation of signal reduction with increasing folds of serial dilution was observed and limit of sensitivity was 0.1 ng concentration (Fig. 2). Of note, the field soil tested here showed positive for rhizomania in a different experiment using ELISA (data not shown). In summary, we have developed an isothermal RT-RPA based CRISPR-Cas12a diagnostic method to detect BNYVV in rhizomania infected roots of sugarbeet.

In conclusion, we present a CRISPR-Cas based method for detecting BNYVV in roots of sugarbeet. We first developed one-step isothermal RT-RPA method for BNYVV detection from rhizomania infected sugarbeet roots. The RT-RPA method is simple, and isothermal as oppose to regular RT-PCR assays. Subsequently, we have developed CRISPR-Cas12a based detection method for BNYVV, which has set the stage for sensitive, specific, and high throughput detection platform for rhizomania evaluation. The development and validation of CRISPR-based BNYVV diagnostic method for sugarbeet roots has advantageous in terms of providing sensitivity and robustness at isothermal condition and hence, would serve as a valuable tool for sugarbeet industries for evaluating viruses for driving disease management strategies. Moreover, this technology developed for virus diagnostic for underground root-tissue can be applied for setting up CRISPR-based detection platform for other crop infecting viruses including soil-borne disease-causing agents.

Figure 1. Rhizomania baiting and RT-RPA mediated detection of BNYVV from *B. vulgaris*. (A) Whole plant pictures of *B. vulgaris* baited for rhizomania under greenhouse condition in pots using infected field soil six weeks post inoculation. (B) Representative individual plants showing root phenotype associated with rhizomania. Extreme care

was taken to gently remove the soil from root. (C) and (D) Detection of RT-RPA amplicon on agarose gel. Even 5 uL (C) and 10 uL (D) loading volume, show strong visual band from a 50 uL reaction. Lanes: infected refers to sugarbeet roots baited for rhizomania disease from field soil. Healthy refers to root obtained from sugarbeet grown in potting mix used for growing plants under laboratory conditions. NTC stands for no template control, and M stands for size marker.

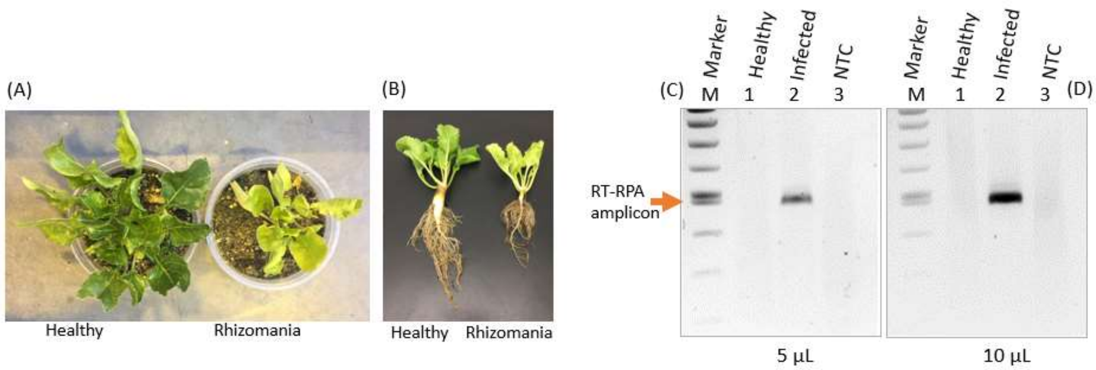


Figure 2. CRISPR-cas12 based detection of BNYVV in root tissue of *B. vulgaris* baited for rhizomania using infected field soil. The template DNA used in this assay was obtained through RT-RPA from rhizomania-infected and healthy roots of sugarbeet. To determine the limit of detection, the RT-RPA product was diluted subjected to CRISPR-Cas12a reporter assay as described in the Materials and Methods. No template reaction serves as the negative control and used for background subtraction. Values plotted on the Y-axis represent background subtracted fluorescence. Whereas X-axis represents dilution concentrations of the RT-RPA generated template DNA. Error bars represents standard deviation (STDEV) on replicates (*n=3*).

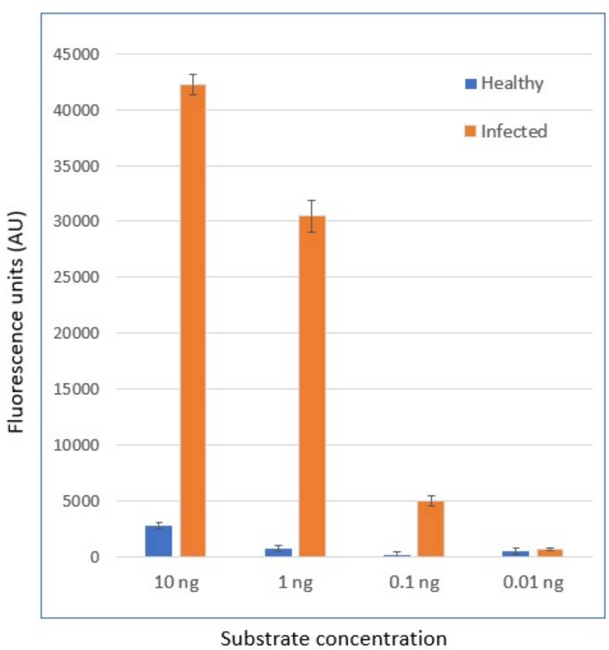


Table.1. Sequences of primers, reporter, CRISPR-guide RNA, and target used in this study. Coordinates relative to target BNYVV RNA-1 are indicated in parenthesis.

Name	Sequence
VR-1	5'-gcgttctgattatcagaatcaacgagttggtg-3' (3064 – 3095)
VR-2	5'-atatgttcaccagtctcatcggaataatgaatg-3' (3528 - 3496)
VR-3	5'-cgttctgattatcagaatcaac-3' (3065 – 3086)
VR-4	5'-atatgttcaccagtctcatcg-3' (3528 – 3508)
Reporter	/56-FAM/TTATT/BHQ-1
BNY-gR1	5'-UAAUUUCUACUAAGUGUAGAUCAGCCUAUGAUUGGCGGUUGC-3' (3180 – 3200)
BNYVV synthetic template DNA (GenBank accession number MT227164)	gcgttctgattatcagaatcaacgagttggtgatgagcttctttcttgggactttcacacgcctcacaaagcattggatgttactggtaagcaaattatttttgttgatgagtttacagcctatgattggcggttgctagctgtgttggcttatagaaatcatgcccatactatttacttagttggtgatgagcagcagactggtattcaagagggtcgtggagaaggaatatcgatacttaacaaaattgatctgtctaaggtttctacacatgttccaatcatgaactttagaaatcctgtccgtgatgttaaggtattaaattatctgttcgggtctcgtatggttcctatgtcttccgttgaaaagggatttagtttcggggatattaaagaattttcgtctttgtcaaatatcccagacactaaaatcattcattattccgatgagactggtgaacatat (3064 –3528)

Acknowledgements

We thank Jonathan Neubauer for technical support with Tecan plate reader, Alyssa Flobinus for general laboratory support, and Alexander Dessert for plant care. We greatly acknowledge Mark Bloomquist, Southern Minnesota Beet Sugar Cooperative for providing field soil for rhizomania analysis. This research was supported by the U. S. Department of Agriculture, Agricultural Research Service. Any commercial products mentioned in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U. S. Department of Agriculture.

References

Rush, C. M., Liu, H. Y., Lewellen, R. T., and Acosta-Leal, R. (2006). The continuing saga of rhizomania of sugar beets in the United States. Plant Dis. 90: 4-15.

Chen, J. S., MA, E., Harrington, L. B., Costa, M. D., Tian, X., Palefsky, M. J., and Doudna, J. A. (2018). CRISPR-Cas12a target binding unleashes indiscriminate single-stranded DNase activity. Science. 360: 436.

Torrance, L., Pead, M. T., and Buxton, G. (1988). Production and some characteristics of monoclonal antibodies against beet necrotic yellow vein virus. Ann. Appl. Biol. 113, 519–530.

Weiland, J. J., Sharma-Poudel., R., Flobinus, A., Cook, D. E., Secor, G. A., and Bolton, M. D. (2020). RNAseq analysis of rhizomania-infected sugar beet provides the first genome sequence of beet necrotic yellow vein virus from the USA and identifies a novel alphanecrovirus and putative satellite viruses. Viruses. 12: 626.

SCREENING OF SUGAR BEET GERMPLASM FOR RESISTANCE TO FUSARIUM YELLOWING DECLINE

Kimberly M. Webb[1]

[1]USDA-ARS, Sugar Beet Research Unit, Fort Collins, CO

Fusarium spp. can lead to significant economic losses for sugar beet growers throughout the United States production region by causing reductions in yield from several associated diseases (Campbell, Fugate & Niehaus, 2011; Hanson & Hill, 2004; Hanson & Jacobsen, 2009; Stewart, 1931) including Fusarium yellows (Stewart, 1931) and Fusarium tip root (Harveson & Rush, 1998; Martyn *et al.* 1989). In 2008, a new sugar beet disease was found in the Red River Valley of MN and ND which caused *Fusarium* yellows-like symptoms but turned out to be more aggressive than Fusarium yellows (Rivera *et al.* 2008). Symptoms differed from the traditional Fusarium yellows by causing discoloration of petiole vascular elements as well as seedling infection and rapid death of plants earlier in the season. Subsequent studies confirmed that the causal agent of this disease was different from any previously described *Fusarium* species and was therefore named *F. secorum* and the disease it causes as Fusarium yellowing decline (Secor *et al.* 2014). Currently, the most effective management strategy for the more common Fusarium yellows is through the use of resistant cultivars and crop rotations with non-hosts (Harveson, Hanson & Hein, 2009) with several sugar beet germplasm being reported to have some resistance for Fusarium yellows (Hanson *et al.* 2009). However, it is unknown if the resistance to Fusarium yellows found in sugar beet will provide any protection against the emerging Fusarium yellowing decline. Therefore, this project proposed to screen multiple sugar beet germplasm for resistance against *F. secorum* which causes Fusarium yellowing decline.

Objectives:

Objective 1: Screen select USDA-ARS, Fort Collins Sugar beet breeding program sugar beet germplasm with known resistance for Fusarium yellows for resistance to Fusarium yellowing decline caused by *F. secorum.*

Year 1 (FY17-18): Screen susceptible sugar beet germplasm and lines with *F. secorum* and determine if differences in pathogen virulence and host susceptibility are prevalent in the population. **(Completed; published Webb et al. 2019. Plant Pathology. 68:1654-1662)**

Year 2 (FY18-19): Screen resistant sugar beet germplasm and lines with *F. secorum* and determine if resistance to Fusarium yellows also confers resistance to Fusarium yellowing decline. **(Completed; manuscript submitted)**

Objective 2: Characterize *F. secorum* population and evaluate phylogenetic relationship with current *F. oxysporum* f. sp. *betae* regional populations. **(Completed; published Webb et al. 2019. Plant Pathology. 68:1654-1662)**

Materials and Methods

***Fusarium* isolates.** *Fusarium* isolates used for these studies were obtained from the long-term culture collections located at either the USDA-ARS Soil Management and Sugar Beet Research Unit (SMSBRU) in Fort Collins, CO or from Dr. Gary Secor (Table 1). Working cultures of all isolates were maintained on potato dextrose agar plates (PDA; Becton, Dickinson, and Co., Sparks, MD) at room temperature until used, and transferred using established protocols (Leslie & Summerell, 2006).

Plant treatment(s). Six susceptible and 26 resistant or tolerant sugar beet lines/germplasm were provided by the breeding program of Dr. Leonard Panella, USDA-ARS, Fort Collins, CO, SESVanderhave and Betaseed for screening (Table 2). Two sets of experiments were completed with the screening the susceptible lines being performed first, followed by a second experiment to screen putative resistant lines. For all experiments, sugar beet seed were planted into 6.5cm black plastic “conetainers” filled with pasteurized potting soil. Plants were grown in a greenhouse with an average daytime temperature of 24°C and average nighttime temperature of 18°C with a 16h photoperiod for 4 weeks.

For all inoculations, approximately two weeks prior to inoculation, spore suspensions were started by plating each isolate to 10 plates of half strength PDA (Becton, Dickinson, and Co., Sparks, MD) and incubating at 25°C with a 12 hr light/dark cycle. After incubation for two weeks, 5 mL sterile nanopure water was added to each plate and the surface of the agar scraped with a sterile "hockey stick" to loosen fungal hyphae and spores. The contents of all 10 plates were then poured through autoclaved double layered cheesecloth and the resulting spore suspension collected into a sterile beaker. The spore concentration was determined with a hemocytometer and then adjusted to a final concentration of approximately 1 x 10^4 conidia per mL by adding nanopure water (100 mL total volume) (Hanson et al. 2009).
Sugar beet varieties were screened by randomly assigning each variety to one of seven "inoculation sets", most of which contained 4-5 varieties. For screening of resistant mterials, each set also always contained two varieties that were used as susceptible controls and checks for effectiveness of inoculations (Monohikari and 902735) (Tanabe et al. 1991; Webb et al. 2019). Each set was inoculated on different experimental dates with each of the eight *Fusarium* isolates (plus one mock negative control; nanopure water) at each inoculation date. Each "set" of varieties were inoculated a total of two times over two experimental dates (replicates). Therefore, up to a total of 10 plants (n=10) were inoculated for each variety by isolate combination, with some combinations having fewer plants due to differences in germination of plants and/or sporulation of the isolates at each experimental date. After inoculation disease severity was rated on a 0-5 Fusarium yellows rating scale (Hanson & Hill, 2004).
Data were analyzed using JMP Pro (SAS Institute Inc., Cary, NC). Due to the complexity of the resistant materials data set (26 varieties, 9 isolate/treatments), data were analyzed using an unsupervised hierarchical clustering using the Ward method to group varieties based on their mean score for the isolate in the panel (Ward, 1963). Each plant was classified as susceptible (score 4-5), moderate resistant/susceptible (score 2-3) and resistant (score 0-1). Isolates were considered highly virulent (score 4-5), moderately virulent (3), lowly virulent (1-2) or non-pathogenic (0) (Table 1). The average score for each variety from each inoculated plant (n=10 plants) was then calculated and this information was used to group varieties with similar patterns of response to the entire *Fusarium* isolate panel; four phenotypical "clusters" were subjectively identified with 3-12 varieties per cluster. One-way ANOVA was used to compare clusters for each isolate to identify significant pathogen by variety interactions using JMP Pro. Significant differences were identified at $p<0.05$.

DNA extractions and translation elongation factor PCR amplification. *Fusarium* isolates were grown in 50 mL potato dextrose broth (PDB; Becton, Dickinson and Co.) by inoculating with a 7 mm diameter mycelium plug taken from a fresh culture of each isolate. Liquid cultures were grown in the dark for 5-7 days at 25°C on a rotary shaker at 100 RPM. Mycelia masses were collected by pouring the filtrate through a double layer of sterile cheese cloth, rinsed with de-ionized water, and then lyophilized at -50°C for 48 h. Lyophilized tissue was ground into a fine powder using a spatula, and DNA extracted using the Invitrogen Easy-DNA extraction kit (Carlsbad, CA) utilizing the manufacturer's protocol for small amounts of plant tissues. Each isolate had 2 biological replicates for PCR amplification and DNA sequencing.

Tef1-α primers were used for PCR amplification (O'Donnell *et al.* 1998) using Thermo Scientific *Taq* polymerase (Waltham, MA) and the following PCR conditions; one cycle of 94ºC for 5 min followed by 33 cycles of 94ºC for 1 min, 55°C for 1 min, and an extension cycle of 72°C for 2 min, followed by final extension cycle of 72°C for 5 min using a Mastercyler gradient thermocycler (Eppendorf, Hamburg, Germany). PCR products were held at 4°C until they could be removed from the thermocycler. PCR amplicons were visualized on a 1.5% agarose gel and purified using the Epoch GenCatch PCR extraction kit (Missouri City, TX). Products were sequenced by Eurofins, MWG/Operon (Huntsville, AL) using primers used for *Tef1-α* amplification. *Tef1-α* gene sequences were manually edited and consensus sequences built using a pair-wise sequence alignment in Genious 6.1.8 (Newark, NJ) for each isolate. Novel gene sequences from *F. secorum* isolates amplified in this study can be obtained from GenBank under accession numbers MH926020-MH926026.

Results and conclusions

Little was known about the range of virulence within *F. secorum* nor how this related to the overall *Fusarium* population previously described from sugar beet. To further characterize the *F. secorum* pathogen population, we obtained *Tef1-α* sequence from seven isolates of *F. secorum* and added this data to a phylogenetic tree that included *F.*

oxysporum f. sp. *betae* (Hill et al. 2011, Webb et al. 2012, Covey et al. 2014 : **Objective 2**). Unexpectedly, the *F. secorum* strains nested into a distinct clade (Clade B) that had included several isolates previously designated as *F. oxysporum* f. sp. *betae*, suggesting that those previous isolates were actually *F. secorum* and had been identified in the broader sugar beet production region prior to discovery of the pathogen (data not shown; Webb et al. 2019). These results prompted an expanded analysis of the *Tef1-α* sequence from genome sequences of publicly available *Fusarium* spp. which indicated that other isolates previously reported as *F. oxysporum* f. sp. *betae* from Clade A were actually *F. commune*, a species that was not previously known to be a sugar beet pathogen. However, isolates previously reported within Clade C could continue to be considered as part of the *Fusarium oxysporum* species complex (data not shown, Webb et al. 2019). Inoculation on susceptible sugar beet with differing genetic backgrounds demonstrated that *F. secorum* strains ranged in virulence from low to highly virulent depending on cultivar (**Objective 1**). This work was published in the journal Plant Pathology (Webb et al. 2019).

Screening of resistant lines (experiment 2, **Objective** 1) was completed in 2020 and a manuscript reporting results has been submitted for publication. Twenty six sugar beet germplasm and commercial hybrids were screened for resistance against the same panel of *F. secorum* isolates from the first experiment. Based on their disease response, these 26 sugar beet varieties could be grouped into four general susceptibility/resistant “clusters” ranging from highly susceptible to highly resistant. Four varieties were resistant to all *F. secorum* isolates, likewise three varieties were susceptible to all isolates (Table 3). However, the other lines appeared to have variable tolerance levels depending on the isolate with some lines being moderately susceptible and other lines moderately resistant. Results from these experiments have been submitted for publication in the Journal of Sugar Beet Research (Webb et al. *submitted*)

Table 1. Panel of *Fusarium* isolates used for screening of sugar beet germplasm and lines.

Isolate name	Original Identified Species†	Current Species Designation‡	Virulence‡	Donor§	Year collected	Location collected
F19	*F. oxysporum*	*F. commune*	HV	L. Hanson	2001	Salem, OR
670-10	*F. secorum*	*F. secorum*	HV	G. Secor	2005	Sabin, MN
845-1-18	*F. secorum*	*F. secorum*	MV	G. Secor	2010	Foxhome, MN
784-24-2C	*F. secorum*	*F. secorum*	HV	G. Secor	2007	Sabin, MN
Fob220a	*F. oxysporum*	*F. secorum*	HV	H. Schwartz	1998	Iliff, CO
Fob257c	*F. oxysporum*	*F. secorum*	MV	H. Schwartz	1998	Brush, CO
938-4	*F. secorum*	*F. secorum*	MV	G. Secor	2010	Moorhead, MN
742-28	*F. secorum*	*F. secorum*	LV	G. Secor	2006	Sabin, MN

†Original identified *Fusarium* species as provided by donor of isolates.

‡Current *Fusarium* species designation and virulence to sugar beet as reported by Webb et al. 2019. *Plant Pathology*. 68: 1654-1162. HV=Highly virulent, MV=Moderately virulent, LV=Lowly virulent.

§Institution of each donor: G. Secor, Dept. Plant Pathology, North Dakota State University, Fargo, ND; L. Hanson, USDA-ARS, Sugarbeet and Bean Research Unit, East Lansing, MI; H. Schwartz, formerly with Dept. of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO.

Table 2. List of sugar beet germplasm and/or commercial hybrids received for resistance screening to *Fusarium secorum.*

Variety	Provider†	Citation (if available)
Monohikari	L. Panella	Tanabe et al. 1991. Sugarbeet [*Beta vulgaris*] cultivar "Monohikari", its development and characteristics. Research Bulletin of the Hokkaido National Agricultural Experiment Station 155:1-47.
902735	SesVanderhave	
FC708	L. Panella	Hecker and Ruppel. 1981. Registration of FC 708 and FC 708 CMS sugarbeet germplasm. Crop Sci. 21:802.
20101008	L. Panella	Panella et al. 2013. Registration of FC1028, FC1037, FC1038, and FC1036 multigerm sugarbeet germplasm with multiple disease resistances. J. Plant Reg. 7:1-9.
20111031	L. Panella	Panella et al. 2013. Registration of FC1028, FC1037, FC1038, and FC1036 multigerm sugarbeet germplasm with multiple disease resistances. J. Plant Reg. 7:1-9.
20131011	L. Panella	
FC221	L. Panella	Panella et al. 2008. Breeding for multiple disease resistance in sugarbeet: registration of FC220 and FC221. J. Plant Reg. 2:146-155.
FC1740	L. Panella	Panella et al. 2018. Registration of FC1740 and FC1741 multigerm, Rhizomania-resistant sugar beet germplasm with resistance to multiple diseases. J. Plant Reg. 12:257-263.
20131010 H14	L. Panella	
20131010 H15	L. Panella	
FC201	L. Panella	Panella and Lewellen. 2005. Registration of FC201, a heterogeneous, disease-resistant, monogerm, O-type sugarbeet population. Crop Sci. 45:1169-1170.
20141022 PF	L. Panella	
20151038 PF	L. Panella	

7927-4-309	L. Panella
5927-4-308	L. Panella
SV-Hybrid FR1+2	SesVanderhave
SV-Hybrid CR3	SesVanderhave
SV-Hybrid B-R1	SesVanderhave
SV-Hybrid A-S	SesVanderhave
TOL 1	KWS Seeds, LLC
TOL 2	KWS Seeds, LLC
TOL 3	KWS Seeds, LLC
MOD 1	KWS Seeds, LLC
MOD 2	KWS Seeds, LLC
MOD 3	KWS Seeds, LLC
SUSC 1	KWS Seeds, LLC
SUSC 2	KWS Seeds, LLC
SUSC 3	KWS Seeds, LLC

[†]Institution of each seed donor: L. Panella, formerly with USDA-ARS, 1701 Centre Ave. Fort Collins, CO; SesVanderhave, 5908 52nd Ave. South, Fargo, ND; KWS Seeds, LLC,5705 W. Old Shakopee Road, Suite 110, Bloomington, MN.

Table 3. Percentage of sugar beet plants that displayed each respective resistance phenotype against the panel of *Fusarium* isolates (one *F. commune* and seven *F. secorum*).

Variety	Susceptible†	Moderate Resistant†	Resistant†	Cluster assignment‡
Susc 2	89.86%	0.00%	10.14%	1
SV Hybrid A-S	88.16%	0.00%	11.84%	1
Susc 3	89.61%	0.00%	10.39%	1
5927-4-308	39.39%	36.36%	24.24%	2
20131011	30.65%	54.84%	14.52%	2
FC221	62.50%	26.56%	10.94%	2
Mod 1	60.32%	26.98%	12.70%	2
FC708	38.89%	48.15%	12.96%	2
Tol 2	66.67%	22.22%	11.11%	2
20131010 H15	35.09%	45.61%	19.30%	2
FC201	52.31%	21.54%	26.15%	2
20101008	8.70%	73.91%	17.39%	2
20151038 PF	22.06%	52.94%	25.00%	2
FC1740	19.18%	43.84%	36.99%	2
Susc 1	35.62%	52.05%	12.33%	3
20111031	0.00%	80.95%	19.05%	3
20141022 PF	13.33%	64.44%	22.22%	3
Mod 2	5.00%	66.67%	28.33%	3
SV Hybrid B-R1	9.09%	43.94%	46.97%	3
SV Hybrid CR3	29.41%	0.00%	70.59%	3
7927-4-309	0.00%	30.14%	69.86%	4
Tol 1	0.00%	0.00%	100.00%	4
20131010 H14	0.00%	50.00%	50.00%	4
Mod 3	11.90%	33.33%	54.76%	4
SV Hybrid FR1+2	10.98%	0.00%	89.02%	4
Tol 3	11.11%	0.00%	88.89%	4

†Percentage of plants (out of 90 plants total; all isolates tested) that had a susceptible (score 4-5), moderate resistant (score 2-3) or resistant (score 0-1) phenotype.

‡Phenotype cluster assignment was based on a multivariate analysis using Jmp Pro which assigned each germplasm/line with a similar response into phenotypic clusters.

PLANT PATHOLOGY LABORATORY: SUMMARY OF 2019-2021 FIELD SAMPLES

Austin K. Lien[1,a], Jason R. Brantner[2,b] and Ashok K. Chanda[3,a]

[1]Reasearcher 3 and Graduate Student, [2]Official Trial Manager and [3]Assistant Professor and Extension Sugarbeet Pathologist
[a]University of Minnesota, Department of Plant Pathology & Northwest Research and Outreach Center, Crookston, MN;
[b]American Crystal Sugar Company, Moorhead, MN
Corresponding Author: Ashok Chanda, achanda@umn.edu

The plant pathology laboratory at the University of Minnesota, Northwest Research and Outreach Center in Crookston receives sugarbeet samples for diagnosis every growing season. These samples have problems caused mostly by plant pathogens, insects, or abiotic causes such as chemical injury (usually herbicide) or nutrient deficiencies. This report summarizes results of samples received during the 2019, 2020, and 2021 growing seasons.

The number of samples received of a particular disease does not always accurately reflect the prevalence of disease. Agricultural staff and consultants may be more comfortable self-diagnosing certain diseases or they may go unnoticed if aboveground symptoms are not observed. However, similarities and differences between 2019, 2020, and 2021 were observed.

In 2019, samples were received from 89 sugarbeet fields and diagnoses are summarized in Figure 1A. *Rhizoctonia solani* was isolated from 37 fields, *Aphanomyces cochlioides* from 11, *Fusarium oxysporum* f. sp. *betae* and/or *Fusarium secorum* from 11, and chemical injury was determined in 16 fields (42, 12, 12, and 18% of fields, respectively). Both *R. solani* and *A. cochlioides* were isolated from 5 fields (6%), and in some fields, no fungal pathogens were isolated, suggesting abiotic causes other than chemical injury. Samples infected by *A. cochlioides* were received starting in early June through early September with a majority of samples being received in July and early August (Fig. 1B). Samples infected by *R. solani* were received starting later in June through early September with the number of samples peaking in early August (Fig. 1B). *Fusarium* spp. were recovered from samples beginning later in June through early August (Fig. 1B)

In 2020, samples were received from 93 sugarbeet fields and diagnoses are summarized in Figure 2A. *R. solani* was isolated from 35 fields, *A. cochlioides* from 13, *Fusarium* spp. from 6, and chemical injury was determined in 2 fields (38, 14, 7, and 2% of fields, respectively). Both *R. solani* and *A. cochlioides* were isolated from 14 fields (15%), and in some fields, no fungal pathogens were isolated, suggesting abiotic causes other than chemical injury. Samples infected by *R. solani* were received from May through September, while samples infected *A. cochlioides* were received from July through early September (Fig. 2B). Samples infected by *Fusarium* spp. were recovered from May through July (Fig. 2B).

In 2021, samples were received from 29 sugarbeet fields and diagnoses are summarized in Figure 3A. *R. solani* was isolated from 17 fields, *A. cochlioides* from 1, *Fusarium* spp. from 2, and chemical injury was determined in 2 fields (57, 3, 7, and 7% of fields, respectively). Both *R. solani* and *A. cochlioides* were isolated from 14 fields (3%), and in some fields, no fungal pathogens were isolated, suggesting abiotic causes other than chemical injury. Samples infected by *R. solani* were received from June through August, while samples infected *A. cochlioides* were received in early June and late July (Fig. 3B). Samples infected by *Fusarium* spp. were recovered late June (Fig. 3B).

The most prevalent pathogen in all three years was *R. solani* while samples infected with *A. cochlioides* alone and with both pathogens together was highest in 2020 and lowest in 2021. It is typical to see development of root rot due to either *R.* solani and/or *A. cochlioides* following periods of excess rainfall, resulting in samples being received in the weeks following excess rainfall events. Although total rainfall in 2019 was greater than 2020 and 2021 in most growing regions (Fig. 4A), most of the rainfall in 2019 was received in September (Fig. 4B). In 2020, a greater amount of rainfall was received in the months of June, July, and August (Fig. 4B), resulting in a greater number of samples infected by *A. cochlioides* (Fig. 2A and 2B). In 2021, the limited rainfall received in June and July (Fig. 4B) and the overall drought conditions that extended through a majority of the growing the season resulted in relatively few samples being received (Fig 3A and 3B). Additionally, the drought conditions in 2021 resulted in several samples with severe nutrient deficiencies due to the immobilization of nutrients. As fields and areas with a history of pathogens are documented, cultural management, variety selection, and the use of effective fungicides, when possible, should continue to be used to reduce losses, inoculum production, and spread of pathogens.

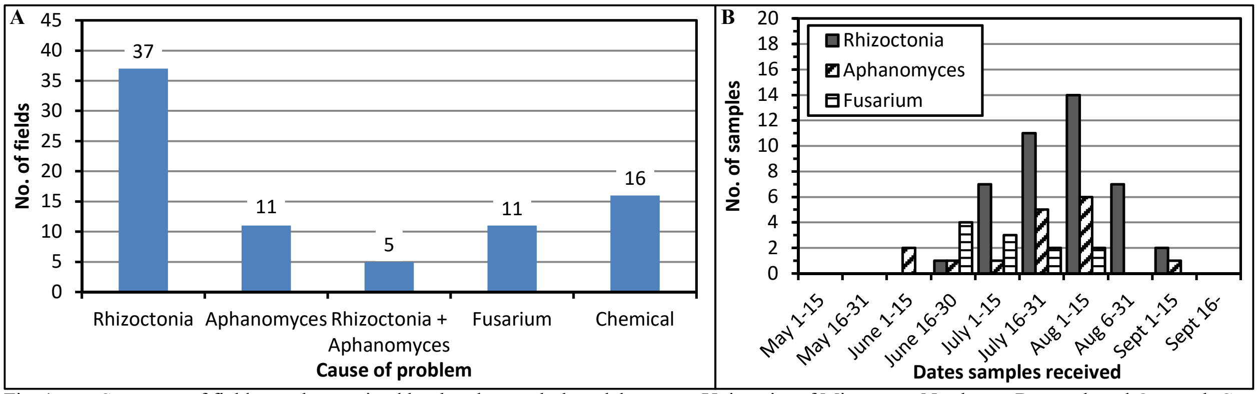


Fig. 1. Summary of field samples received by the plant pathology laboratory, University of Minnesota, Northwest Research and Outreach Center, Crookston in 2019. Results are reported by **A.**) diagnoses and **B.**) dates samples were received for *Rhizoctonia, Aphanomyces*, and *Fusarium*, the three most common root pathogens.

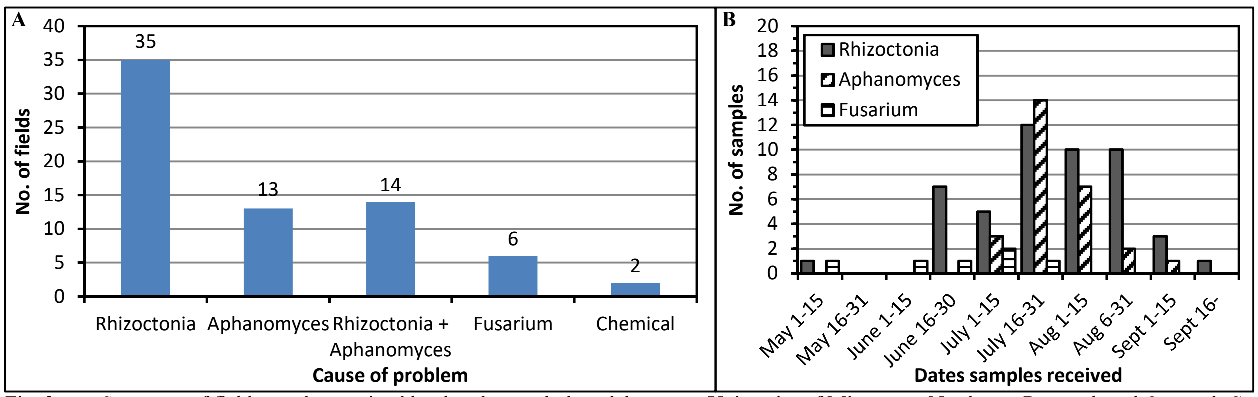


Fig. 2. Summary of field samples received by the plant pathology laboratory, University of Minnesota, Northwest Research and Outreach Center, Crookston in 2020. Results are reported by **A.**) diagnoses and **B.**) dates samples were received for *Rhizoctonia, Aphanomyces*, and *Fusarium*, the three most common root pathogens.

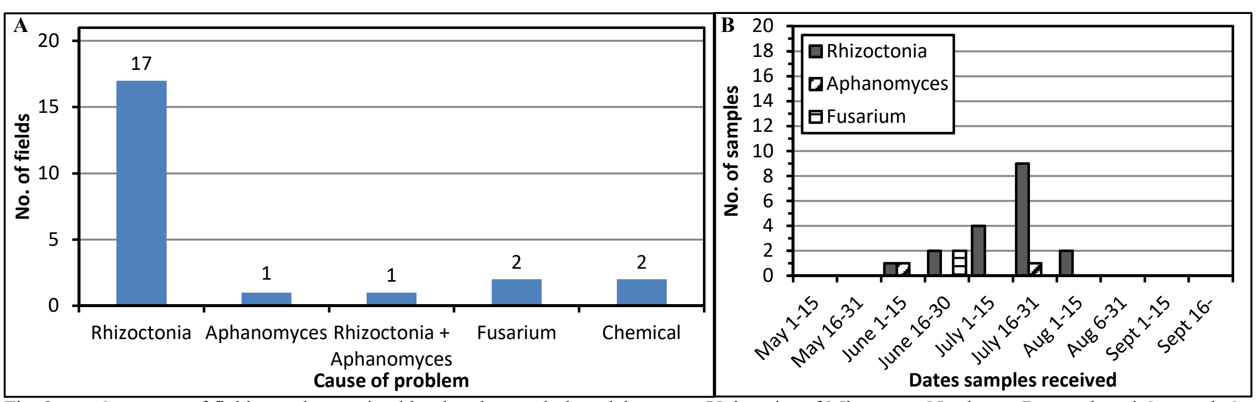


Fig. 3. Summary of field samples received by the plant pathology laboratory, University of Minnesota, Northwest Research and Outreach Center, Crookston in 2021. Results are reported by **A.**) diagnoses and **B.**) dates samples were received for *Rhizoctonia, Aphanomyces*, and *Fusarium*, the three most common root pathogens.

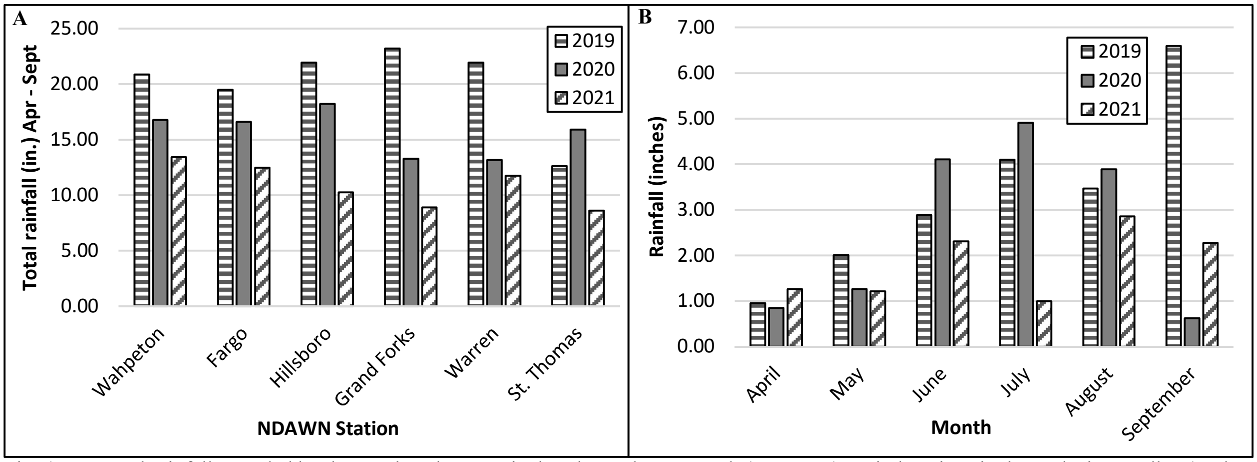


Fig. 4. Total rainfall recorded by the North Dakota Agricultural Weather Network (NDAWN) at six locations in the Red River Valley (Wahpeton, Fargo, Hillsboro, Grand Forks, Warren, MN and St. Thomas). Rainfall is reported in inches for the 2019, 2020, and 2021 growing season months of April through September. Rainfall is reported by **A.**) location and **B.**) month (averaged for all 6 locations).

ACKNOWLEDGEMENTS

We thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for funding of this diagnostic service; agricultural staff of American Crystal Sugar Company, Minn-Dak Farmers Cooperative, Southern Minnesota Beet Sugar Cooperative, and crop consultants for submitting samples; student workers Kenan McQueen, Yeonshik “Donny” You, Derefaa Cline, Anke Wiersma, Muira MacRae James Deleon, and Luke Noah for technical assistance.

EVALUATION OF AT-PLANTING FUNGICIDE TREATMENTS FOR CONTROL OF *RHIZOCTONIA SOLANI* ON SUGARBEET IN 2021

[1]Austin K. Lien, [2]Jeff Nielsen and [3]Ashok K. Chanda

[1]Reasearcher 3 and Graduate Student; [2]Reasearcher 2; [3]Assistant Professor and Extension Sugarbeet Pathologist
University of Minnesota, Department of Plant Pathology & Northwest Research and Outreach Center, Crookston, MN
Corresponding Author: Ashok Chanda, achanda@umn.edu

Rhizoctonia damping-off and crown and root rot (RCRR) caused by *Rhizoctonia solani* AG 2-2 have been the most common root diseases on sugarbeet in Minnesota and North Dakota for several years (1-3, 5,6, 10). Disease can occur throughout the growing season and reduce plant stand, root yield, and quality (4). Warm and wet soil conditions favor infection. Disease management options include rotating with non-host crops (cereals), planting partially resistant varieties, planting early when soil temperatures are cool, improving soil drainage, and applying fungicides as seed treatments, in-furrow (IF), and/or postemergence. An integrated management strategy should take advantage of multiple control options to reduce Rhizoctonia crown and root rot (4).

OBJECTIVES

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

MATERIALS AND METHODS

The trial was established at the University of Minnesota, Northwest Research and Outreach Center (NWROC), Crookston. Field plots were fertilized for optimal yield and quality. A moderately susceptible variety (Crystal 803RR) with a 2-year average Rhizoctonia rating of 4.8 (12) was used. Treatments were arranged in a randomized complete block design with four replicates. Seed treatments and rates are summarized in Tab. 1 and were applied by Germains Seed Technology, Fargo, ND. In-furrow fungicides (Tab. 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 untreated control included no Rhizoctonia effective seed or in-furrow fungicide treatment at planting. Prior to planting, soil was infested with a mixture of four isolates of *R. solani* AG 2-2-infested whole barley (50 kg/ha) by hand-broadcasting in plots, and incorporating with a Rau seedbed finisher. The trial was sown in six-row plots (22-inch row spacing, 25-ft rows) on May 10 at 4.5-inch seed spacing. Counter 20G (8.9 lb/A) was applied at planting and Lorsban (2 pt/A) was applied June 08 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 02, and Sequence (glyphosate + S-metolachlor, 2.5 pt/A) with additional glyphosate (8 fl oz/A) was applied on June 15 and June 29. Cercospora leaf spot was controlled by Provysol + Manzate Max (4 fl oz + 1.5 qt/A) on July 12, Supertin + Topsin M (8 + 10 fl oz/A) on July 27, and Minerva + Manzate Pro-Stick (13 fl oz + 2 lbs/A) on Aug 17.

Plant stands were evaluated beginning 15 days after planting (May 25) through 42 days after planting (Jun 22) by counting the number of plants in the center two rows of each plot. Data were collected for root rot severity, number of harvested roots, and yield at harvest. On Sept 24, plots were defoliated and the center two rows of each plot were harvested mechanically and weighed for root yield. Twenty roots per plot also 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 10% incremental increase per each unit of rating (0 = healthy root, 10 = root completely rotted). Disease incidence was reported as the percent of rated roots with > 0% of rot on the root surface. Ten representative roots from each plot were analyzed for sugar quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. Data were subjected to analysis of variance using SAS Proc GLM (SAS Institute, Cary, NC). Treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance. Orthogonal contrasts were used to compare seed treatment versus in-furrow fungicides and seed treatment and in-furrow fungicides versus the untreated control.

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

Application	Product	Active ingredient (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
In-furrow	AZteroid FC 3.3	Azoxystrobin (11)	5.7 fl oz product/A
In-furrow	Quadris	Azoxystrobin (11)	9.5 fl oz product/A
In-furrow	Xanthion	Pyraclostrobin (11) + *Bacillus amyloliquefaciens* (BM02)	9.0 + 1.8 fl oz product/A
In-furrow	Elatus	Azoxystrobin (11) + Benzovindiflupyr (7)	7.1 oz product/A
In-furrow	Proline	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 FC 3.3 and 9.5 fl oz Quadris contain 56 and 58 g azoxystrobin, respectively; 9 + 1.8 fl oz Xanthion contains 56 g pyraclostrobin + ~1.2 x 10^{12} viable spores of *Bacillus amyloliquefaciens* strain MBI 600; 7.1 oz Elatus contains 60 g azoxystrobin and 30 g benzovindiflupyr; 5.7 fl oz Proline contains 67 g prothioconazole; 13.6 fl oz Propulse contains 67 g each of fluopyram and prothioconazole; 6.7 fl oz Priaxor contains 27 g fluxapyroxad and 55 g pyraclostrobin

RESULTS AND DISCUSSION

Early part of the 2021 growing season was very dry at this site during the period of May-June resulting in none to low early season disease pressure. Rainfall was 0.95 in. during the month of May and 1.65 in. during the month of June compared to a 30-year average of 2.79 and 3.92 in., respectively. These dry conditions resulted in less than optimal stands of 141 plants per 100 ft. row averaged across all treatments in this trial at 28 days after planting (DAP). There could be possible stand reduction from use of 10-34-0 starter fertilizer under these dry conditions. There were significant ($p \leq 0.05$) differences among treatments for plant stands at 22, 28, 35 and 42 days after planting (DAP) (Fig. 1). Nevertheless, the differences were generally small and there was no difference in stands among treatments by harvest. Zeltera seed treatment and Xanthion in-furrow had higher stands numerically over the time period. Among all treatments, Systiva had lowest recoverable sugar T^{-1}. When seed treatments and in-furrow fungicides were compared as two groups, stands at 22 and 28 DAP were significantly higher for seed treatments compared to in-furrow fungicides. For harvest parameters, % sugar and recoverable sugar T^{-1} were higher for in-furrow fungicides compared to seed treatments. There was no difference among treatments for other harvest parameters. Similar results were obtained in 2016, 2017 and 2019 (7-9). Lack of sufficient early-season soil moisture resulted poor establishment of Rhizoctonia inoculum in soil and subsequently resulted in very low disease pressure throughout the season in 2021.

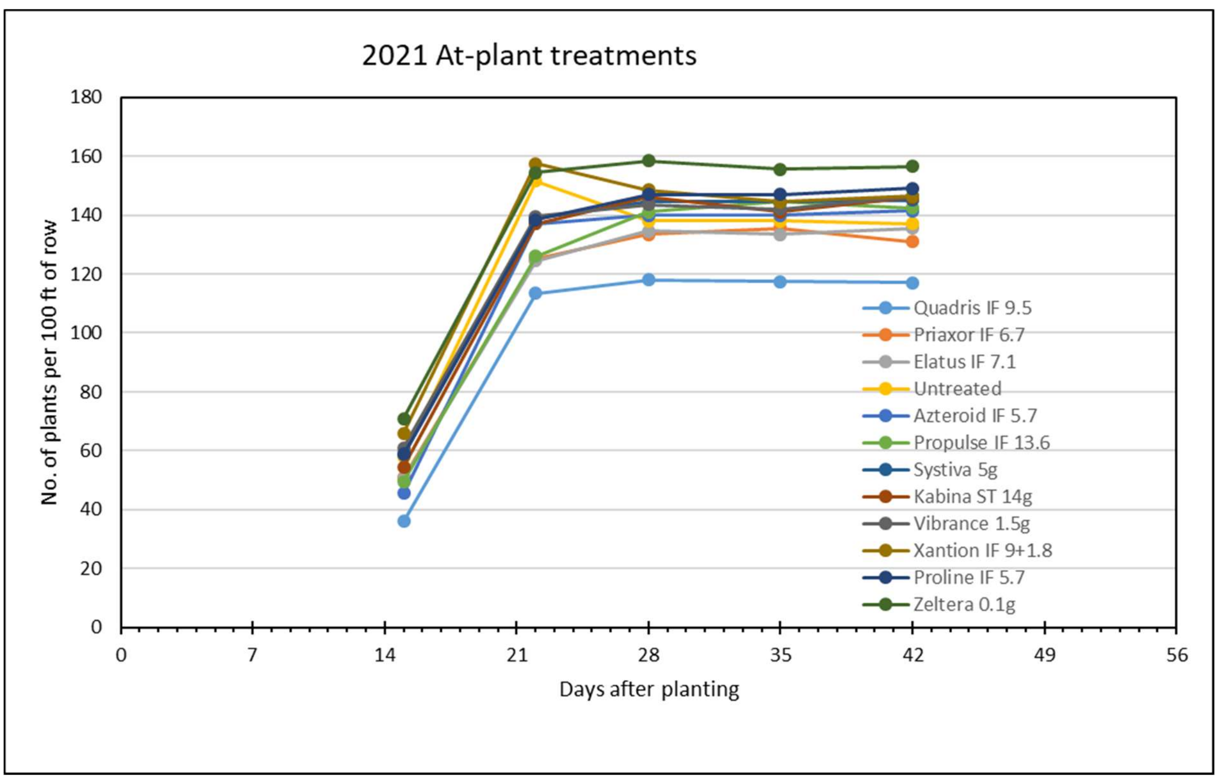


Fig. 1. Emergence and stand establishment for seed treatments and in-furrow fungicides compared to a nontreated control in a sugarbeet field trial infested with Rhizoctonia solani AG 2-2 at the University of Minnesota, NWROC, Crookston. In-furrow treatments were applied at-planting with 6 gallons total volume/A; There were significant (P < 0.05) differences among treatments for plant stands at 22, 28, 35 and 42 days after planting.

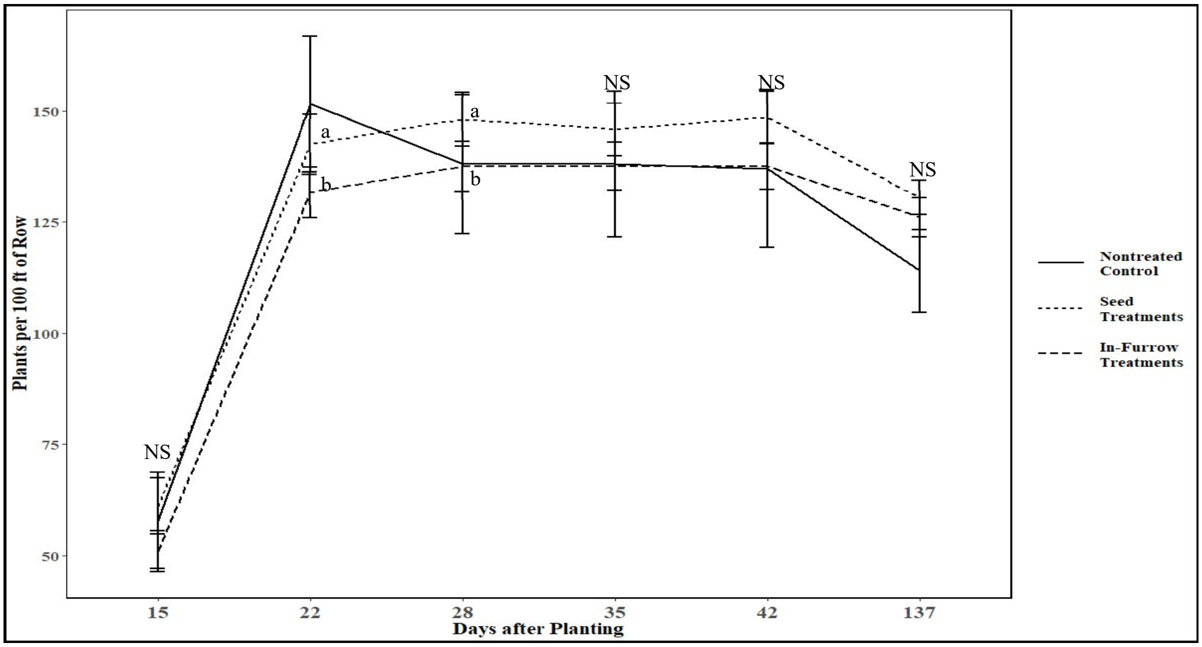


Fig. 2. Emergence and stand establishment for seed treatments and in-furrow fungicides compared to a nontreated control in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2 at the University of Minnesota, NWROC, Crookston. In-furrow treatments were applied at-planting with 6 gallons total volume/A; For each stand count date, treatments with the same letter are not significantly different. There were no significant (P = 0.05) differences among treatments for plant stand at 15, 35, 42, and 137 days after planting.

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

Treatment and rate (Application type)[z]	Plant Stand at Harvest	Plant Loss (%)[y,t]	RCRR Severity (0-10)[x]	RCRR Incidence (%)[w]	Sugar (%)[t]	SLM (%)[t]	Yield (tons/A)	RST (lb/ton)[v,t]	RSA (lb/A)[u]
¥Vibrance	127	13.2 bcd	0.31	10.0	17.6 ab	1.24	26.1	327 ab	8538
¥Kabina	132	12.1 bcd	0.24	12.5	17.2 b	1.23	25.7	320 b	8240
§AZteroid FC 3.3	134	7.4 cd	0.24	6.3	17.4 ab	1.18	24.9	325 ab	8110
§Xanthion	131	18.7 ab	0.16	5.0	17.5 ab	1.23	24.7	326 ab	8072
§Propulse	135	7.8 cd	0.56	15.0	17.6 ab	1.26	24.6	326 ab	8034
¥Zeltera	134	16.0 abc	0.13	6.3	17.5 ab	1.24	24.6	326 ab	8026
§Quadris	115	5.6 d	0.25	12.5	18.0 a	1.19	23.8	336 a	8017
§Proline 480 SC	133	12.2 bcd	0.18	10.0	17.7 ab	1.19	24.2	330 ab	8006
Nontreated Control	114	24.5 a	0.71	15.0	17.5 ab	1.20	23.3	327 ab	7602
§Elatus	121	11.6 bcd	0.45	10.0	17.9 ab	1.21	22.8	333 ab	7602
§Priaxor	116	14.8 bcd	0.41	8.8	17.5 ab	1.19	23.3	325 ab	7566
¥Systiva	130	10.7 bcd	0.28	6.3	16.6 c	1.27	23.8	307 c	7301
LSD	-	9.27	-	-	0.64	-	-	13.3	-
P-value	0.1736	0.0168	0.3277	0.5563	0.0250	0.7870	0.5099	0.0234	0.5551

Seed vs in-furrow contrast analysis[s]

Mean of Seed treatments	131	13.0	2.38	8.8	17.2	1.24	25.0	320	8026
Mean of In-furrow treatments	126	11.2	3.21	9.6	17.6	1.21	24.1	329	7915
P-value	0.2902	0.3700	0.4125	0.6987	**0.0071**	0.1310	0.1260	**0.0049**	0.6292

[z] Treatments were applied as seed treatment or in-furrow application

[y] Plant loss percent equals 100 * (Maximum number of live plants – number of harvested roots) / (Maximum number of live plants)

[x] Percent severity of Rhizoctonia crown and root rot based on ratings described in text

[w] Percent incidence of rated roots with > 0% of rot on the root surface

[v] Recoverable sucrose per ton

[u] Recoverable sucrose per acre equals yield * RST

[t] Means followed by the same letter are not significantly based on Fisher's least significant difference (LSD) test at the 0.05 significance level

[s] 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

ACKNOWLEDGEMENTS

We thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for funding this research; BASF, Bayer, Mitsui Chemicals Agro, Inc., Syngenta, Valent, and Vive Crop Protection for providing products; Crystal Beet Seed for providing seed; Germains Seed Technology for treating seed; the University of Minnesota, Northwest Research and Outreach Center, Crookston for providing land, equipment and other facilities; Jeff Nielsen for plot maintenance; Kenan McQueen, Donny You, James Deleon, and Luke Noah for technical assistance; American Crystal Sugar Company, Moorhead, MN for sugarbeet quality analysis.

LITERATURE CITED

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

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

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

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

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

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

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

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

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

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

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

Niehaus, W.S. and Moomjian, D.L. 2021. Results of American Crystal's 2020 official coded variety trials. 2020 Sugarbeet Res. Ext. Rept. 51:171-200.

INTEGRATED MANAGEMENT OF RHIZOCTONIA ON SUGARBEET WITH RESISTANT VARIETIES, AT-PLANTING TREATMENTS, AND POSTEMERGENCE FUNGICIDES IN 2021

[1]Austin K. Lien, [2]Jeff Nielsen and [3]Ashok K. Chanda

[1]Reasearcher 3 and Graduate Student; [2]Reasearcher 2; [3]Assistant Professor and Extension Sugarbeet Pathologist
University of Minnesota, Department of Plant Pathology & Northwest Research and Outreach Center, Crookston, MN
Corresponding Author: Ashok Chanda, achanda@umn.edu

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

OBJECTIVES

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

MATERIALS AND METHODS

The trial was established at the University of Minnesota, Northwest Research and Outreach Center (NWROC), Crookston. Field plots were fertilized for optimal yield and quality. Plots were set up in a split-split plot design; main plots were varieties, the first split was at-panting treatments, and the last split was postemergence azoxystrobin timings. A combination of a moderately susceptible variety (Crystal 803RR; 2-year average Rhizoctonia rating of 4.8) and a resistant variety (Crystal 804RR; 2-year average Rhizoctonia rating of 3.8) with fluxapyroxad (Systiva) seed treatment, in-furrow azoxystrobin (Quadris) on fluxapyroxad (Systiva), nontreated seed, or in-furrow azoxystrobin (Quadris @ 9.5 fl oz/A as dribble in-furrow) on nontreated seed was planted in four replicated plots (Table 1). Systiva was used at 5 g ai/unit seed and applied by Germains Seed Technology, Fargo, ND. Each variety by at-planting treatment combination was planted in triplicate, so that at the 4- or 8-leaf stage, one plot of each variety by at-planting treatment combination received a 7-inch band postemergence application of azoxystrobin (14.3 fl oz product/A) while one was left as a stand-alone treatment. Controls for each variety included no at-planting treatment with each postemergence azoxystrobin timing and without postemergence azoxystrobin. Postemergence azoxystrobin was applied in a 7-inch band in 10 gallon/A using 4002 nozzles and 34 psi on June 10 (4-leaf stage, 34 days after planting) or June 21 (8-leaf stage, 45 days after planting).

The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 07 at 4.5-inch seed spacing. Prior to planting, soil was infested with a mixture of four isolates of *R. solani* AG 2-2-infested whole barley at 50 kg/ha by hand broadcast. Additionally, Ethotron (4 pt/A) was applied with a spray boom mounted to the front of a Rau seedbed finisher the width of individual plots to incorporate both the pre-plant herbicide and *Rhizoctonia*-infested barely, and prepare the seedbed with one pass in the direction of the rows. Starter fertilizer (3 gallons/A 10-34-0) was applied in-furrow across all treatments. Counter 20G (8.9 lb/A) was applied at planting and Lorsban (2 pt/A) was applied on June 08 to control sugar beet root maggot. For the postemergence control of weeds, glyphosate (4.5 lb ae/gallon, 32 oz/A) was applied on May 27, and Sequence (glyphosate + S-metolachlor, 2.5 pt/A) with additional glyphosate (8 oz/A) was applied on June 08 and June 28. Cercospora leaf spot was controlled by Provysol + Manzate Max (4 fl oz + 1.5 qt/A) on July 12, Supertin + Topsin M (8 + 10 fl oz/A) on July 27, and Minerva + Manzate Pro-Stick (13 fl oz + 2 lbs/A) on Aug 17.

Plant stands were evaluated beginning 18 days after planting (May 25) through 46 days after planting (Jun 22) by counting the number of live plants in the center two rows of each plot. Data were collected for root rot severity, number of harvested roots, and yield at harvest. On Sept 27, plots were defoliated and the center two rows of each plot were harvested mechanically and weighed for root yield. Twenty roots per plot were arbitrarily selected and root surfaces were rated for the severity of Rhizoctonia crown and root rot (RCRR) using a 0 to 10 scale with 10% incremental increase per each unit of rating (0 = healthy root, 10 = root completely rotted). Disease incidence was reported as the percent of rated roots with > 0% of rot on the root surface. 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 R (v 4.1.2, R Core Team 2021) with the package *agricolae* (v 1.3-5). The *ssp.plot* function was used for the variance analysis of a split-split plot design, which is divided into three parts: the plot-factor analysis, the subplot factor analysis, and the sub-subplot analysis. Fisher's least significant difference (LSD) was used for post hoc analysis at a 0.05 level of significance with the respective error terms.

Table 1. Application type, product names, active ingredients, and rates of fungicides used at planting in a field trial for control of *Rhizoctonia solani* AG 2-2 on sugarbeet. Each at-plant treatment was used in combination with a Rhizoctonia resistant (2-year average rating = 3.8) and moderately susceptible (2-year average rating = 4.8) variety, and all treatment combinations in triplicate, with one set receiving a postemergence 7-inch band application of azoxystrobin (14.3 fl oz/A) at 4- or 8-leaf stage. Standard rates of Apron + Thiram and 45 g/unit Tachigaren were on all seed.

Application	Product	Active ingredient	Rate
None	-	-	-
Seed	Systiva	Fluxapyroxad	5 g a.i./unit seed
In-furrow (dribble)	Quadris	Azoxystrobin	9.5 fl oz product/A

RESULTS AND DISCUSSION

Early part of the 2021 growing season was very dry at this site during the period of May-June resulting in none to low early season disease pressure. Rainfall was just 0.95 in. during the month of May and 1.65 in. during the month of June compared to a 30-year average of 2.79 and 3.92 in., respectively. These dry conditions resulted in less than optimal stands of 168 plants per 100 ft. row averaged across all treatments in this trial. There could be possible stand reduction from use of 10-34-0 starter fertilizer under these dry conditions. There were no significant stand differences between resistant (R) and moderately susceptible (MS) varieties from 2.5 to 6.5 weeks after planting (WAP) (Fig. 1A). There were no significant stand differences between nontreated, Systiva ST, Quadris in-furrow, Systiva ST + Quadris in-furrow at-planting treatments (Fig. 1B). There were no significant stand differences between no post and 4- or 8-leaf postemergence applications (Fig 1C.). Slight to no root rot severity and very low root rot incidence (< 10%) were observed for all treatments in this trial (Table 2). A two-way interaction of variety x post treatment was observed for number of harvestable roots and recoverable sugar A^{-1} (RSA). Both 4- and 8-leaf postemergence applications resulted in an increase of ~500 lbs sucrose (Fig. 2) and more (~10 per 100 ft. of row) harvestable roots (Tab. 2) in the moderately susceptible variety only compared to the no postemergence treatment. For percent sucrose, sugar loss to molasses, and recoverable sucrose T^{-1} (RST), no significant differences were observed between varieties or at-panting treatments or postemergence treatments in 2021 (Table 2). No two-way or three-way interactions were observed for the above harvest parameters. Lack of sufficient early-season soil moisture resulted poor establishment of Rhizoctonia inoculum in soil and subsequently resulted in very low disease pressure throughout the season in 2021.

Table 2. Main effects of variety, at-planting, and postemergence fungicide treatments on Rhizoctonia crown and root rot and sugarbeet yield and quality in sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2 at the University of Minnesota, NWROC, Crookston

Main effect	Plant Stand at Harvest[V]	Plant Loss (%)[U]	RCRR Severity (0-10)[T]	RCRR Incidence (%)[S]	Sugar (%)	SLM (%)	Yield (tons/A)	RST (lb/ton)[R]	RSA (lb/A)[Q]
Variety[Y]									
Resistant	129	20.4	0.11	8.3	17.6	1.33	22.1	325	7167
Susceptible	138	20.3	0.18	8.6	18.1	1.24	22.0	337	7399
P-value	0.168	0.961	0.102	0.876	0.086	0.072	0.592	0.075	0.228
LSD[Z]	-	-	-	-	-	-	-	-	-
At-planting[X]									
Untreated	129	22.0	0.12	7.3	17.7	1.30	22.3	329	7334
Systiva	135	21.7	0.12	7.3	18.0	1.27	21.3	334	7102
Quadris	135	18.3	0.16	10.4	17.8	1.26	22.8	331	7524
Systiva + Quadris	133	19.2	0.17	9.0	17.8	1.30	21.7	330	7171
P-value	0.516	0.087	0.727	0.620	0.280	0.336	0.189	0.209	0.282
LSD	-	-	-	-	-	-	-	-	-
Postemergence[W]									
None	131	21.5	0.18	9.4	17.8	1.28	21.7	331	7167
Quadris 4-leaf	134	20.1	0.12	8.6	17.8	1.28	22.0	331	7285
Quadris 8-leaf	135	19.4	0.13	7.5	17.8	1.29	22.4	331	7397
P-value	0.329	0.278	0.273	0.504	0.967	0.796	0.256	0.987	0.314
LSD	-	-	-	-	-	-	-	-	-
Variety x at-planting[¥]	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety x Post[¥]	**0.049**	NS	NS	NS	NS	NS	**0.042**	NS	**0.036**
At-planting x Post[¥]	NS	NS	NS	**0.012**	NS	NS	NS	NS	NS
Variety x At-planting x Post[¥]	NS	NS	NS	NS	NS	NS	NS	NS	NS

[Z] LSD = Least Significant Difference, *P* = 0.05
[Y] Values represent mean of 48 plots (4 replicate plots across 4 at-planting treatments and 3 postemergence treatments)
[X] Systiva @ 5 g a.i /unit and Quadris In-furrow @ 9.5 fl oz./A via drip tube; Values represent mean of 24 plots (4 replicate plots across 2 varieties and 3 postemergence treatments)
[W] Quadris Postemergence @ 14.5 fl oz./A in a 7 inch band; Values represent mean of 24 plots (4 replicate plots across 2 varieties and 3 at-planting treatments)
[V] Plants per 100 ft of row
[U] Plant loss percent equals 100 * (Maximum number of emerged plants – number of harvested roots) / (Maximum number of emerged plants)
[T] Percent severity of Rhizoctonia crown and root rot based on ratings described in text
[S] Percent incidence of rated roots with > 0% of rot on the root surface
[R] Recoverable sucrose per ton
[Q] Recoverable sucrose per acre equals yield * RST
[¥] *P*-values < 0.05 indicate a statistically significant interaction; NS = not significantly different

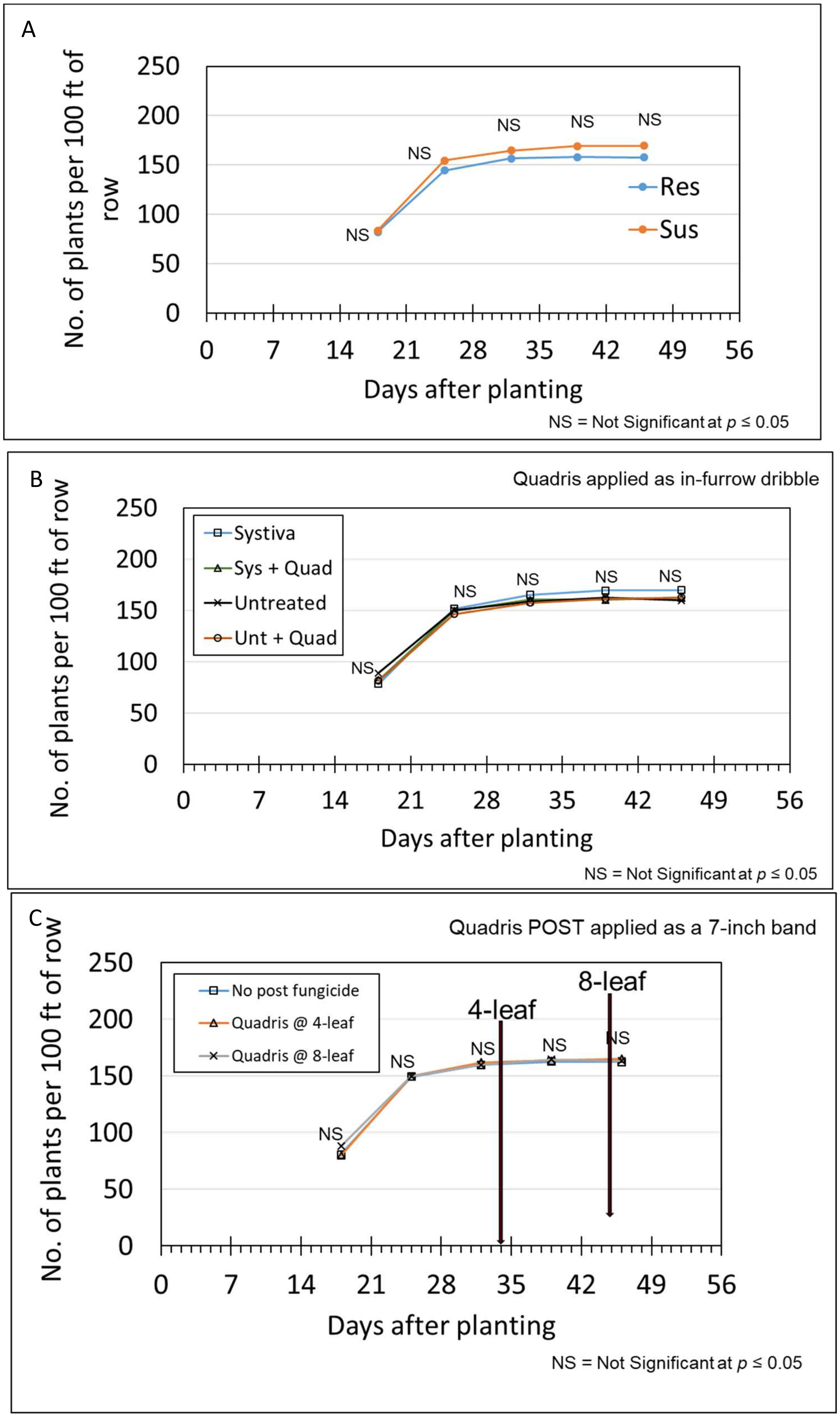


Fig. 1. Effects of **A**) sugarbeet varieties; Res = 3.8 rating, Sus = 4.8 rating for Rhizoctonia **B**) at-planting treatments, Sys = Systiva seed treatment @ 5 g/unit seed, Quad = Quadris in-furrow dribble at 9.5 fl oz/A, and **C**) postemergence treatments on stand establishment from 18 to 46 days after planting (DAP) Postemergence azoxystrobin (Quadris) was applied in a 7-inch band in 10 gallon/A using 4002 nozzles at 34 psi on June 10 (4-leaf stage, 34 days after planting) or June 21 (8-leaf stage, 45 days after planting). NS indicates no statistical significance between treatments on a given day at $p < 0.05$.

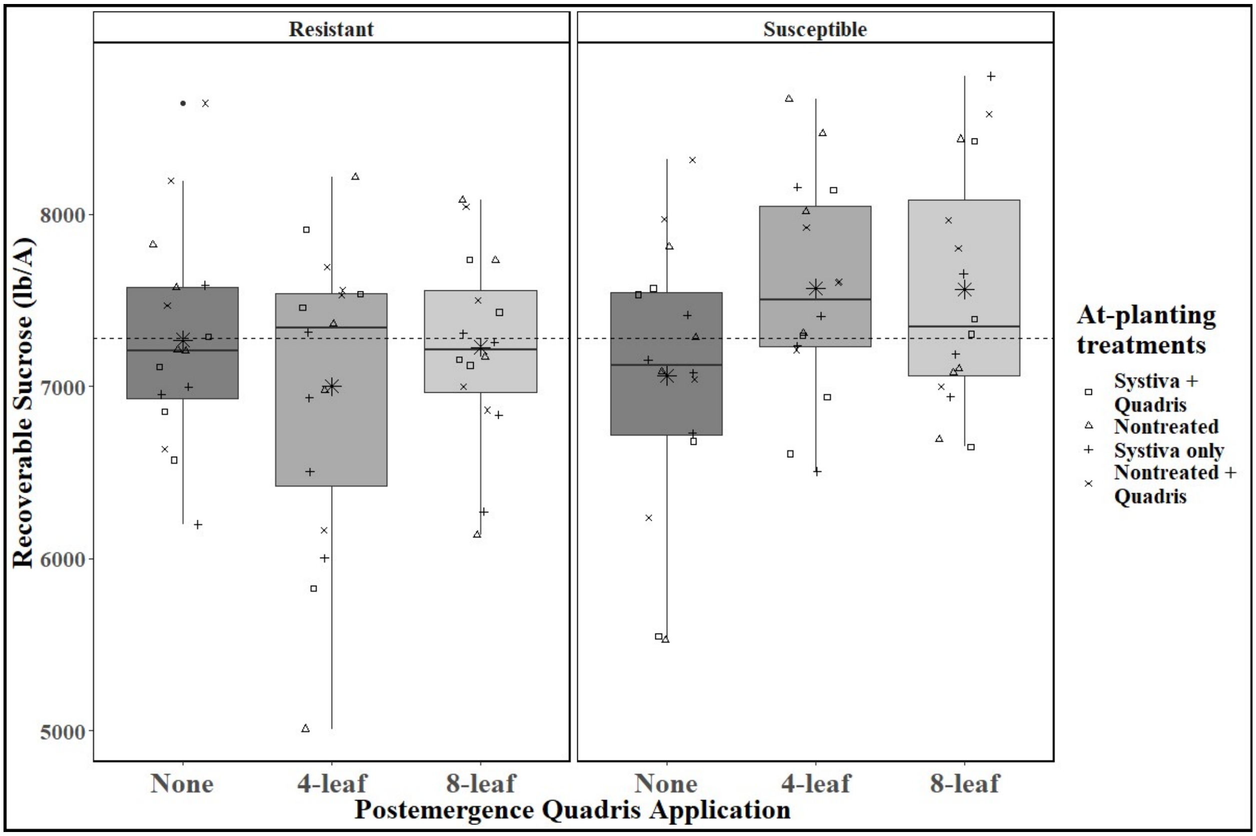


Fig. 2. Effect of variety x postmergence Quadris application on recoverable sucrose per acre (RSA). Data shown represents mean of 16 plots averaged across all at-planting treatments. Each boxplot represents the inter-quartile range, each solid line represents the median, and asterisks represents the mean of each treatment. Individual points above or below a box plot represent potential outliers. The horizontal dotted line represents the mean of all treatments.

ACKNOWLEDGEMENTS

We thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for funding this research; BASF and Syngenta for providing products; Crystal Beet Seed for providing seed; Germains Seed Technology for treating seed; the University of Minnesota, Northwest Research and Outreach Center, Crookston for providing land, equipment and other facilities; Jeff Nielsen for plot maintenance; Yeonshik "Donny" You, Kenan McQueen, James Deleon, and Luke Noah for technical assistance; American Crystal Sugar Company, East Grand Forks, MN for sugarbeet quality analysis.

LITERATURE CITED

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

Brantner, J.R. and Chanda, A.K. 2017. Plant pathology laboratory: summary of 2015-2016 field samples. 2016 Sugarbeet Res. Ext. Rept. 41:260-261.

Brantner, J.R., H.R. Mickelson, and E.A. Crane. 2014. Effect of *Rhizoctonia solani* inoculum density and sugarbeet variety susceptibility on disease onset and development. 2013 Sugarbeet Res. Ext. Rept. 44:203-208.

Chanda, A. K., Brantner, J. R., Lien, A., Metzger, M., Burt E., Bloomquist, M., and Mettler, D. 2021. Integrated Management of Rhizoctonia on Sugarbeet with Resistant Varieties, At-Planting Treatments, and Postemergence Fungicides. 2020 Sugarbeet Res. Ext. Rept. 51: 141-151

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

Chanda, A. K., Brantner, J. R., Metzger, M., Bloomquist, M., and Mettler, D. 2019. Integrated Management of Rhizoctonia on Sugarbeet with Varietal Resistance, At-Planting Treatments and Postemergence Fungicides. 2018 Sugarbeet Res. Ext. Rept. 49:166-175.

Chanda, A. K., Brantner, J. R., Metzger, M., Bloomquist, M., and Groen, C. 2018. Integrated Management of Rhizoctonia on Sugarbeet with Varietal Resistance, At-Planting Treatments and Postemergence Fungicides. 2017 Sugarbeet Res. Ext. Rept. 48:129-136.

Chanda, A. K., Brantner, J. R., Metzger, M., Bloomquist, M., and Groen, C. 2017. Integrated Management of Rhizoctonia on Sugarbeet with Varietal Resistance, At-Planting Treatments and Postemergence Fungicides. 2016 Sugarbeet Res. Ext. Rept. 47:174-179.

Niehaus, W.S. and Moomjian, D.L. 2021. Results of American Crystal's 2020 official coded variety trials. 2020 Sugarbeet Res. Ext. Rept. 51:171-200.

IMPROVING SUGARBEET RESISTANCE TO CERCOSPORA LEAF SPOT THROUGH GWAS AND DOUBLED HAPLOID

Chenggen Chu[1], Muhammad Massub Tehseen[2], Rachael Claire Poore[1], Melvin D. Bolton[1], Mohamed F.R. Khan[3], Mike Metzger[4], and Xuehui Li[2]

[1]USDA-ARS, Edward T. Schafer Agricultural Research Center, Fargo, ND 58102, [2]Department of Plant Science, North Dakota State University, Fargo, ND 58108, [3]Extension Sugarbeet Specialist, North Dakota State University & University of Minnesota, and [4]Minn-Dak Farmers Cooperative, Wahpeton, ND 58075

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). Meanwhile, genetic studies suggested that CLS resistance was complicatedly inherited. However, major genes conferring CLS resistance were also reported. Smith and Gaskill (1970) have assumed that CLS resistance is controlled by at least four or five genes with effects varied depending on the severity of infection. Taguchi et al. (2011) reported four QTLs conferring the resistance carried by the line 'NK-310mm-O'. Abd El-Fatah et al. (2020) reported some molecular DNA and isozyme markers showed obvious association with sugarbeet resistance to CLS. Thus, evaluation of CLS resistance in sugarbeet genetic resources followed by genome-wide association studies (GWAS) will be an efficient way of identifying resistance genes and developing markers to assist selection by pyramiding resistance genes from different sources to achieve long-lasting resistance.

However, genetic heterozygosity and heterogeneity are common attributes of sugarbeet germplasms due to the self-incompatibility nature of the species, which greatly increase difficulties in genetic and breeding research such as gene identification, marker development and estimation of allele effects. Haploids and doubled haploids (DHs) only carry one set of chromosomes from their diploid parents. This eliminates the interactions between different homologous alleles in haploid/DH plants since either only one copy of homologous alleles exists in haploid or two identical copies of alleles present in DH for each locus. Also, the DH method only takes one year to develop completely homozygous and genetically stable genotypes, which greatly accelerates germplasm development in sugarbeet.

Sugarbeet haploid plants can be induced through gynogenesis by culturing unfertilized female gametophytes (ovules) (Hosemans and Bossoutrot, 1983) with the haploid induction efficiency varying from 1 to 15% (Pazuki et al., 2018). Therefore, the ovule culture is the most promising technique for DH development in different genetic resources.

The objectives of this research will include: 1) using SNP (single nucleotide polymorphisms) markers from GBS (genotype-by-sequencing) to genotype all available genetic resources of sugarbeet in the US, and then conducting genetic diversity analysis to reveal the potential of those resources for broadening the genetic base of sugarbeet; 2) conducting GWAS to identify genomic regions associated with CLS resistance; and 3) using different resistant resources to develop new DH breeding lines with stable resistance.

Materials and methods

A total of 1,935 *Beta vulgaris* germplasm lines were collected for this research, which included 1,080 accessions of sugarbeet, 86 accessions of fodder beet, 67 accessions of leaf veg, 82 accessions of root veg, and 595 accessions of wild relatives but were mainly from *B. maritima* (Table 1).

Table 1. List of accessions in *Beta vulgaris* collection used in this research.

Species	Number of accessions
Beta atriplicifolia	6
Beta macrocarpa	11
Beta macrorhiza	2
Beta palonga	1
Beta patula	3
Beta procumbens	1
Beta webbiana	1
Beta maritima L.	595
Beta vulgaris L.	1315
Fodder beet	86
Leaf beet	67
Root veg	82
Sugarbeet	1,080
Total	1,935

Whole genomic DNA was extracted from leaf samples using a DNA purification system from King Fisher, Inc., and DNA samples were co-digested with two restriction enzymes NsiI (recognizes ATGCA^T sites) and BfaI (cuts C^TAG sites) to develop sequencing libraries. An Illumina HiSeq 2000 was used to sequence about 100-bp from both directions of enzyme cutting sites. SNP calls were made using the reference-based TASSEL pipeline with EL10.2 assemblies from the sugarbeet line EL10 as the reference genome, to obtain SNPs covering the whole genome. Genetic diversity analysis was conducted using computer program TASSEL v5.0 (https://tassel.bitbucket.io/) and a phylogenetic tree was drawn by the online tree drawing tool iTOL v6 (https://itol.embl.de/). The Population structure of the collection was analyzed using the computer program STRUCTURE v2.3.4 (https://web.stanford.edu/group/pritchardlab/structure.html)

Preliminary GWAS analysis was conducted through computer program TASSEL v5.0 using the SNP data from this research and the existing historic CLS disease severity data collected from 797 *B. vulgaris* germplasms and stored in the U.S. NPGS (National Plant Germplasm System, https://www.ars-grin.gov/npgs/).

For haploid/DH development, sugarbeet lines F1024 and F1042 were used for setting up the DH procedures. Briefly, the unfertilized flowers were stored in a fridge at 4 ˚C for a week and ovules were dissected after flowers were sterilized in 20% bleach solution for 25 minutes. Ovules were then cultured on the MS growth media containing sucrose (60 g/L), 6-BAP (1 mg/L) and kinetin (1 mg/L) for over 4 weeks under light at 27 ˚C. The enlarged and germinated ovules were transferred to new growth media to promote callus growth and seedling regeneration. The induced seedling was then moved to rooting media that contained sucrose (30 g/L) and NAA (5 mg/L). Once the root was developed, the seedling was transplanted into the soil with 16 hr of day length under 25 ˚C. Root tips were collected for chromosome counting after being stained by Feulgen staining. Colchicine treatment for chromosome doubling was conducted either using callus tissue or the seedlings that have been treated at 4 ˚C for over three months for inducing reproduction. If callus tissue was used for colchicine treatment, 40 µl colchicine solution (33 mg/ml) was added to a mini cup containing ten callus pieces in 2 ml liquid media (growth media with no agar added). The mini cup was kept at 18 ˚C overnight and callus tissue pieces were then transferred to rooting media on the next day. Once planets with roots were induced from the rooting media, they were transplanted into the soil in a growth chamber, followed by cold treatment for three months and then moved to a greenhouse till matured seeds were obtained.

If seedlings were used for colchicine treatment, the cold treated seedlings were pulled out from soil and the root was cleaned in water. The seedlings were then transferred into 50-ml centrifuge tubes with each containing about 40 ml 1.5 g/L colchicine solution. The tubes along with seedlings were put into a centrifuge and spun at 50 G for 3 minutes. After dumping the colchicine solution, the tubes and seedlings were spun again at the same speed for 3 minutes to remove the extra colchicine solution from seedling leaves. The seedlings were then transplanted back to soil in a growth chamber for two weeks and the recovered seedlings were moved to a greenhouse till matured seeds were obtained. All plants from colchicine treatment were individually bagged and all seeds harvested from each plant were DHs.

Results & discussion

A total of 148,137 SNPs were obtained in the germplasm collection and covered the whole sequenced genome according to EL10.2 assemblies (Table 2). SNP coverage was uniform on each chromosome, which indicated that SNP markers in the collection were suitable for genetic diversity analysis and GWAS.

Table 2. SNPs from GBS in the collection of 1,935 *B. vulgaris* germplasms.

Chromosome /scaffold	Number of SNPs	Covering region (Mb)*
Chr. 1	15,746	64.1
Chr. 2	14,674	56.8
Chr. 3	15,466	57.1
Chr. 4	16,987	66.1
Chr. 5	19,115	67.7
Chr. 6	19,140	72.2
Chr. 7	15,693	60.9
Chr. 8	16,666	61.8
Chr. 9	14,277	55.6
Scaffold_10	73	0.3
Scaffold_11	124	0.8
Scaffold_12	16	0.6
Scaffold_13	105	0.6
Scaffold_14	74	0.5
Scaffold_16	111	0.2
Scaffold_17	34	0.1
Scaffold_18	16	0.06
Total	**148,137**	**565.46**

* According to McGrath et al. (2020), the whole sequenced genome of EL10.2 assemblies have a total of 580 Mb. The nine scaffolds were not anchored to any chromosome yet with each covered the genomic region ranging from 0.1 to 1.0 Mb.

Structure analysis based on SNPs indicated that five sub-populations were included in the germplasm collection with accessions tended to be clustered according to their usage (Fig. 1a). However, the genetic background in the four clusters had a high level of admixture, which agreed with the expected low genetic diversity among sugarbeet germplasms in those clusters (Fig. 1b).

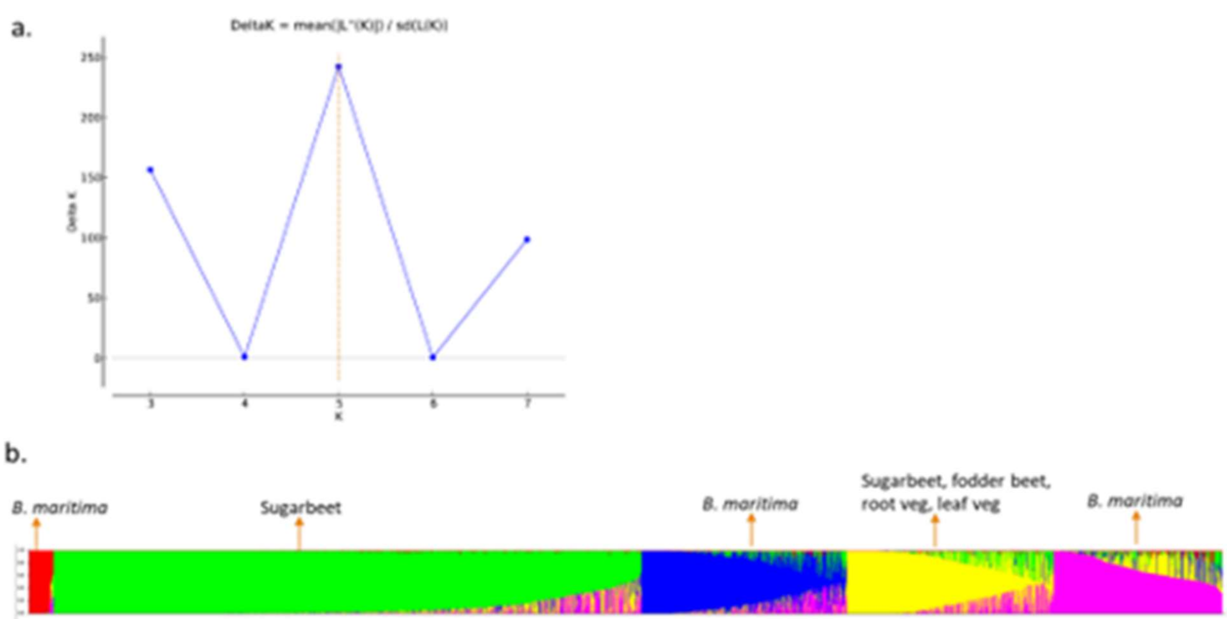


Fig. 1. Structure analysis in the *B. vulgaris* germplasms using the computer program STRUCTURE v2.3.4. (a) Analysis from STRUCTURE indicated five sub-populations in the germplasm collection. (b) Genetic admixture among sub-populations.

Phylogenetic tree analysis using the tools TASSEL and iTOL further supported the results from population structure analysis (Fig. 2). Except for a cluster of 355 accessions mainly from *B. maritima* that showed a more distinct genetic distance from the others, the rest of the germplasms were closely related and confirmed the narrow genetic diversity in sugarbeet germplasms.

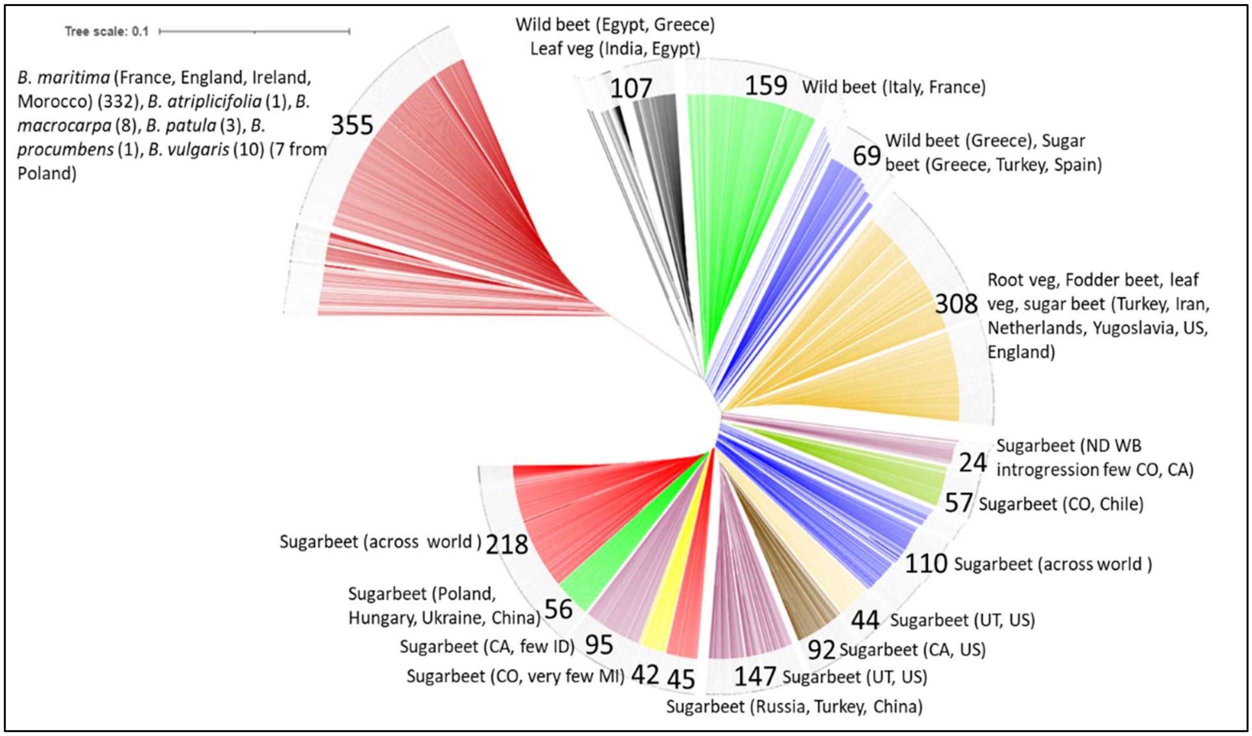


Fig. 2. Phylogenetic tree of the *B. vulgaris* germplasms obtained using computer program TASSEL v5 and iTOl v.6. The number in each cluster indicates the number of accessions in the cluster.

From the database of NPGS (https://npgsweb.ars-grin.gov/), the historical CLS data have been collected from 797 accessions of *B. vulgaris* (Table. 3). The CLS ratings were recorded in a 0 – 9 system where 0 is immune to CLS, 1 – 3 as resistant, 4 - 6 as moderately susceptible, and 7 - 9 as susceptible to CLS.

Table 3. The historical CLS data that have been collected from 797 accessions of *B. vulgaris.* *

Species	Number of accessions	Average CLS ratings	Range of CLS ratings
Beta atriplicifolia	4	4.5	3 - 8
Beta macrocarpa	1	9.0	9.0
Beta maritima L.	390	4.7	0 - 9
Beta vulgaris L.	402	6.4	1 - 9
Fodder beet	75	7.3	1 - 9
Leaf veg	37	6.5	3 - 9
Root veg	56	6.5	3 - 9
Sugarbeet	234	6.0	3 - 9

* Data was downloaded from database of NPGS (https://npgsweb.ars-grin.gov/)

Among germplasms been rated for reaction to CLS, *B. maritima* accessions showed the better CLS resistance with 131 out of 390 accessions were CLS resistant, whereas only 12 out of 402 cultivated beets lines were rated as “3” or below (Fig. 3), indicated that some *B. maritima* accessions will be more promising for using as the CLS resistance sources.

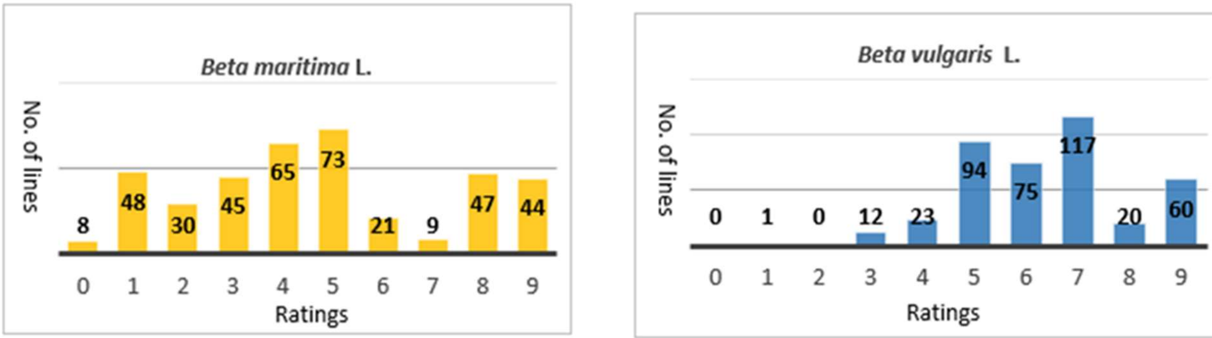


Fig. 3. CLS rating distribution in accessions of *B. maritima* (left) and cultivated *B. vulgaris* (right).

GWAS in the 797 accessions found genomic regions on chromosomes 1, 4, 5, 6, 7, and 8 were significantly associated with the resistance (Fig. 4 and Table. 4) and each region explained 4 - 5% of trait variations. However, since those CLS reaction data were collected at different times under different environments, the GWAS results presented here mostly indicated the ability of GWAS for identifying the CLS resistance genes, therefore, the resistance associated genomic regions identified from the historic data needs to be validated using new disease data from well-designed experiments to be conducted during the 2022 crop season.

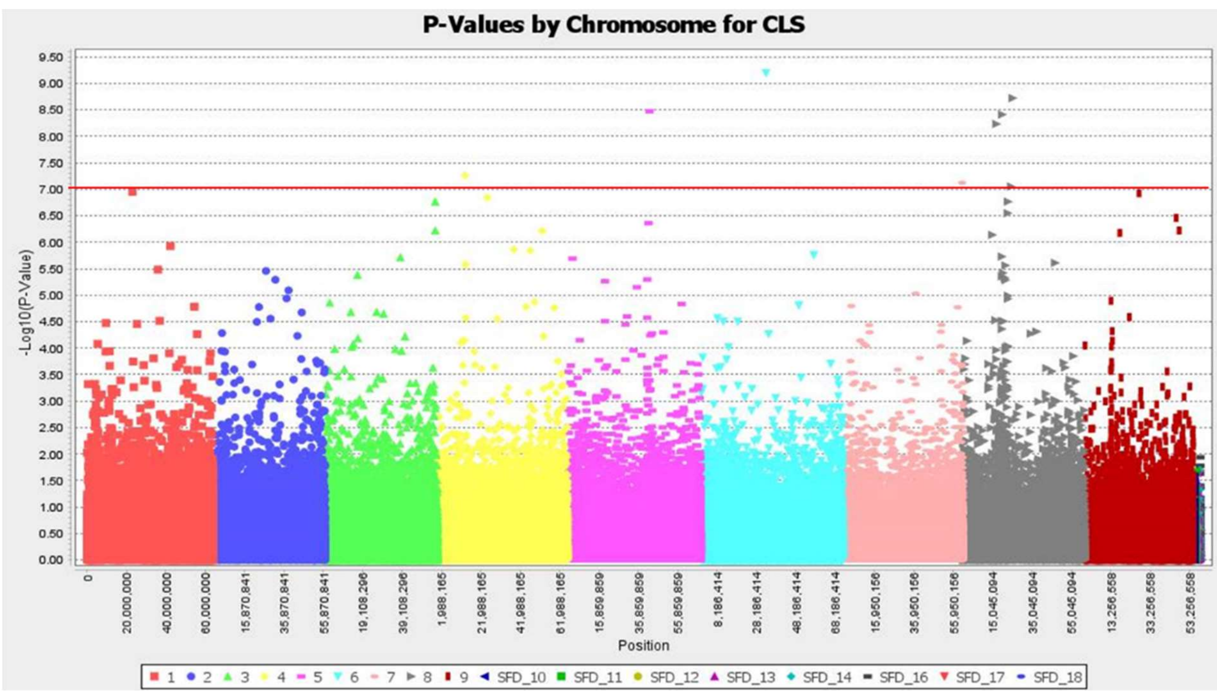


Fig. 4. Manhattan plot of association mapping of CLS resistance in 797 accessions of *B. vulgaris* using the historic disease data. The threshold was set as LOD = 7 that is indicated using a red horizontal line.

Table 4. List of SNP markers significantly associated with CLS resistance in the historic data

SNP Marker	LOD	Additive effect	Dominant effect	Marker R^2	Allele effect			
S1_23048025	7	-2.8	3.13	0.04	A	-5.9	G	0.3
S4_13904356	7.3	-1.5	0.82	0.04	A	-2.3	G	0.7
S5_41539664	8.5	-2.1	2.07	0.05	A	-4.1	G	0
S6_32978686	9.2	-2.9	3.01	0.05	C	-5.9	G	0.1
S7_60416461	7.1	0.8	1.28	0.04	A	0.4	G	-2.1
S8_16880753	8.2	-1.6	1.34	0.05	A	-2.9	G	0.2
S8_19832249	8.4	-1.8	1.6	0.05	A	-3.43	G	0.2
S8_24350838	7.1	-1.2	-0.98	0.04	A	-0.2	G	2.1
S8_25199724	8.7	-2	2.09	0.05	C	-4.1	G	0

For DH production, over 5,000 unfertilized ovules from sugarbeet lines F1024 and F1042 were cultured, and callus tissue was successfully induced from 27 individual ovules with an induction rate of 0.5%. Seedlings were regenerated from all callus tissues and chromosome counting using root tip cells confirmed they are haploids. Colchicine treatment using callus tissue was conducted and seedling regeneration from the treated callus is ongoing. The colchicine treatment on haploid seedlings will be conducted once the seedlings finished the vernalization processes. Fig. 5 shows the procedures of haploid induction through ovule culture and chromosome counting confirmed nine chromosomes carried in each observed cell.

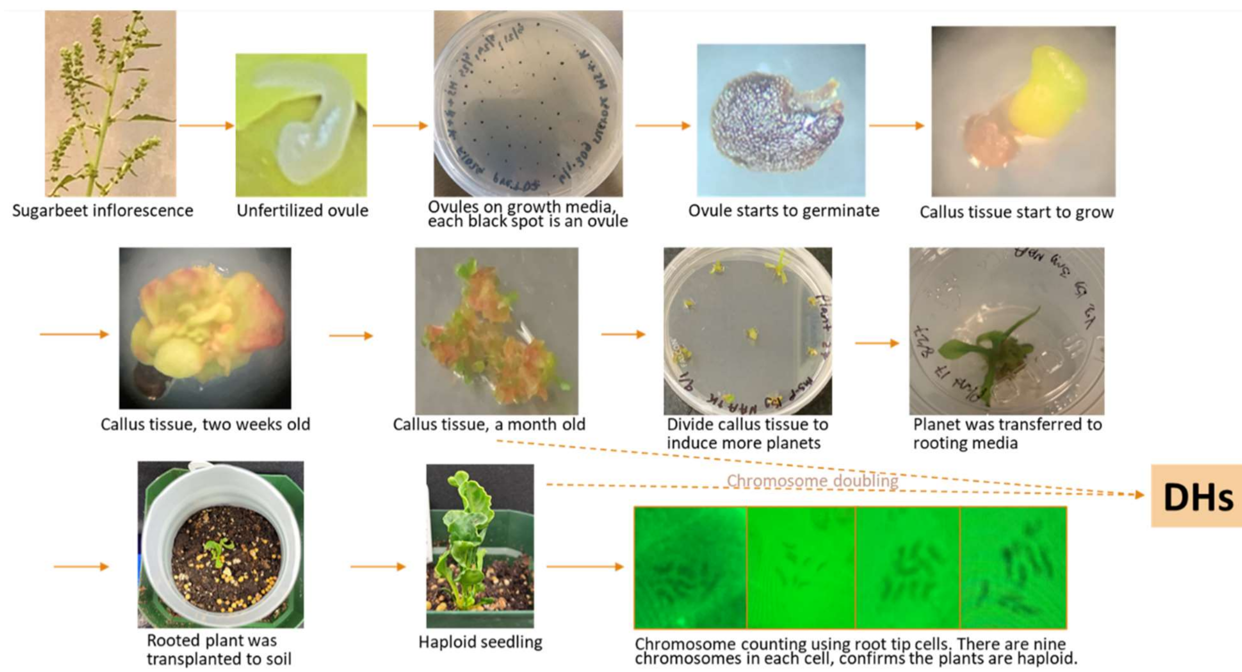


Fig. 5. The procedure of doubled haploid production in sugarbeet by ovule culture. Chromosome counting using root tip cells confirmed the plants regenerated from ovule callus are haploids.

Acknowledgements

Thanks to Dr. Barbara Hellier at the USDA - NPGS in Pullman, WA for providing all germplasms, and Dr. Kevin Dorn at USDA – ARS in Fort Collins, CO for providing help during GBS SNP calling. This research is supported by the Sugarbeet Research and Education Board of Minnesota and North Dakota, the Beet Sugar Development Foundation (BSDF), and the USDA-ARS CRIS project No. 3060-21000-044-000-D. Mention of trade names or commercial

products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the US Department of Agriculture. The US Department of Agriculture is an equal opportunity provider and employer.

References

Abd El-Fataha, B.E.S., M. Hashem, K.A.M. Abo-Elyousr, H.M.M. Khalil Bagy, S.A.M. Alamri. 2020. Genetic and biochemical variations among sugar beet cultivars resistant to Cercospora leaf spot. Physiological and Molecular Plant Pathology. 109:101455.

Hosemans, D., and D. Bossoutrot. 1983. Induction of haploid plants from in vitro culture of unpollinated beet ovules (Beta vulgaris L.). Z Pflanzenzucht. 91:74-77

Leuterbach, M.C., M.J.C. Asher, E. DeAmbrogio, E. Biancardi, P. Stevenato, and L. Frese. 2004. Sources of resistance to diseases of sugar beet in related I germplasm: I. Foliar diseases. Euphytica 139:105-121.

Pazuki, A., F. Aflaki, S. Gürel, A. Ergul, and E. Gürel. 2018. Production of doubled haploids in sugar beet (Beta vulgaris): an efficient method by a multivariate experiment. Plant Cell Tiss Organ Cult 132:85-97.

Smith, G.A., and J.O. Gaskill. 1970. Inheritance of resistance to Cercospora leaf spot in sugar beet. J. Am. Soc. Sugar Beet. 16: 172-180.

Taguchi, K., T. Kubo, H. Takahashi, and H. Abe. 2011. Identification and precise mapping of resistant QTLs of Cercospora Leaf Spot resistance in sugar beet (Beta vulgaris L.). G3. 1:283-291.

Verreet, J.A., P. Wolf, and F.J. Weis. 1996. Threshold values used as a basis for integrated control of Cercospora beticola - the IPS Sugar Beet Model. Proceedings of the IIRB, Vol. 59, pp:55–69.

Vogel, J., C. Kenter, C. Holst, and B. Märländer. 2018. New generation of resistant sugar beet varieties for advanced integrated management of Cercospora leaf spot in central Europe. Front. Plant Sci. 9:222.

EFFICACY OF FUNGICIDES FOR CONTROLLING CERCOSPORA LEAF SPOT ON SUGARBEET

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

[1]Extension Sugarbeet Specialist, North Dakota State University & University of Minnesota
[2]Research Technician, Plant Pathology Department, North Dakota State University

Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola* Sacc., is the most economically damaging foliar disease of sugarbeet in Minnesota and North Dakota. The disease reduces root yield and sucrose concentration and increases impurity concentrations resulting in reduced extractable sucrose and higher processing losses (Smith and Ruppel, 1973; Khan and Smith, 2005). Roots of diseased plants do not store well in storage piles that are processed in a 7 to 9 month period in North Dakota and Minnesota (Smith and Ruppel, 1973). Cercospora leaf spot is managed by integrating the use of tolerant varieties, reducing inoculum by crop rotation and tillage, and fungicide applications (Khan et al; 2007). It is difficult to combine high levels of Cercospora leaf spot resistance with high recoverable sucrose in sugarbeet (Smith and Campbell, 1996). Consequently, commercial varieties generally have only moderate levels of resistance and require fungicide applications to obtain acceptable levels of protection against Cercospora leaf spot (Miller et al., 1994) under moderate and high disease severity.

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

MATERIALS AND METHODS

A field trial was conducted at Foxhome, MN in 2021. The experimental design was a randomized complete block with four replicates. Field plots comprised of six 30-feet long rows spaced 22 inches apart. Plots were planted on 2 May with a variety susceptible to Cercospora Leaf Spot. Seeds were treated with Tachigaren (45 g/kg seed), Poncho Beta and Kabina. Seed spacing within the row was 4.7 inches. Weeds were controlled with herbicide applications (Ethotron @ 6 pt) on 7 May, (Roundup Powermax @ 32 fl oz; Outlook @ 12 fl oz; Stinger @ 3 fl oz; Amsol @ 1%v/v; Interlock @ 4 fl oz per acre) on 26 May and (Roundup Powermax @ 32 fl oz; Outlook @ 12 fl oz; Amsol @ 1% v/v; Interlock @ 4 fl oz per acre) on 16 June as well as hand weeding throughout the summer. Azoxy 2SC (14.3 fl oz per acre) was applied on 28 May Quadris (14.3 fl oz) was applied on 17 June to control *Rhizoctonia solani*. Govern (1 pint per acre) was applied on 3 June to control insects. Plots were inoculated on 30 June with *C. beticola* inoculum.

Fungicide spray treatments were applied with a CO_2 pressurized 4-nozzle boom sprayer with 11002 TT TwinJet nozzles calibrated to deliver 17 gpa of solution at 60 p.s.i pressure to the middle four rows of plots. Most fungicide treatments were initiated on 9 July. Treatments included five fungicide applications on 9 July (application A), 21 July (application B), 3 August (application C), 16 August (application D) and 30 August (application E). Applications that were initiated at row closure were treated starting on 28 June. Treatments were applied at rates indicated in Table 1.

Cercospora leaf spot severity was rated on the leaf spot assessment scale of 1 to 10 (Jones and Windels, 1991). A rating of 1 indicated the presence of 1- 5 spots/leaf or 0.1% disease severity and a rating of 10 indicated 50% or higher disease severity. Cercospora leaf spot severity was assessed five times during the season. The rating performed on 31 August is reported.

Plots were defoliated mechanically and harvested using a mechanical harvester on 29 September. The middle two rows of each plot were harvested and weighed for root yield. Twelve to 15 representative roots from each plot, not including roots on the ends of the plot, were analyzed for quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. The data analysis was performed with the ANOVA procedure of the Agriculture Research Manager, version 2019.4 software package (Gylling Data Management Inc., Brookings, South Dakota). The least significant difference (LSD) test was used to compare treatments when the F-test for treatments was significant.

RESULTS AND DISCUSSIONS

The research site received adequate amounts of rainfall (Figure 1) and heat units resulting in good crop growth and row closure early July. However, there was not much rainfall in July through mid-August and the temperature was high with at least 10 days that reached 90 F (Figure 1 and 2). The hot and dry environment was not favorable for development of *C. beticola*. As such, disease severity ratings done in July and August showed that the disease had not reached economic damaging threshold in the non-treated inoculated check on August 17. However, after about 2 inches of rainfall from August 20 through 28, *C. beticola* developed rapidly resulting in death of the oldest leaves and regrowth in the check.

The high disease severity in the non-treated check, especially during September, resulted in significantly lower tonnage, sugar concentration, and recoverable sucrose per acre compared to all fungicide treatments. Since there were few rainfall events during July and August (Figure 2), all fungicide treatments were effective at significantly reducing disease severity. Treatments where the first fungicide application was made before row closure with subsequent applications at 14-day intervals did not result in any significant improvement in disease control nor recoverable sucrose compared to treatments where the first fungicide application was made at first symptoms and then at 14 day intervals. There were two treatments where no quinone outside inhibitor (QoI) nor demythylation inhibitor (DMI) fungicides were included in the mixtures of the rotation program that resulted in effective control of CLS and high recoverable sucrose. These treatments which comprised mainly of multi-site fungicides may be instrumental in reducing the population of QoI and DMI resistant populations of *C. beticola*.

This research indicated that fungicides should be applied starting promptly at first symptoms of CLS or at disease onset and continued during the season once environmental conditions are favorable for disease development. Each application should comprise of at least two modes of action, and when necessary such as during periods of regular rainfall, spray interval should be reduced from 14 to 12 or 10 days. In 2021, the most critical fungicide mixture applications were those made on or after August 16 when the environment became very favorable for infection and disease development.

General comments for Cercospora leaf spot control in growers' fields in North Dakota and Minnesota <u>where inoculum levels will probably be high in 2020 and CLS tolerant</u> (KWS ratings of 5.2 and less) varieties are grown:
The first fungicide application should be made when disease symptoms are first observed (which entails scouting) or soon after row closure especially if the crop was planted early and environmental conditions were favorable for good crop growth. If the first application is late, control will be difficult all season.
Since the pathogen population is very high, especially from the central Red River Valley going south, fungicide applications should be made at regular intervals (14 or 10 to 12 during periods with more rainfall).
Use mixtures of fungicides that are effective at controlling Cercospora leaf spot in an alternation program.
Use the recommended rates of fungicides to control Cercospora leaf spot.
During periods of regular rainfall, shorten application interval from 14 days to 12 or 10 days; use aerial applicators during periods when wet field conditions prevent the use of ground rigs.
Limit or avoid using fungicides to which the pathogen population has become resistant or less sensitive.
Only one application of a benzimidazole fungicide (such as Topsin M 4.5F) in combination with a protectant fungicide (such as Super Tin). The use of multi-site fungicides such as TPTH, Copper, and EBDCs mixed with a QoI or DMI fungicides will increase the effectiveness of the QoIs and DMIs.
Avoid using fungicides in an area where laboratory testing shows that the fungus has developed resistance or reduced sensitivity to that particular fungicide or particular mode of action.
Use high volumes of water (15 to 20 gpa for ground-rigs and 3 to 5 gpa for aerial application) with fungicides for effective disease control.
Based on the 2022 *C. beticola* population and sensitivity testing, CLS spray applications should start at disease onset just after row closure, or when symptoms are first observed in the field, factory district, sentinel plants or in CLS inoculated trials.
The following fungicides in several classes of chemistry are registered for use in sugarbeet:

<u>Strobilurins</u>	**<u>Sterol Inhibitors</u>**	**<u>Ethylenebisdithiocarbamate (EBDC)</u>**
Gem	Eminent/Minerva	Penncozeb
(Priaxor)	Inspire XT	Manzate
	Proline	Mancozeb
	Revysol	Maneb
	Enable	(Mankocide)
	Topguard	

<u>Benzimidazole</u>	**<u>TriphenylTin Hydroxide (TPTH)</u>**	**<u>Copper</u>**
Topsin	SuperTin	Kocide 2000 and 3000
	AgriTin	Badge SC, Badge X2

ChampION, Champ DP and WG
Cuprofix Ultra 40 Disperss
MasterCop

Products with multiple modes of action include Priaxor, Minerva Duo, Acropolis, Lucento, Mankocide, ProPulse, Delaro, Dexter Max, and Brixen. See publication PP622-20 for more details.

Products within ( ) indicate that they comprise of more than one mode of action.

Table 1. Effect of fungicides on Cercospora leaf spot control and sugarbeet yield and quality at Foxhome, MN in 2021.

Treatment and rate/A	CLS*	Root yield	Sucrose concentration	Recoverable sucrose		Returns**
	1-10	Ton/A	%	lb/Ton	lb/A	$/A
Inspire XT 7 fl oz + Manzate Max 1.6 qt*/Manzate Max 1.6 qt/ Super Tin 8 fl oz + Topsin 20 fl oz/ Proline 5.7 fl oz + NIS 0.125% v/v + Manzate Max 1.6 qt/ Manzate Max 1.6 qt/ Super Tin 8 fl oz + Priaxor 6.7 fl oz**	**3.8**	**42.10**	**17.75**	**328.6**	**13,863**	**2,203**
Inspire XT 7 fl oz + Badge SC 32 fl oz/ Super Tin 8 fl oz + Topsin WSB 10 oz wt/ Proline 5.7 fl oz + Induce 0.125% v/v + Manzate Prostick 2 lb/ Super Tin 8 fl oz + Priaxor 6.7 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt	4.3	40.82	17.71	329.3	13,460	2,155
Provysol 4 fl oz + Induce 0.125% v/v + Manzate Prostick 2 lb/ Super Tin 8 fl oz + Badge SC 32 fl oz/ Proline 5.7 fl oz + Induce 0.125% v/v + Manzate Prostick 2 lb/ Super Tin 8 fl oz + Priaxor 6.7 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt	4.3	43.59	17.20	317.4	13,812	2,118
Manzate Max 1.6 qt + Super Tin 8 fl oz/ Proline 5.7 fl oz + NIS 0.125% v/v + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Badge SC 32 fl oz/ Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Badge SC 32 fl oz	4.8	38.04	18.17	336.8	12,829	2,082
Manzate Max 1.6 qt*/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125% v/v + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt**	**3.8**	**41.15**	**17.56**	**324.6**	**13,396**	**2,076**
Manzate Max 1.6 qt + Badge SC 32 fl oz/ Super Tin 8 fl oz + Badge SC 32 fl oz/ Manzate Max 1.6 qt + Badge SC 32 fl oz/ Super Tin 8 fl oz + Badge SC 32 fl oz/ Manzate Max 1.6 qt + Badge SC 32 fl oz	4.5	37.80	17.96	333.5	12,639	2,072
Manzate Maz 1.6 qt*/ Proline 5.7 fl oz + NIS 0.125% v/v + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Minerva 13 fl oz + Manzate Max 1.6**	**3.5**	**41.34**	**17.44**	**321.7**	**13,322**	**2,050**
Manzate Max 1.6 qt*/Proline 5.7 fl oz + NIS 0.125% v/v + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Provysol 4 fl oz + Manzate Max 1.6**	**4.0**	**38.00**	**17.94**	**331.7**	**12,658**	**1,998**
Regev 8.5 fl oz + Badge SC 32 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Minerva 13 fl oz + Badge SC 32 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125% v/v + Badge SC 32 fl oz	3.8	42.56	16.95	310.2	13,245	1,967

Lucento 5.5 fl oz + Manzate Prostick 2 lb/ Super Tin 8 fl oz + Topsin WSB 10 oz/ Topguard 14 fl oz + Manzate Prostick 2 lb/ Super Tin 8 fl oz + Priaxor 6.7 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt	4.0	39.66	17.29	318.7	12,645	1,966
Manzate Max 1.6 qt + Badge SC 32 fl oz/ Super Tin 8 fl oz + Badge SC 32 fl oz/ Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Badge SC 32 fl oz/ Proline 5.7 fl oz + NIS 0.125% v/v + Manzate Max 1.6 qt	4.5	39.54	17.31	319.1	12,643	1,958
Manzate Max 1.6 qt + Super Tin 8 fl oz/ Minerva 13 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Badge SC 32 fl oz/ Manzate Max 1.6 qt + Inspire XT 7 fl oz/ Manzate Max 1.6 qt + Super Tin 8 fl oz/	4.0	42.83	16.74	307.5	13,152	1,946
Regev 8.5 fl oz + Super Tin 8 fl oz/ Badge SC 32 fl oz + Manzate Max 1.6 qt/ Minerva 13 fl oz + Badge SC 32 fl oz/ Super Tin 8 fl oz +Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125% v/v + Badge SC 32 fl oz	4.5	40.13	16.98	313.9	12,659	1,920
Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Topsin 20 fl oz/ Proline 5.7 fl oz + NIS 0.125% v/v + Manzate Max 1.6 qt/ Manzate Max 1.6 qt/ Super Tin 8 fl oz + Priaxor 6.7 fl oz	**4.5**	**39.46**	**17.16**	**315.6**	**12,507**	**1,909**
Provysol 4 fl oz + Manzate Max 1.6 qt**/ Super Tin 8 fl oz + Topsin 20 fl oz/ Proline 5.7 fl oz + NIS 0.125% v/v + Manzate Max 1.6 qt/ Super Tin 8 fl oz + Priaxor 6.7 fl oz**	**4.8**	**39.31**	**17.02**	**311.5**	**12,249**	**1,857**
Manzate Max 1.6 qt + Badge SC 32 fl oz/ Proline 5.7 fl oz + NIS 0.125% v/v + Manzate Max 1.6 qt/ Manzate Max 1.6 qt + Badge SC 32 fl oz/ Inspire XT 7 fl oz + Manzate Max 1.6 qt/ Manzate Max 1.6 qt + Badge SC 32 fl oz	4.0	36.81	17.33	320.1	11,787	1,826
Regev 8.5 fl oz + Topsin 10 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Minerva 13 fl oz + Badge SC 32 fl oz/ Super Tin 8 fl oz + Manzate Max 1.6 qt/ Proline 5.7 fl oz + NIS 0.125% v/v + Badge SC 32 fl oz	4.3	39.61	16.59	303.8	11,994	1,736
Untreated Check	10.0	31.86	15.07	274.2	8,759	1,253
LSD (P=0.05)	**0.79**	**4.49**	**0.89**	**20.3**	**1,301**	**282**

*Cercospora leaf spot measured on 1-10 scale (1 = 1- 5 spots/leaf or 0.1% severity and 10 = 50% severity) on 10 September.
**Returns based on American Crystal payment system and subtracting fungicide costs and application.
***Treatment started at row closure on 28 June
****Treatment started on 21 July

References

Jones, R. K.., Windels, C. E. 1991. A management model for Cercospora leaf spot of sugarbeets. Minnesota Extension Service. University of Minnesota. AG-FO-5643-E

Khan, J., del Rio, L.E., Nelson, R., Khan, M.F.R. 2007. Improving the Cercospora leaf spot management model for sugar beet in Minnesota and North Dakota. Plant Dis. 91, 1105-1108.

Khan, M.F.R., Smith, L.J. 2005. Evaluating fungicides for controlling Cercospora leaf spot on sugarbeet. J. Crop Prot. 24, 79-86.

Miller, S.S., Rekoske, M., Quinn, A., 1994. Genetic resistance, fungicide protection and variety approval policies for controlling yield losses from Cercospora leaf spot infection. J. Sugar Beet Res. 31, 7-12.

Smith, G.A., Campbell, L.G., 1996. Association between resistance to *Cercospora* and yield in commercial sugarbeet. Plant Breed. 115, 28-32.

Smith, G.A., Ruppel, E.G., 1973. Association of Cercospora leaf spot, gross sugar, percentage sucrose and root weight in sugarbeet. Can. J. Plant Sci. 53, 695-696.

Treatment in purple is based on Minn-Dak Farmers Cooperative recommendation.

Treatments in blue are based on American Crystal Sugar Company recommendation.

Treatments in green are based on Southern Minnesota Beet Sugar Cooperative recommendation.

Figure 1.

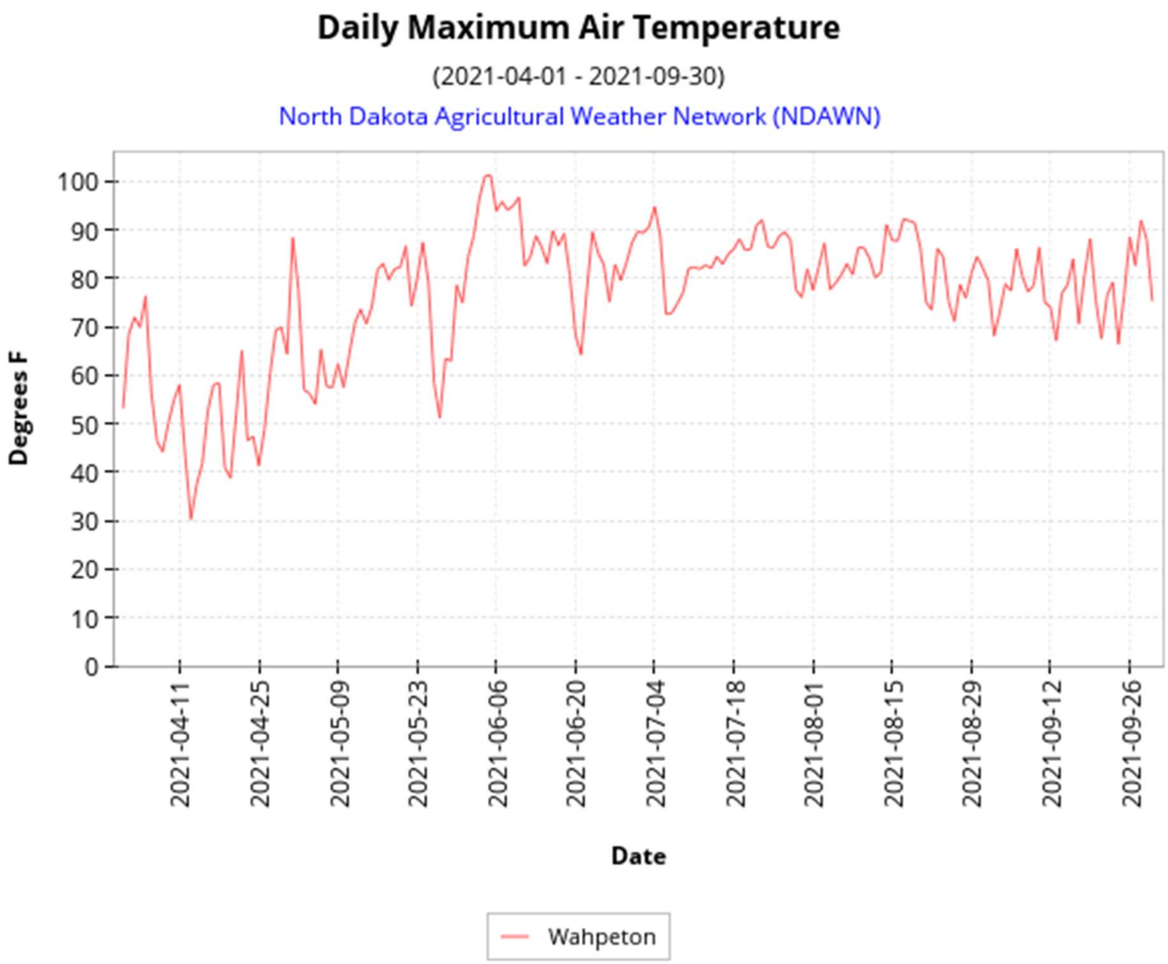
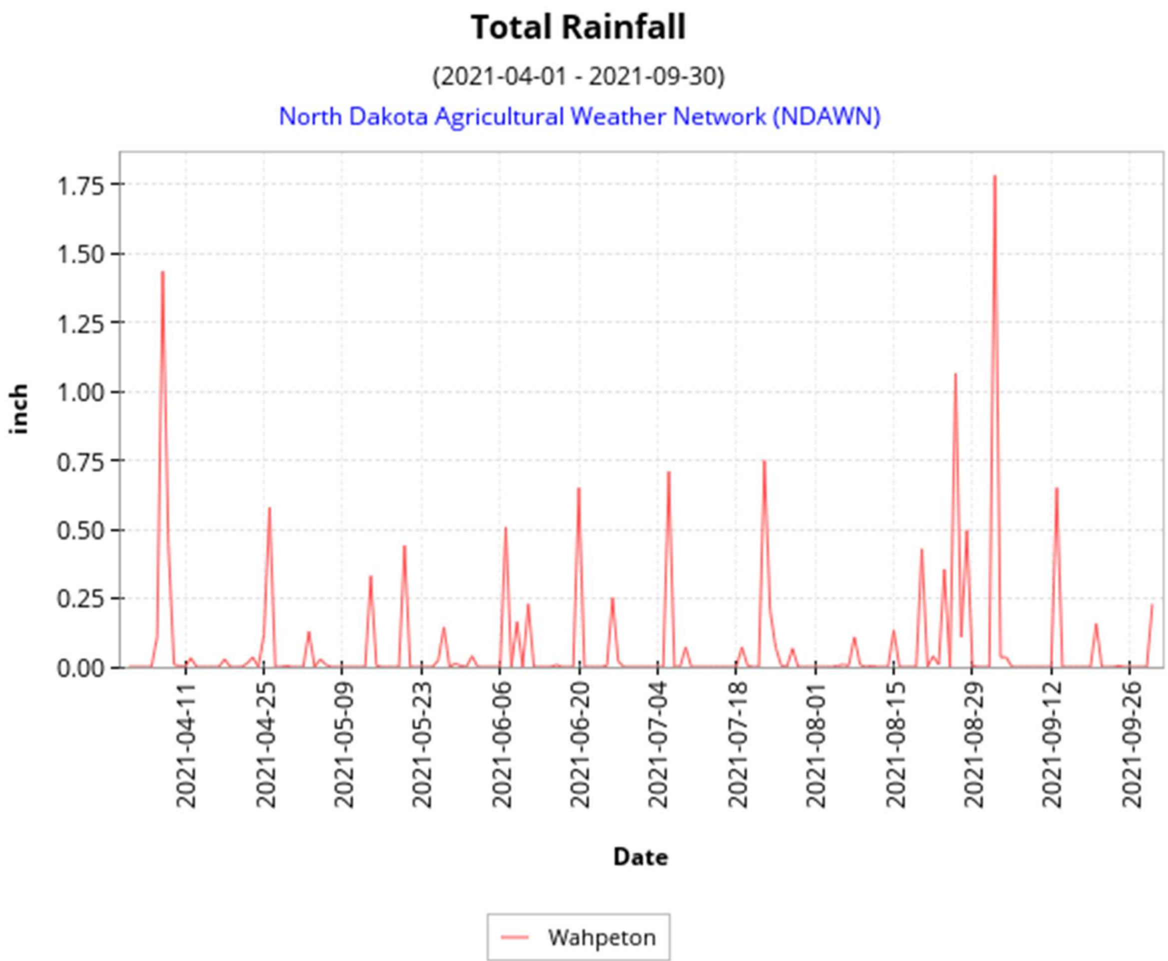


Figure 2.



Total Rainfall
(2021-04-01 - 2021-09-30)
North Dakota Agricultural Weather Network (NDAWN)
inch
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
2021-04-11
2021-04-25
2021-05-09
2021-05-23
2021-06-06
2021-06-20
2021-07-04
2021-07-18
2021-08-01
2021-08-15
2021-08-29
2021-09-12
2021-09-26
Date
Wahpeton

EARLY DETECTION OF CERCOSPORA BETICOLA SPORE PRODUCTION IN COMMERCIAL SUGARBEET FIELDS

Gary Secor[1], Viviana Rivera[1], Nathan Wyatt[2], Melvin Bolton[2]

[1]Department of Plant Pathology, North Dakota State University, Fargo, ND 58108 and [2]USDA-ARS, Edward T. Schafer Agricultural Research Center, Fargo, ND 58102

Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola,* is the most important leaf spot disease of sugar beet and is endemic in sugarbeet fields in the Red River Valley. Severity of CLS varies from year to year and can cause serious economic losses if not managed by crop rotation, cultural practices, resistant cultivars, and application of fungicides. In recent years, fungicides were applied earlier and more often from two to six times per season.

Timing of fungicide applications, especially the first application, is highly variable. First applications are based on calendar, first appearance of disease (first spot in the field) or first observation CLS in the area. Subsequent fungicide applications are based on daily infection values (DIV's) calculated from using relative humidity (RH) and temperature in the field. As DIV's increase, disease favorability increases, and fungicide applications are recommended when a threshold is reached. Two models are most often used for forecasting conditions favorable for CLS infection in the field and subsequent fungicide application: the Shane and Teng model developed in the mid-1980's and BEETcast developed in 2004. Both use weather-based data (RH and temperature) to calculate DIV's to predict field infection by *C. beticola*. Both models monitor conditions favorable for disease development after conidia or disease are detected. The forecasting model does not include conditions favorable for spore production and germination, which may be important and overlooked parts of predicting early infection.

Recent work examining the optimal conditions for *C. beticola* spore germination identified the presence of free water at lengths of time greater-than or equal to 4 hours in vitro. Across all treatments, spore germination was higher when free water was present (95%) compared to 100% RH (30%). Germination begins in two hours at 10°C and increases with time and temperature. Additionally, in 2021 latent *C. beticola* infection was detected in asymptomatic sugarbeets as early as mid-June. Taken together, this new information raises questions regarding early season spore dispersal and early season environmental conditions that may be favorable to *C. beticola* spore germination and the beginning of infection. To address these questions, spore traps were deployed to detect *C. beticola* spores and monitor weather data relevant to disease progression throughout the year.

Objectives

1) To detect and monitor early *C. beticola* spore production in sugar beet fields using spore traps and to correlate spore production with temperature and leaf wetness conditions
2) To detect early season latent infection of sugar beet plants and fungicide resistance profile using PCR testing
3) To monitor the first appearance of CLS in commercial sugar beet fields
4) To correlate spore detection, latent detection and first leaf spot appearance and weather conditions to forecast date of first fungicide application for control of CLS in commercial sugarbeet fields

Materials and Methods

Spore traps (Spornado) and weather stations were installed in six commercial sugarbeet fields at the locations Renville, Oxbow, and Perley. Weather stations were equipped with leaf wetness sensors as earlier work in our lab verified the necessity of free water for spore germination. Spornado filters were collected three times/week from May 3 to August 2 and tested for the presence of *C. beticola* DNA by PCR. From early June to late July of 2021, leaves were sampled from 57 commercial fields in two production areas for the presence of *C. beticola* DNA by PCR. These sites were also monitored for appearance of CLS spots. Weather station data was used to identify likely environmental conditions favorable for *C. beticola* germination by examining patterns of leaf wetness in relation to collected weather data.

Results and Discussion

C. beticola spores were first detected May 3, and detection continued until August 2. *C. beticola* DNA was first detected in asymptomatic sugarbeet leaves in one production area (SMBSC) on June 17 in 12% of the leaf samples and in the second production area (ACSC) on June 14 in 8% of the leaf samples and 16% of the locations sampled. The incidence of *C. beticola* infection by PCR during the sampling period in 2021 ranged from 12% to 77% at SMBSC and 16% to 90% at ACSC. The first CLS spots were observed in the ACSC area on June 29.

Given the early detection of *C. beticola* spores on May 3 and the early detection of *C. beticola* DNA on June 17, weather data from May and June collected at spore trap locations was examined. Each location was equipped with leaf wetness sensors. Average temperatures across all time points surpassed 10°C necessary for the *C. beticola* spore germination initiation. Leaf wetness data corresponding to continuous four-hour windows was extracted from the data and compared to collected weather data. The most closely associated weather phenomena was rainfall and was the best predictor of subsequent leaf wetness for a four hour period. This data however was inconsistent at various location-month combinations (Figures 1-6). The Renville location data showed the best level of prediction for rainfall data and leaf wetness in both May and June with rainfall immediately precluding increases in leaf wetness (Figures 1 and 2). The Oxbow location showed consistent data for the month of June but not May with rainfall data in June predicting increased leaf wetness for continuous four hour periods (Figures 3 and 4). The Perley location was the most unreliable of the three locations with inference related to leaf wetness difficult to make (Figures 5 and 6). Data from the Perley location shows a pattern more indicative of leaf wetness based on a daily cycle. This indicates that there are more factors involved in predicting leaf wetness from weather data.

Based on our data, we suggest that forecasting models be adjusted to recommend fungicide application early in the growing season before CLS is observed. This study also confirms the utility of *C. beticola* spore trapping and PCR detection of infection by *C. beticola* before CLS is observed. It is of note that 2021 was a drought year and we plan to repeat this study in 2022.

Figures

Figure 1: The two panel figure below shows leaf wetness data (top) and rainfall data (bottom) taken on an hourly basis for the month of May at the Renville location. Each point in the top leaf wetness panel shows the relative leaf wetness with brown points representing timepoints belonging to a >4 hour window of time where leaf wetness was elevated. This is a condition for *Cercospora beticola* spore germination. The bottom panel depicts hourly rainfall with blue dots representing rain and black dots representing no rainfall.

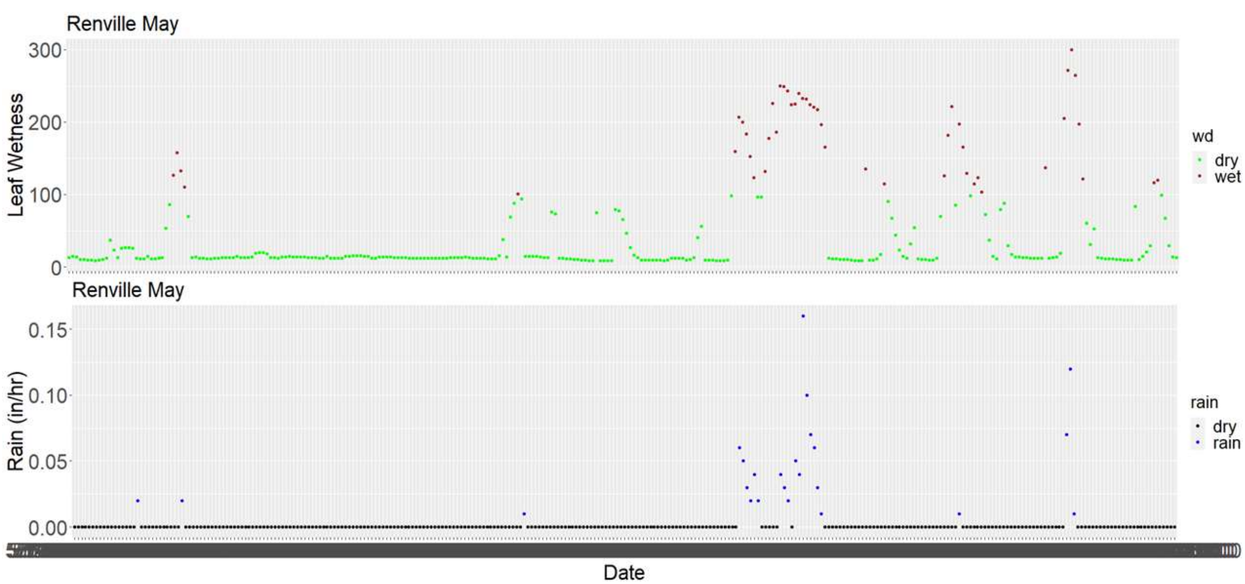


Figure 2: The two-panel figure below shows leaf wetness data (top) and rainfall data (bottom) taken on an hourly basis for the month of June at the Renville location. Each point in the top leaf wetness panel shows the relative leaf wetness with brown points representing timepoints belonging to a >4 hour window of time where leaf wetness was elevated. This is a condition for *Cercospora beticola* spore germination. The bottom panel depicts hourly rainfall with blue dots representing rain and black dots representing no rainfall.

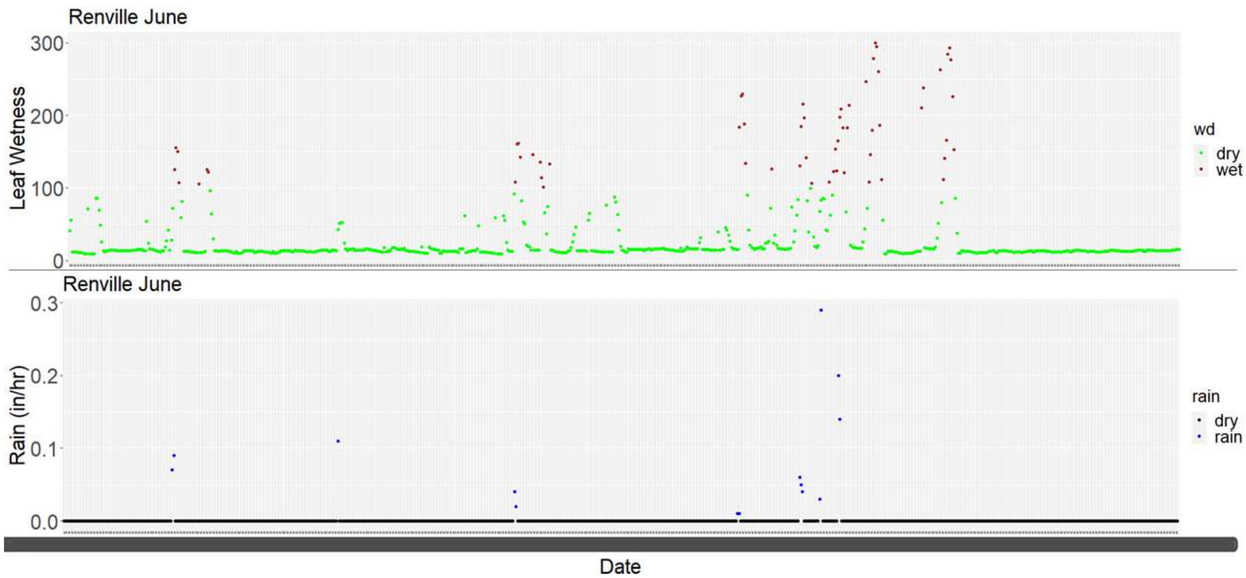


Figure 3: The two-panel figure below shows leaf wetness data (top) and rainfall data (bottom) taken on an hourly basis for the month of May at the Oxbow location. Each point in the top leaf wetness panel shows the relative leaf wetness with brown points representing timepoints belonging to a >4 hour window of time where leaf wetness was elevated. This is a condition for *Cercospora beticola* spore germination. The bottom panel depicts hourly rainfall with blue dots representing rain and black dots representing no rainfall.

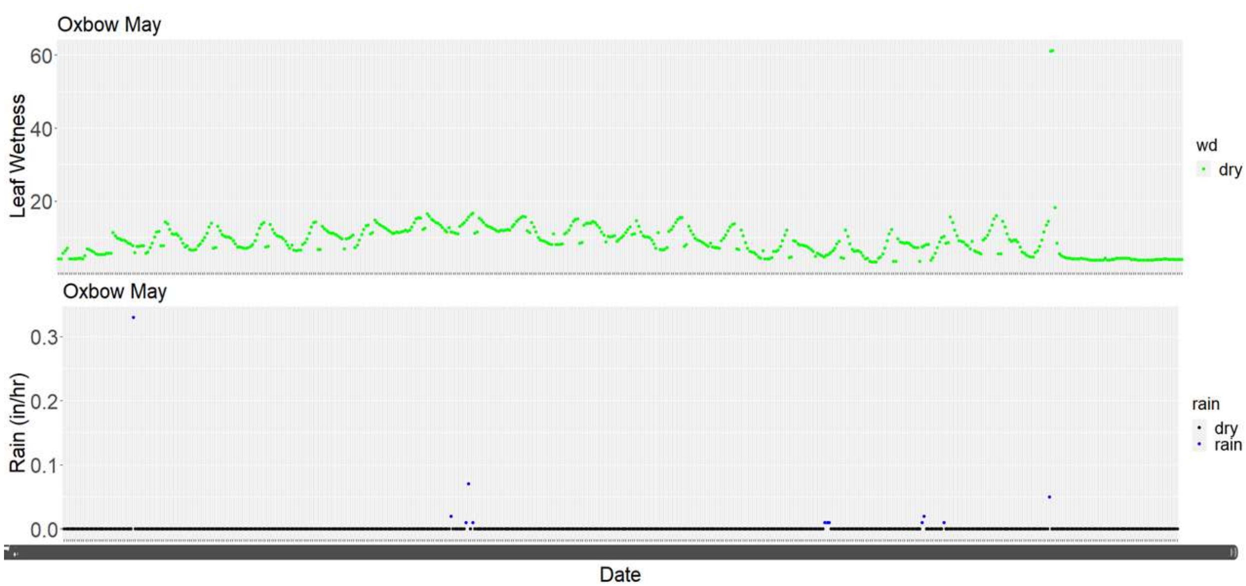


Figure 4: The two-panel figure below shows leaf wetness data (top) and rainfall data (bottom) taken on an hourly basis for the month of June at the Oxbow location. Each point in the top leaf wetness panel shows the relative leaf wetness with brown points representing timepoints belonging to a >4 hour window of time where leaf wetness was elevated. This is a condition for *Cercospora beticola* spore germination. The bottom panel depicts hourly rainfall with blue dots representing rain and black dots representing no rainfall.

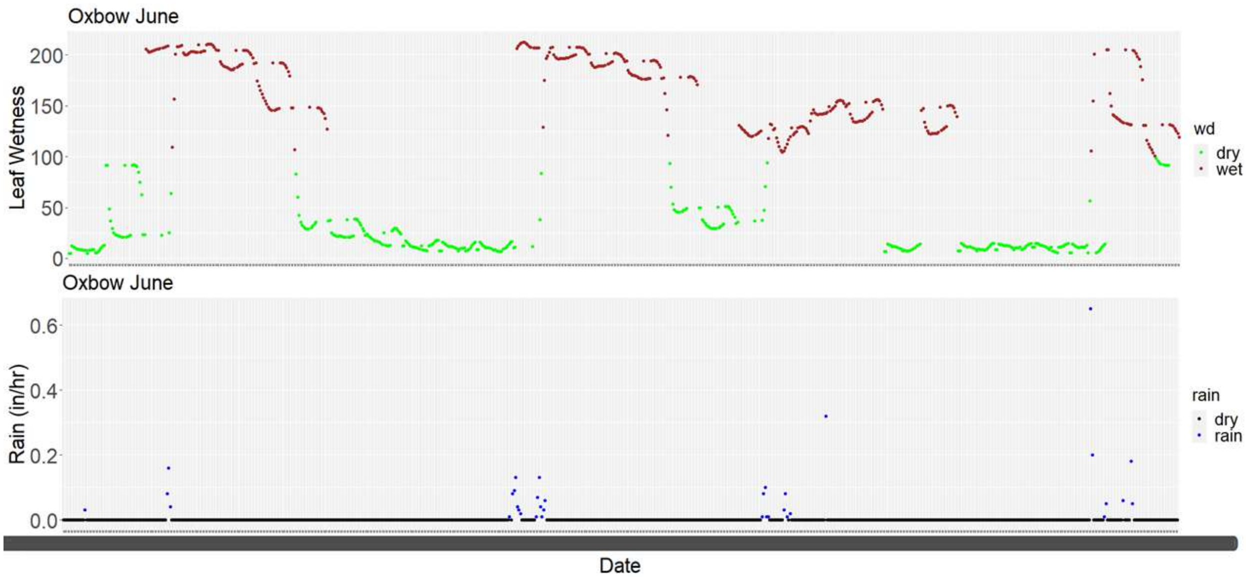


Figure 5: The two-panel figure below shows leaf wetness data (top) and rainfall data (bottom) taken on an hourly basis for the month of May at the Perley location. Each point in the top leaf wetness panel shows the relative leaf wetness with brown points representing timepoints belonging to a >4 hour window of time where leaf wetness was elevated. This is a condition for *Cercospora beticola* spore germination. The bottom panel depicts hourly rainfall with blue dots representing rain and black dots representing no rainfall.

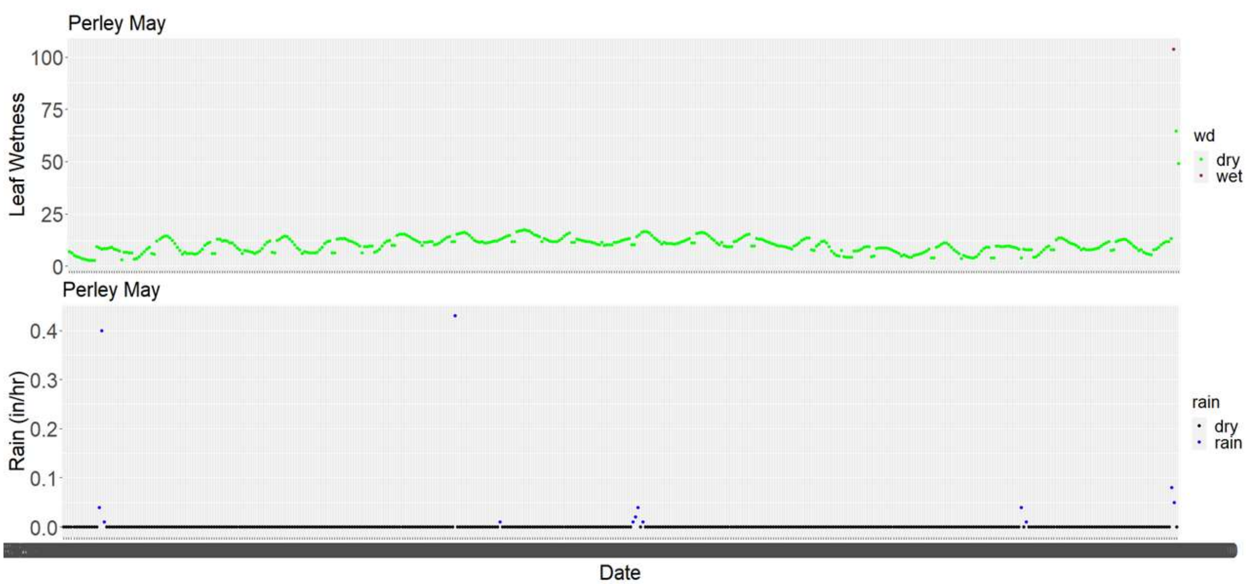
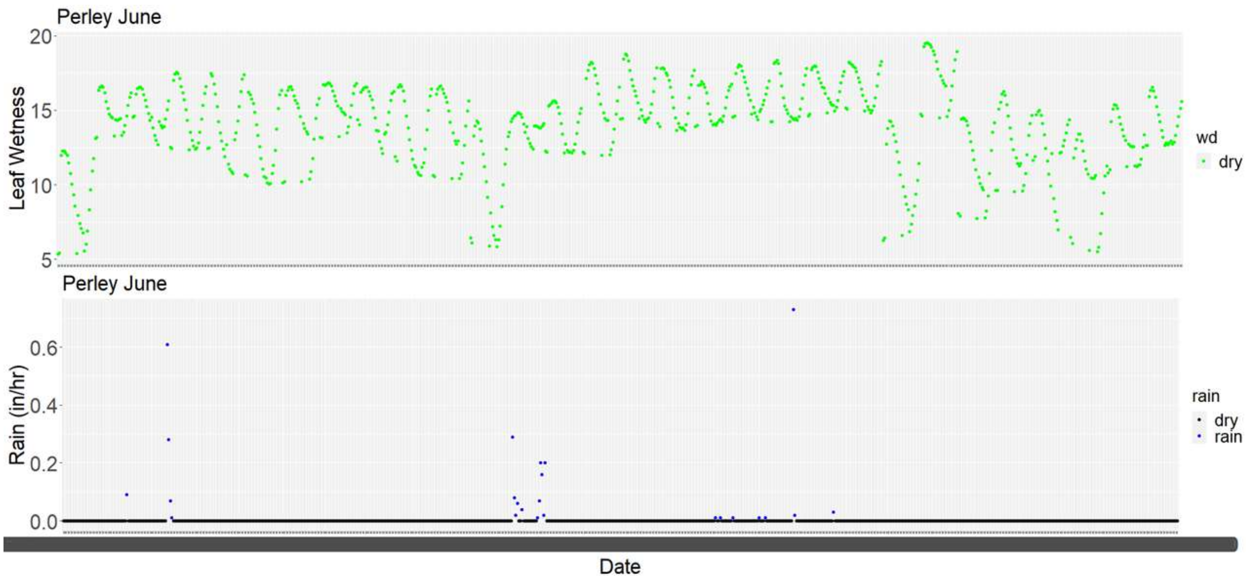


Figure 6: The two-panel figure below shows leaf wetness data (top) and rainfall data (bottom) taken on an hourly basis for the month of June at the Perley location. Each point in the top leaf wetness panel shows the relative leaf wetness with brown points representing timepoints belonging to a >4 hour window of time where leaf wetness was elevated. This is a condition for *Cercospora beticola* spore germination. The bottom panel depicts hourly rainfall with blue dots representing rain and black dots representing no rainfall.


Perley June
20
15
10
5
Leaf Wetness
wd
dry
Perley June
0.6
0.4
0.2
0.0
Rain (in/hr)
rain
dry
rain
Date

SENSITIVITY OF *CERCOSPORA BETICOLA* TO FOLIAR FUNGICIDES IN 2021

Gary Secor[1], Viviana Rivera[1], Melvin Bolton[2]
[1]Department of Plant Pathology, North Dakota State University, Fargo, ND 58108 and [2]USDA-ARS, Edward T. Schafer Agricultural Research Center, Fargo, ND 58102

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 2021, 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 2021, 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 2021, with financial support of the Sugarbeet Research and Extension Board of MN and ND, we tested 592 *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. The numbers were fewer in 2021 due to a shortage of testing materials from our suppoliers. 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 2021, 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=592) 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%) **(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%). 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, and because there is a fitness penalty with tine resistance, resistance will decline as tine usage declines.

DMI (triazoles). Resistance as measured by RF values increased in 2021 for Inspire, Proline Eminent and Provysol (**Figure 3**). Percent of isolates with EC_{50} values >100 ppm were detected for all four 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 5).** 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 2021 (**Figure 6**). Resistance to Headline did not decline in 2021 (**Figure 6**). Resistance was found at high levels in all factory districts, but isolates with the G143A mutatin in the population was lowest in the Minn-Dak factory district (**Figure 7**). The reason for this reduction is not clear, and we need ot monitor this trend, as we do not know if this mutation has the ability to revert to the sensitive wild type or not. We will continue to monitor for resistance to Headline in the RRV production area, particularly because Headline is often the only fungicide used, and is used annually even in the absence of disease. We do not know if there is a fitness penalty associated with the G143A mutation, but based on observation in other locations where QoI resistance due to the G143A mutation is widespread, it appears that isolates with the G143A mutation are stable and remain in the population.

SUMMARY

1. Resistance to Tin at 1.0 µg/ml almost disappeared in our region from 2003-2010, but has increased since 2011, probably due to increased use. Tin resistance declined in 2018 and 2019, but in 2020 and 2021, the number of fields with tin resistance increased by 320% and 144% respectively, and the percentage of spores with resistance/field doubled in 2020 and increased by 144% in 2021. Almost all field have itne 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 2021, as in past years, but there was a reduction in Headline resistance in th e population collected from the Minn-Dak factory district for reasons unknown. These findings precluded the effective use of Headline for CLS management in 2021. Headline is not recommended for CLS management, but can be used for frost protection.

4. We recommend continuing disease control recommendations currently in place including fungicide rotation, using high label rate of fungicides, mixtures with mancozeb or copper, scouting at end of the season to decide the necessity of a late application, using fungicide resistance maps for fungicide selection, using a resistant variety, spray intervals of 14 days, and applying fungicides to insure maximum coverage. Improvements in fungicide coverage using proper spray nozzles and spray parameters such as timing, rate, interval and coverage should be implemented.

New varieties with higher levels of resistance were evaluated in the field with excellent disease resistance profiles. We urge the use of varieties with better CLS resistance. We did not receive enough samples of Cls samples CR+ varieties to evluate the impact of this genetic resistance on fungicide resistance.

Based on our lab observations, we recommend better cultural practices such as earlier fungicide application and destruction of initial inoculum at field edges to provide better disease control that will help with fungicide resistance management in CLS sugarbeet system. Work is ongoing to adjust the forecasting model to include environmental factors affecting spore germination.

Figure 1. Incidence and severity of tin resistance in *C. beticola* isolates collected from sugarbeet fields in ND and MN from 2003 to 2021

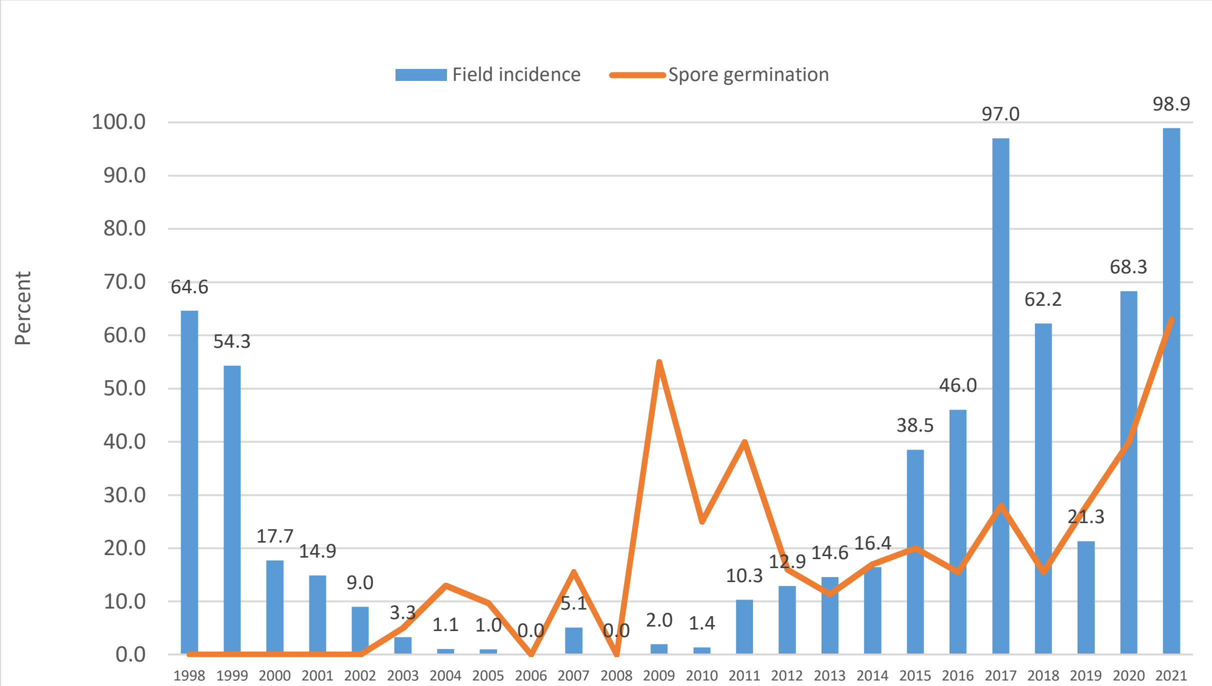


Figure 2. Incidence of fields with *C. beticola* isolates resistant to tin collected in ND and MN from 2018 to 2021 by factory district

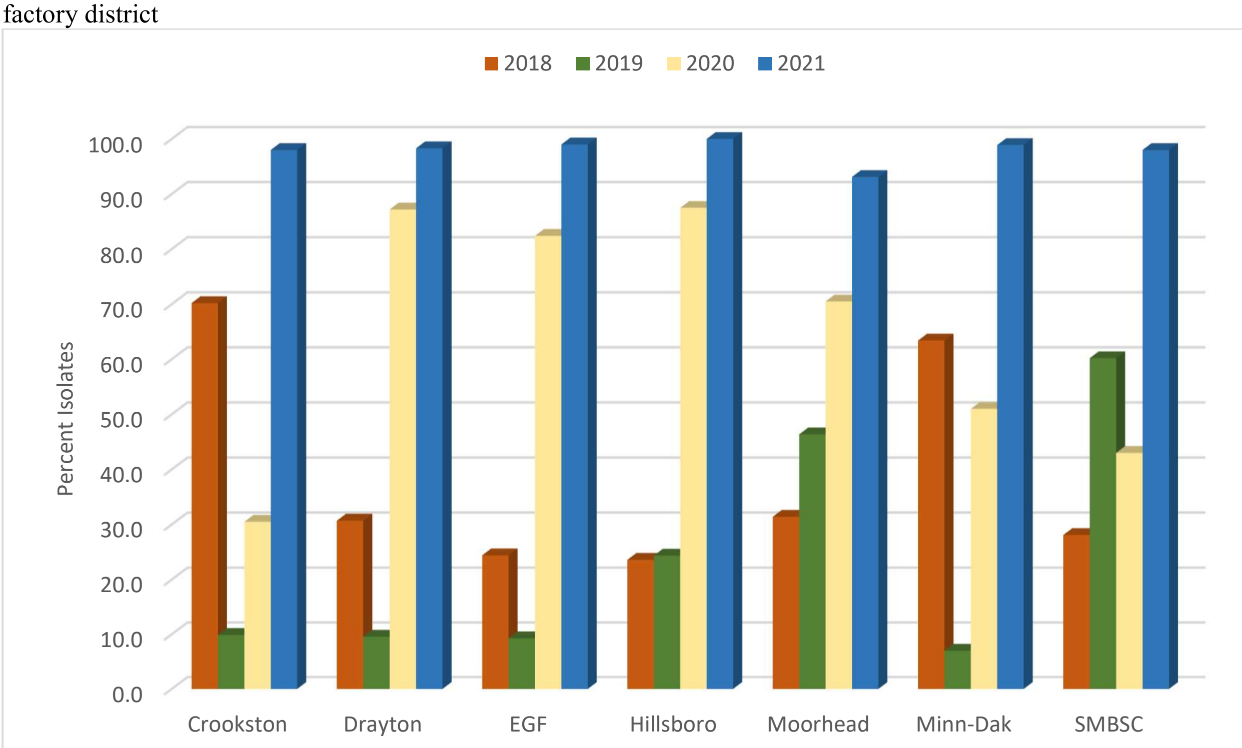


Figure 3. Resistance Factor of C. beticola isolates collected in ND and MN from 2017 to 2021 to Eminent, Inspire, Proline and Provysol

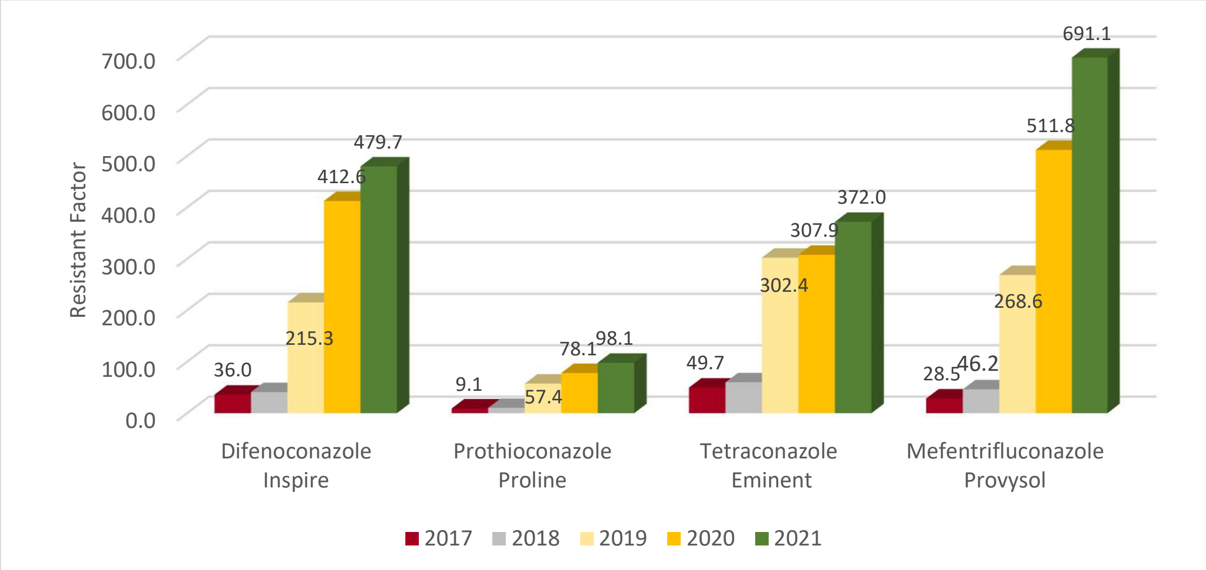


Figure 4. Distribution of sensitivity to Eminent, Inspire, Proline and Provysol of *C. beticola* isolates collected in 2021 as expressed by EC_{50} values

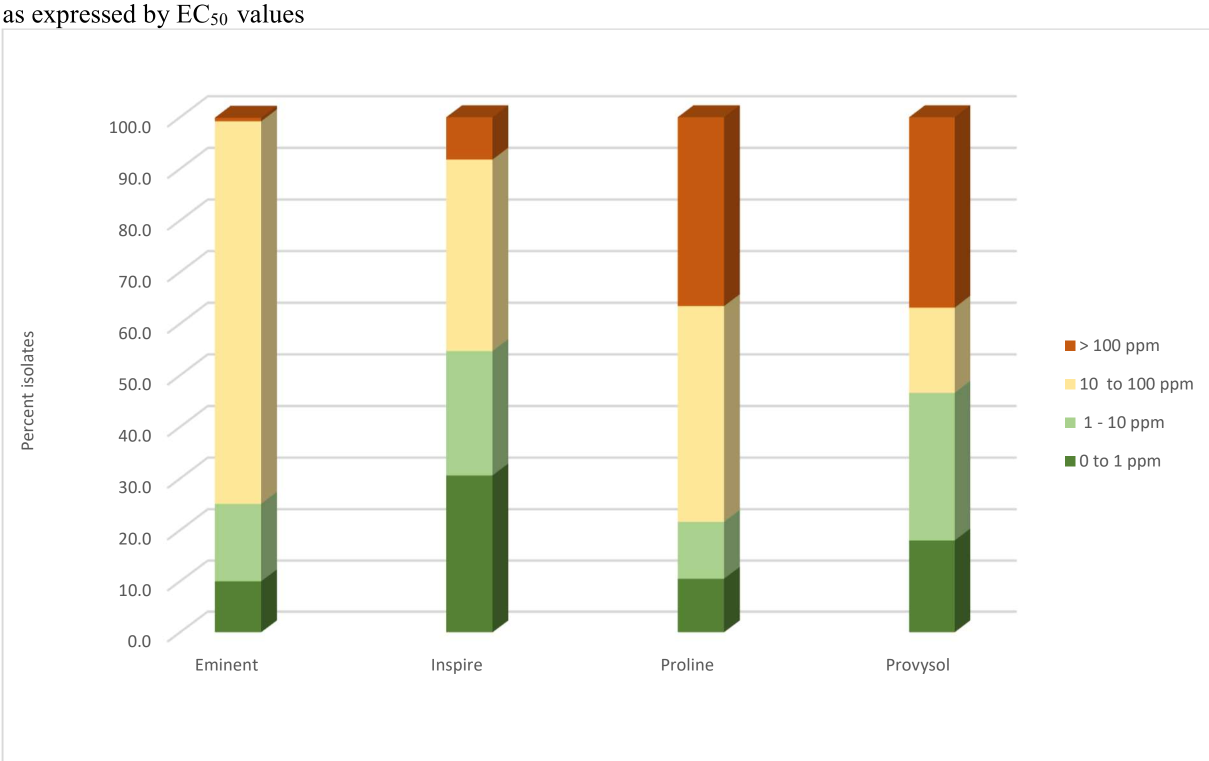


Figure 5. Sensitivity of *C. beticola* isolates collected in 2021 to Eminent, Inspire, Proline and Provysol by factory district as expressed by RF values

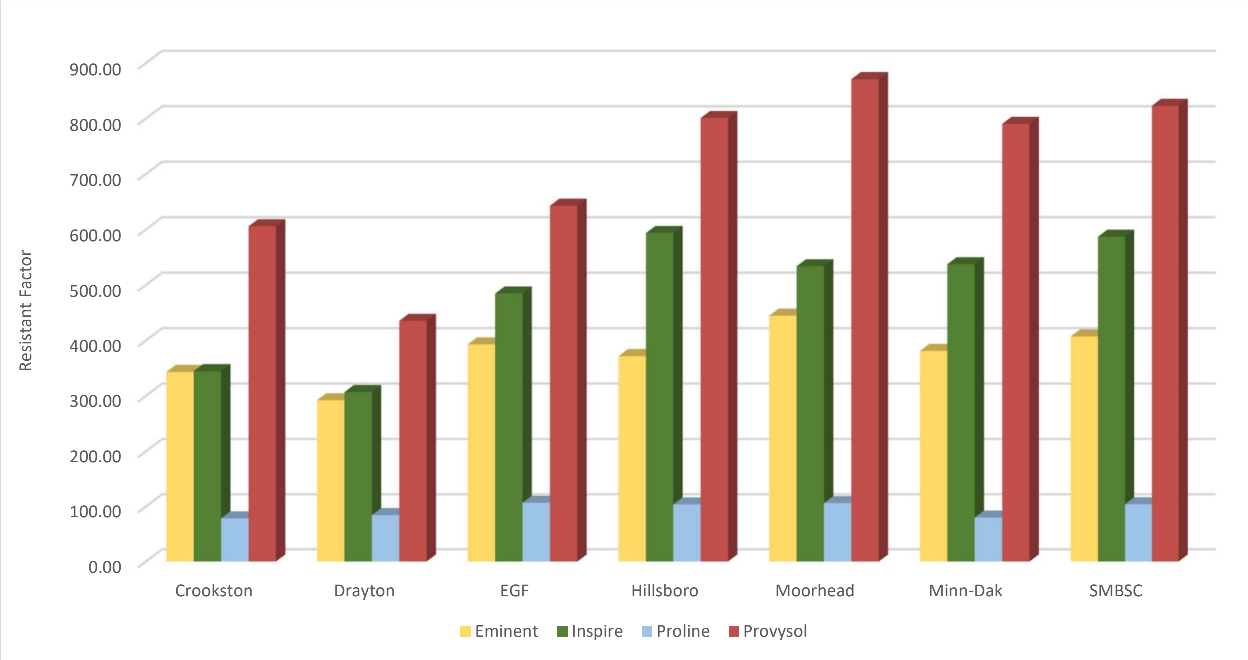


Figure 6. Sensitivity of *C. beticola* isolate populations collected in ND and MN to Headline from 2012 to 2021 as expressed by the percentage of spores with G143A mutation

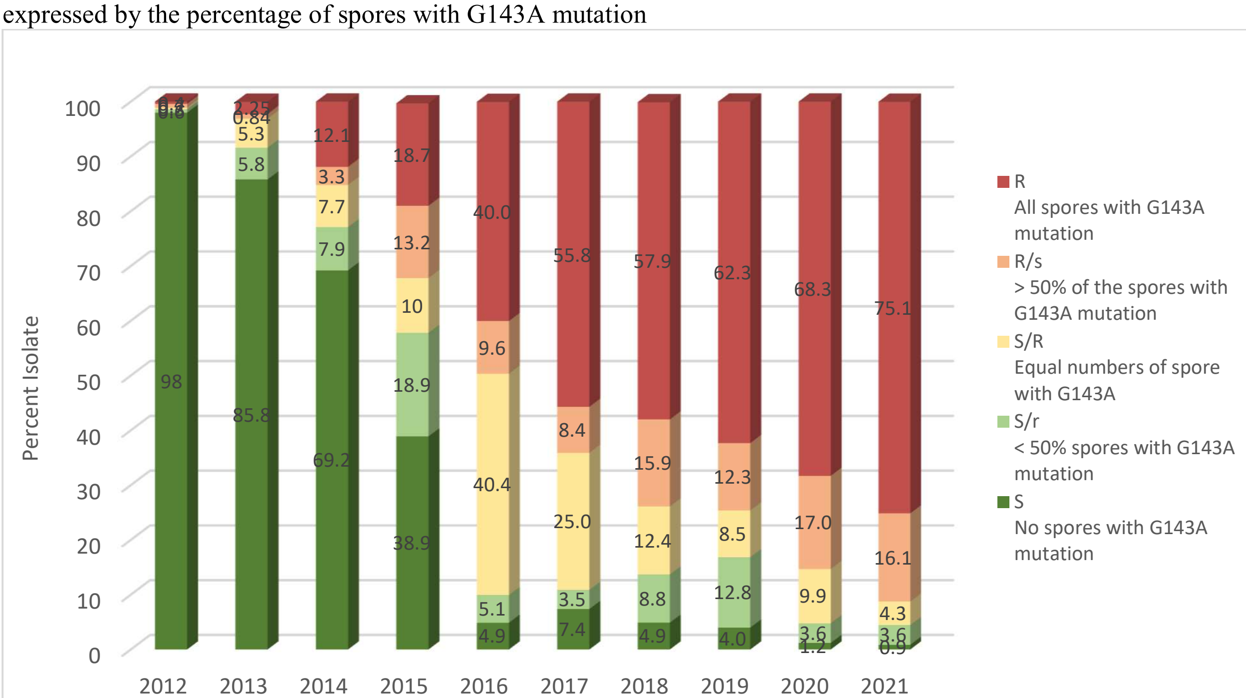
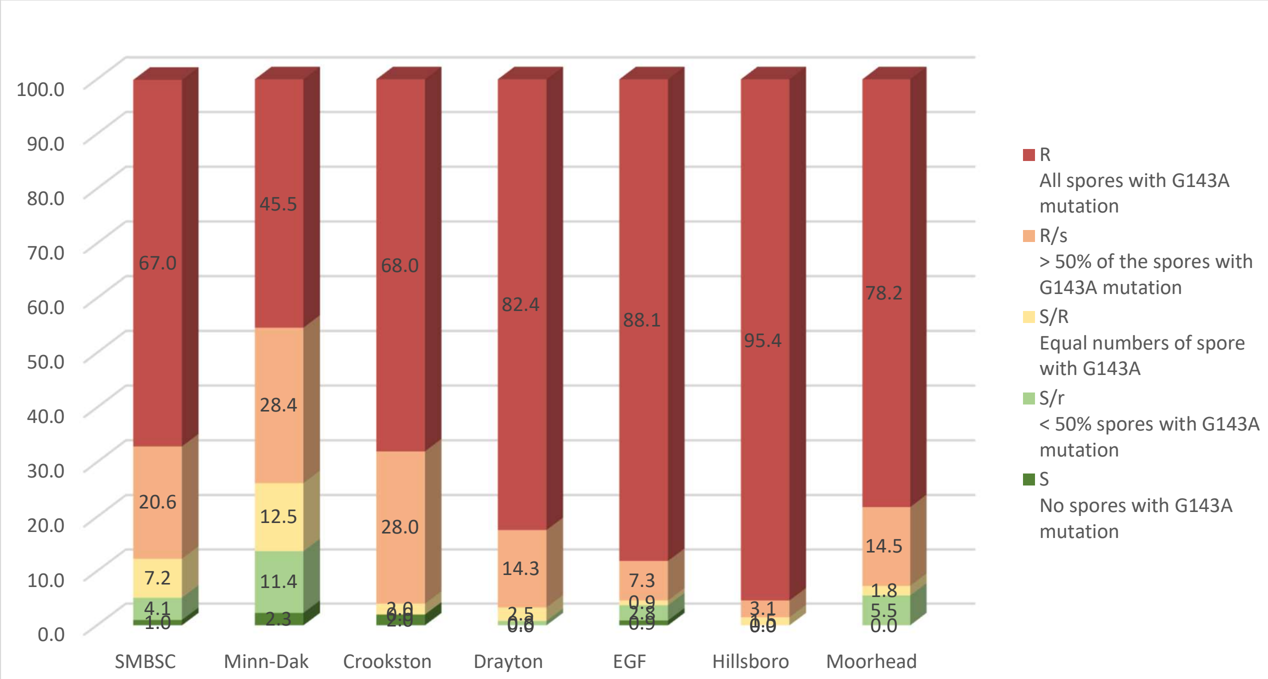


Figure 7. Sensitivity of *C. beticola* isolate populationss collected in ND and MN in 2021 to Headline by factory district as measured by the percentage of spores with G143A mutation



VARIETY TESTING

NOTES

RESULTS OF AMERICAN CRYSTAL SUGAR COMPANY'S 2021 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 2021 American Crystal OVTs and describes the procedures and cultural practices involved in the trials.

Table	Information in the Table
1	ACSC approved varieties for 2022
2	Multi-year performance of approved varieties (all locations combined)
3	Performance of ACSC Aphanomyces specialty varieties
4	Disease ratings for ACSC tested varieties (multiple diseases)
5	Root Aphid Ratings
6	Official trial sites, cooperators, plant and harvest dates, soil types and disease notes
7	Seed treatments applied to seed used in the OVTs
8-19	2021 Roundup Ready variety trials and combined trials
20-23	Approval calculations for ACSC market
24	Aphanomyces disease nursery ratings
25	Cercospora disease nursery ratings
26	Rhizoctonia disease nursery ratings
27	Fusarium disease nursery ratings
28	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 2021 official coded variety performance trials and disease nurseries were planted at 18 sites by American Crystal Sugar Company (ACSC) including 13 yield trial sites and five disease nurseries. Seven additional disease nurseries were planted by third party cooperators. Thanks are extended to the dedicated Technical Services staff involved in the official trial plot care, harvest, and data analysis.

Results from the Official Variety Trial sites were good. Stands in the trials were generally very good this year despite adverse conditions for emergence. Eleven sites were used for variety approval calculations. Two sites were abandoned due to erratic emergence (St. Thomas and Caledonia). Rhizoctonia crown and root rot was minimal in 2021. AZteroid in-furrow, seed treatments, and one application of Quadris were used to control Rhizoctonia. Revenue calculations in 2021 are based on a hypothetical $45.65 payment (5-year rolling average) at 17.5% sugar and 1.5% SLM not considering hauling or production costs.

Fusarium ratings are from one Moorhead site. Rhizoctonia crown and root rot ratings are from two RRV nurseries. Aphanomyces root rot ratings are from the Shakopee, MN nursery with more early-season and less late-season disease pressure. The dry growing season was not conducive for Aphanomyces development, so there are no yield results under Aphanomyces conditions or Aphanomyces ratings from the Red River Valley for 2021. Cercospora leafspot ratings are from Foxhome and Randolph, MN. Root aphid ratings are from a greenhouse assay at Shakopee, MN and a field trial at Longmont, CO. Another set of ratings from a growth chamber assay at Moorhead may be added at a later date.

2021 harvest conditions were excellent. Soil moisture levels remained average to dry throughout the months of August and September creating good harvest conditions in all five Factory Districts.

The 2021 data has been combined with previous years' data and results are enclosed. Bolter data is presented in plants per acre based on 60,000 seeds per acre. Results for the yield trials from individual sites are available on the internet.

In 2021, all commercial and second-year varieties are compared to the same set of benchmarks as 2020. First-year entries are compared to a new set of benchmarks for approval, and that set of benchmarks will stay with those entries through their second year of approval. The only table with the new set of benchmarks and resulting benchmark mean is the projected calculation for first-year entries. When first-year entries are in a larger table that includes commercial and second-year experimental entries, the benchmark means will be for the commercial and second-year entries. As a result, the percent of benchmark for first-year entries in that larger table won't match the percent of benchmarks in the projected calculation for approval of first-year entries table.

Conventional trials were not planted in the 2021 OVT trials. Conventional varieties that were approved for 2020 and 2021 sales are permitted to continue in 2022 sales.

Yield trials were planted to stand at 4.5 inches. Plots were planted crosswise (90°) to the cooperators' normal farming operations, where possible. Plot row lengths for all official trials were maintained at 46 feet with about 39 feet harvested. Planting was performed with a 12-row SRES vacuum planter. The GPS controlled planter gave good single seed spacing which facilitated emergence counting. Seed companies had the option of treating seed with 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 with Event (surfactant) and full rates of fungicides were applied using a pickup sprayer driven down the alleys. Two applications of Roundup were made in the 4-6 (32 oz) and 8-12 (22 oz) leaf stages. Hand weeding was used where necessary. All yield trials were treated with Quadris in a band during the 6-10 leaf stage (14 oz) for Rhizoctonia control. Treatments used for Cercospora control in 2021 included Inspire XT/Manzate Max, Agri Tin/Incognito, Proline/Manzate Max, Manzate Max, and Priaxor/Agri Tin. Ground spraying was conducted by ACSC technical staff using 20 GPA and 75-80 psi.

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, new in 2019) 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, Jamison Bernstein, Heidi Purrington, Alec Deschene, and Nick Weller, 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, Betaseed staff for Aphanomyces and Cercospora nursery data, and KayJay Ag Services for sampling and coding all variety entries.

Table 1.
Varieties Meeting ACSC Approval Criteria for the 2022 Sugarbeet Crop ++

Roundup Ready ®	Full Market	Aph Spec	Rhc Spec	High Rzm
BTS 8629	Yes Yes	Yes New		Hi Rzm Hi
BTS 8882	Yes	Yes		Rzm Hi
BTS 8927	Yes	Yes		Rzm Hi
BTS 8938	Yes	Yes	Yes	Rzm Hi
BTS 8961	New	New		Rzm Hi
BTS 8018	New	New		Rzm Hi
BTS 8034	New	New		Rzm Hi
BTS 8073	New	New		Rzm Hi
BTS 8092			New	Rzm
Crystal 572	Yes Yes	New		Hi Rzm Hi
Crystal 684	Yes Yes	Yes Yes		Rzm Hi
Crystal 793	Yes Yes	Yes Yes		Rzm Hi
Crystal 796	Yes Yes	Yes Yes		Rzm Hi
Crystal 803	New New	Yes		Rzm Hi
Crystal 804	New New	New	Yes Yes	Rzm Hi
Crystal 912	New	New		Rzm Hi
Crystal 913		New	New	Rzm Hi
Crystal 021		New	New	Rzm Hi
Crystal 022		New	New	Rzm Hi
Crystal 025			New	Rzm Hi
Crystal 026				Rzm Hi
Crystal 029				Rzm
Hilleshög HM9528	Yes Yes	Yes		Hi Rzm
Hilleshög HIL9708	Yes Yes	Yes+	Yes	Rzm
Hilleshög HIL9920	New New	Yes Yes		Hi Rzm Hi
Hilleshög HIL2317	New New	New		Rzm Hi
Hilleshög HIL2320				Rzm Hi
Hilleshög HIL2366		New		Rzm Hi
Hilleshög HIL2367				Rzm Hi
Hilleshög HIL2368			New	Rzm
Maribo MA504 Maribo	Yes Yes			Hi Rzm Hi
MA717	Yes	Yes+		Rzm Hi
Maribo MA902				Rzm
SV 265	Yes Yes			Hi Rzm Hi
SV 268	Yes Yes	Yes+		Rzm Hi
SV 285	New	Yes		Rzm Hi
SV 375				Rzm
SV 203		New		
SX 1888	Yes Yes	Yes Yes		Hi Rzm Hi
SX 1898	New	New		Rzm Hi
SX 1804				Rzm

2019 Conventional	Full Market	High Rzm
Crystal R761	Yes	Hi Rzm
Crystal 620	Yes	Hi Rzm
Crystal 840	Yes	Hi Rzm
Crystal 950	Yes	Hi Rzm
Hilleshög HM3035Rz	Yes	Rzm
SX 8869 Cnv	Yes	Hi Rzm
SV 48777	Yes	Hi Rzm

Aph Spec = variety meets Aphanomyces specialty requirements
Rhc Spec = variety meets Rhizoctonia specialty requirements Hi
Rzm = may perform better under severe Rhizomania.
New = newly approved

+ Previously approved Specialty variety not meeting current Specialty approval standards. According to Approval Policy, may be sold as Specialty in 2022
++ Roundup Ready sugarbeets are subject to the ACSC RRSB Bolter Destruction Policy Created 11/11/2021
Roundup Ready ® is a registered trademark of Monsanto Company.

Table 2. Performance Data of RR Varieties During 2020 & 2021 Growing Seasons (All Locations Combined) Approved for Sale to ACSC Growers in 2022 +++

Variety	Yrs Com	Rev/Ton ++ 21	Rev/Ton 2 Yr	Rev/Ton 2Y%	Rev/Acre ++ 21	Rev/Acre 2 Yr	Rev/Acre 2Y%	Rec/Ton 21	Rec/Ton 2 Yr	Rec/Acre 21	Rec/Acre 2 Yr	Sugar 21	Sugar 2 Yr	Yield 21	Yield 2 Yr	Molasses 21	Molasses 2 Yr	Emerg 21	Emerg 2 Yr	Bolter / Ac 21	Bolter / Ac 2 Yr	CR + 21	CR + 2 Yr	Aph Root+ 21	Aph Root+ 2 Yr	Rhizoc.+ 21	Rhizoc.+ 2 Yr	Fusarium+ 21	Fusarium+ 2 Yr	Rzm+
Previous Approved # locations		11	18		11	18		11	18	11	18	11	18	11	18	11	18	11	18	11	18	2	5	1	4	2	4	1	3	
BTS 8629	4	46.49	45.44	92	1590	1498	112	323	320	11076	10571	17.28	17.09	34.4	33.1	1.13	1.08	81	74	0	0	4.78	4.66	4.2	4.1	4.2	4.3	4.2	4.0	Hi
BTS 8882	2	46.33	44.99	91	1554	1468	110	322	319	10856	10419	17.34	17.07	33.8	32.8	1.22	1.14	81	77	0	0	4.92	4.81	3.2	3.8	4.3	4.3	3.2	2.7	Hi
BTS 8927	1	52.48	52.78	107	1572	1527	115	343	346	10313	10017	18.21	18.25	30.2	29.1	1.04	0.97	70	74	0	0	4.48	4.45	4.5	4.2	3.7	4.0	4.0	3.3	Hi
BTS 8938	1	49.53	48.64	99	1574	1492	112	333	331	10608	10154	17.76	17.60	31.9	30.7	1.10	1.04	68	67	0	0	4.71	4.68	4.1	4.0	3.8	3.9	4.5	4.1	Hi
BTS 8961	1	48.14	46.82	95	1556	1485	111	329	325	10652	10321	17.60	17.36	32.5	31.8	1.17	1.11	77	75	0	0	4.53	4.61	4.8	4.4	3.7	3.9	3.3	2.8	Hi
Crystal 572	5	50.88	50.94	103	1530	1468	110	338	339	10200	9794	18.02	18.02	30.3	29.0	1.13	1.06	81	77	3	1	4.75	4.61	4.5	4.4	3.9	4.0	3.3	2.9	Hi
Crystal 684	3	45.89	45.04	91	1533	1483	111	321	319	10770	10527	17.25	17.08	33.7	33.1	1.21	1.14	80	77	0	0	4.54	4.49	3.6	3.8	3.8	4.0	2.8	2.5	Hi
Crystal 793	3	51.29	50.39	102	1625	1570	118	339	337	10805	10529	18.04	17.87	32.0	31.3	1.08	1.01	80	75	0	0	4.13	4.22	3.7	3.8	4.4	4.6	2.8	2.7	Hi
Crystal 796	2	48.03	46.83	95	1578	1475	111	328	325	10820	10247	17.59	17.37	33.1	31.6	1.18	1.12	82	78	0	0	4.98	4.96	4.7	4.3	4.1	4.3	3.0	2.6	Hi
Crystal 803	1	50.56	49.79	101	1597	1521	114	337	335	10672	10242	17.97	17.80	31.8	30.6	1.13	1.04	81	79	3	1	3.86	3.89	3.9	3.9	4.4	4.7	3.5	3.0	Hi
Crystal 804	1	47.03	44.99	91	1591	1487	112	325	319	11041	10555	17.39	17.06	34.2	33.2	1.15	1.13	79	72	0	0	4.68	4.72	3.4	3.5	3.8	3.8	2.8	2.6	Hi
Crystal 912	NC	48.05	46.96	95	1665	1593	120	328	325	11422	11074	17.54	17.33	35.0	34.1	1.13	1.06	79	77	0	0	5.13	4.94	4.0	3.8	3.8	3.7	4.1	3.9	Hi
Crystal 913	1	51.35	50.08	101	1579	1534	115	340	336	10493	10322	18.05	17.83	31.1	30.8	1.08	1.03	78	76	0	0	4.10	4.12	4.4	4.1	3.9	4.3	3.7	3.1	Hi
Hilleshög HIL2317	1	49.88	49.56	100	1451	1418	106	335	334	9750	9589	17.84	17.76	29.2	28.7	1.12	1.05	75	73	0	0	4.57	4.81	5.0	4.4	4.8	4.9	6.1	6.0	Hi
Hilleshög HIL9528	6	45.74	45.94	93	1392	1377	103	320	322	9741	9659	17.14	17.18	30.4	30.0	1.13	1.08	75	72	0	0	4.52	4.68	5.5	4.6	4.5	4.5	4.9	4.8	Hi
Hilleshög HIL9708	4	47.67	47.83	97	1402	1386	104	327	328	9647	9534	17.45	17.47	29.6	29.1	1.11	1.05	79	76	0	0	4.65	4.81	6.3	5.1	3.8	3.8	4.8	4.2	Rzm
Hilleshög HIL9920	3	50.17	49.57	100	1497	1448	109	335	334	10041	9787	17.91	17.78	30.0	29.3	1.14	1.06	76	73	0	0	4.75	4.78	4.6	4.1	4.7	4.9	5.5	5.9	Hi
Maribo MA504	5	45.75	45.09	91	1401	1385	104	320	319	9831	9809	17.20	17.04	30.8	30.8	1.18	1.09	79	75	0	0	5.07	5.21	7.0	6.0	4.9	4.9	4.8	4.5	Hi
Maribo MA717	3	44.88	46.29	94	1414	1434	108	317	323	10012	10033	17.03	17.25	31.6	31.1	1.16	1.10	74	74	0	0	4.68	4.89	6.7	5.3	4.3	4.5	5.1	4.9	Hi
Maribo MA902	1	47.68	48.23	98	1427	1410	106	327	330	9808	9658	17.47	17.54	30.1	29.3	1.12	1.05	84	78	0	0	4.63	4.80	7.0	5.5	3.8	3.9	4.5	4.3	Hi
SV 265	4	47.66	48.17	98	1416	1406	106	327	330	9725	9624	17.42	17.50	29.8	29.2	1.07	1.02	76	72	0	0	4.30	4.42	4.9	4.5	4.2	4.2	5.7	5.7	Hi
SV 268	4	49.52	48.52	98	1552	1435	108	333	331	10462	9778	17.79	17.61	31.5	29.6	1.13	1.07	82	74	0	0	5.18	4.98	4.9	4.7	4.4	4.8	6.2	5.1	Hi
SV 285	1	50.28	49.94	101	1524	1449	109	336	336	10211	9737	17.90	17.82	30.5	29.0	1.11	1.04	82	73	0	0	4.78	4.64	4.5	4.4	4.3	4.1	6.3	5.8	Hi
SV 375	2	50.43	48.86	99	1541	1447	109	336	332	10313	9853	17.91	17.64	30.8	29.8	1.09	1.04	81	72	0	2	4.71	4.74	4.8	4.4	4.2	4.4	5.9	5.6	Hi
SX 1888	2	47.99	47.69	97	1434	1390	104	328	328	9829	9577	17.57	17.49	30.0	29.3	1.17	1.09	76	69	0	2	5.03	4.85	4.1	4.1	4.3	4.2	5.7	5.6	Hi
SX 1898	1	50.21	50.12	102	1479	1494	112	336	336	9932	10065	17.91	17.86	29.8	30.0	1.13	1.04	77	75	0	0	4.76	4.74	5.0	4.4	4.3	4.2	5.7	5.5	Hi
Newly Approved																														
BTS 8018	NC	50.94	49.87	101	1622	1562	117	338	335	10817	10514	17.97	17.78	32.2	31.4	1.08	1.01	83	79	0	6	2.31	2.36	4.5	4.2	3.8	4.0	3.2	2.8	Hi
BTS 8034	NC	46.59	46.89	95	1587	1561	117	323	325	11041	10828	17.34	17.37	34.3	33.3	1.17	1.10	83	81	0	0	2.56	2.63	3.2	3.8	3.9	4.2	2.7	2.5	Hi
BTS 8073	NC	49.30	49.63	101	1533	1535	115	332	335	10393	10382	17.76	17.77	31.4	31.1	1.14	1.05	80	76	0	0	4.56	4.62	4.3	3.9	3.7	3.9	3.6	3.1	Hi
BTS 8092	NC	49.22	48.57	98	1611	1543	116	332	331	10914	10529	17.67	17.54	33.0	31.9	1.07	1.00	80	75	0	0	4.62	4.44	4.1	4.0	3.8	3.8	4.1	3.9	Hi
Crystal 021	NC	48.59	47.78	97	1620	1554	117	330	328	11043	10693	17.64	17.47	33.6	32.6	1.14	1.06	76	71	0	0	2.28	2.24	4.2	3.8	3.4	3.6	4.2	3.5	Hi
Crystal 022	NC	51.73	52.52	106	1543	1539	116	341	345	10221	10134	18.12	18.22	30.2	29.5	1.08	0.99	79	75	0	0	4.97	4.84	4.8	4.3	3.5	3.5	3.5	3.1	Hi
Crystal 025	NC	49.52	49.15	100	1531	1488	112	333	333	10368	10122	17.82	17.73	31.3	30.5	1.16	1.08	76	71	8	4	4.84	4.70	3.5	3.5	3.8	3.7	2.4	2.5	Hi
Crystal 026	NC	47.97	47.84	97	1602	1546	116	328	329	10971	10625	17.61	17.53	33.6	32.4	1.21	1.10	81	77	0	0	4.43	4.60	3.7	3.7	3.3	3.5	2.8	2.6	Hi
Crystal 029	NC	50.24	49.65	101	1512	1494	112	336	335	10162	10107	17.90	17.79	30.5	30.3	1.13	1.06	83	78	0	0	4.59	4.63	4.3	3.9	3.9	4.1	2.9	2.7	Hi
Hilleshög HIL2320	NC	46.93	47.95	97	1411	1439	108	324	329	9781	9899	17.40	17.54	30.2	30.2	1.19	1.10	82	77	0	0	4.78	4.94	4.7	4.1	3.8	4.2	4.5	4.5	Hi
Hilleshög HIL2366	NC	48.97	48.21	98	1481	1432	107	331	330	10032	9813	17.68	17.54	30.3	29.8	1.12	1.05	85	82	0	0	5.01	4.98	5.8	4.8	4.0	4.1	4.6	4.6	Hi
Hilleshög HIL2367	NC	47.80	48.58	98	1443	1441	108	327	331	9901	9846	17.55	17.64	30.3	29.8	1.19	1.10	82	76	0	0	4.75	4.92	5.1	4.3	4.1	4.2	4.3	4.4	Hi
Hilleshög HIL2368	NC	50.84	51.61	105	1339	1320	99	338	341	8924	8761	18.02	18.13	26.5	25.7	1.15	1.06	82	77	0	0	4.66	4.67	5.3	4.5	2.9	3.2	4.4	4.1	Hi
SV 203	NC	50.87	49.93	101	1478	1472	110	338	336	9853	9918	18.00	17.84	29.3	29.6	1.11	1.05	78	71	0	0	4.75	4.89	4.3	4.3	4.3	4.3	6.0	5.6	Hi
SX 1804	NC	49.88	48.91	99	1512	1453	109	334	332	10164	9894	17.83	17.66	30.5	29.9	1.12	1.06	80	75	0	0	4.80	4.78	4.1	4.0	4.2	4.3	5.4	5.5	Hi
Benchmark var. mean		49.65	49.36		1403	1333		334	334	9475	9038	17.89	17.80	28.6	27.2	1.21	1.12	78	73											

2 Yr is mean of 2 years data, 2 Y% is 2-Yr mean as % of benchmark varieties. Emergence is % of planted seeds producing a 4 leaf beet. Created 11/10/2021

++2021 Revenue estimate based on a $45.65 beet payment (5-yr ave) at 17.5% crop with a 1.5% loss to molasses and 2020 Revenue estimate based on a $45.12 beet payment. Revenue does not consider hauling or production costs.

+ Aph ratings from RRV & Shakopee (res.<4.4, susc>5.0). CR from Randolph MN, Foxhome MN & Michigan (res.<4.4, susc>5.0). Fusarium from RRV (res.<3.0, susc>5.0). Rhizoc. from Mhd (res.<3.8, susc>5). Hi may perform better under severe Rzm.

Bolters /Ac are based upon a plant stand of 60,000. +++2020 Sites include Casselton, Glyndon, Ada, Grand Forks, Scandia, E Grand Forks and Bathgate

+++2021 Sites include Casselton, Glyndon, Georgetown, Hendrum, Hillsboro, Grand Forks, Scandia, Climax, Forest River, Hallock and Bathgate

Table 3. Performance Data of RR Varieties - Under Aphanomyces Conditions (Relative to Susceptible Checks) approved for 2022 Growing Season +++

	Years	Rev/Ton			Rev/Acre			Rec/Ton		Rec/Acre		Sugar		Yield		CR Rating +		Aph Root +		Fusarium +		Rhizoctonia +	Description Comm
		2021#	2020	%Sus	2021#	2020	%Sus	2021#	2020	2021#	2020	2021#	2020	2021#	2020	21	2Yr	21	2 Yr	21	2Yr	21	2Yr
# of locations		0	2	2	0	2	2	0	2	0	2	0	2	0	2	2	5	3	4	1	3	2	4
Previously Approved																							
BTS 8629	4	--	32.72	106	--	789	134	--	276.5	--	6493	--	15.03	--	23.1	4.78	4.66	4.2	4.1	4.2	4.0	4.2	4.3
BTS 8882	2	--	32.66	106	--	772	131	--	276.3	--	6407	--	15.02	--	22.9	4.92	4.81	3.2	3.8	3.2	2.7	4.3	4.3
BTS 8927	1	--	43.12	140	--	985	167	--	312.6	--	7070	--	16.58	--	22.4	4.48	4.45	4.5	4.2	4.0	3.3	3.7	4.0
BTS 8938	1	--	37.24	121	--	848	144	--	292.4	--	6467	--	15.70	--	21.6	4.71	4.68	4.1	4.0	4.5	4.1	3.8	3.9
BTS 8961	1	--	36.54	119	--	835	142	--	290.0	--	6478	--	15.64	--	22.0	4.53	4.61	4.8	4.4	3.3	2.8	3.7	3.9
Crystal 572	5	--	38.70	126	--	786	133	--	297.5	--	5929	--	15.99	--	19.6	4.75	4.61	4.5	4.4	3.3	2.9	3.9	4.0
Crystal 684	3	--	32.62	106	--	799	136	--	276.2	--	6622	--	14.93	--	23.6	4.54	4.49	3.6	3.8	2.8	2.5	3.8	4.0
Crystal 793	3	--	37.97	123	--	886	150	--	294.9	--	6732	--	15.80	--	22.4	4.13	4.22	3.7	3.8	2.8	2.7	4.4	4.6
Crystal 796	2	--	36.17	117	--	795	135	--	288.6	--	6223	--	15.55	--	21.2	4.98	4.96	4.7	4.3	3.0	2.6	4.1	4.3
Crystal 803	1	--	39.43	128	--	908	154	--	299.9	--	6793	--	16.03	--	22.3	3.86	3.89	3.9	3.9	3.5	3.0	4.4	4.7
Crystal 804	1	--	33.22	108	--	864	147	--	278.7	--	7144	--	15.14	--	25.4	4.68	4.72	3.4	3.5	2.8	2.6	3.8	3.8
Crystal 912	NC	--	35.21	114	--	886	150	--	285.5	--	7041	--	15.44	--	24.4	5.13	4.94	4.0	3.8	4.1	3.9	3.8	3.7
Crystal 913	1	--	39.55	128	--	951	161	--	300.2	--	7129	--	16.06	--	23.5	4.10	4.12	4.4	4.1	3.7	3.1	3.9	4.3
Hilleshög HIL2317	1	--	36.66	119	--	741	126	--	290.5	--	5836	--	15.50	--	20.0	4.57	4.81	5.0	4.4	6.1	6.0	4.8	4.9
Hilleshög HIL9528	6	--	36.06	117	--	720	122	--	288.2	--	5703	--	15.42	--	19.6	4.52	4.68	5.5	4.6	4.9	4.8	4.5	4.5
Hilleshög HIL9708	4	--	34.56	112	--	644	109	--	283.0	--	5192	--	15.19	--	18.1	4.65	4.81	6.3	5.1	4.8	4.2	3.8	3.8
Hilleshög HIL9920	3	--	35.57	115	--	706	120	--	286.5	--	5606	--	15.37	--	19.3	4.75	4.78	4.6	4.1	5.5	5.9	4.7	4.9
Maribo MA504	5	--	31.25	101	--	565	96	--	271.4	--	4779	--	14.65	--	17.3	5.07	5.21	7.0	6.0	4.8	4.5	4.9	4.9
Maribo MA717	3	--	34.86	113	--	731	124	--	284.0	--	5834	--	15.24	--	20.2	4.68	4.89	6.7	5.3	5.1	4.9	4.3	4.5
Maribo MA902	1	--	37.28	121	--	652	111	--	292.5	--	5126	--	15.61	--	17.6	4.63	4.80	7.0	5.5	4.5	4.3	3.8	3.9
SV 265	4	--	37.96	123	--	839	142	--	294.9	--	6388	--	15.77	--	21.3	4.30	4.42	4.9	4.5	5.7	5.7	4.2	4.2
SV 268	4	--	38.06	124	--	829	141	--	295.2	--	6339	--	15.89	--	21.3	5.18	4.98	4.9	4.7	6.2	5.1	4.4	4.8
SV 285	1	--	38.37	125	--	822	139	--	296.3	--	6301	--	15.89	--	21.1	4.78	4.64	4.5	4.4	6.3	5.8	4.3	4.1
SV 375	2	--	36.41	118	--	769	130	--	289.4	--	5989	--	15.55	--	20.4	4.71	4.74	4.8	4.4	5.9	5.6	4.2	4.4
SX 1888	2	--	37.03	120	--	787	133	--	291.6	--	6038	--	15.67	--	20.3	5.03	4.85	4.1	4.1	5.7	5.6	4.3	4.2
SX 1898	1	--	37.53	122	--	855	145	--	293.4	--	6643	--	15.74	--	22.6	4.76	4.74	5.0	4.4	5.7	5.5	4.3	4.2
Newly Approved																							
BTS 8018	NC	--	40.59	132	--	982	167	--	303.9	--	7256	--	16.22	--	23.6	2.31	2.36	4.5	4.2	3.2	2.8	3.8	4.0
BTS 8034	NC	--	35.57	115	--	887	150	--	286.7	--	7046	--	15.53	--	24.3	2.56	2.63	3.2	3.8	2.7	2.5	3.9	4.2
BTS 8073	NC	--	39.92	130	--	935	159	--	301.6	--	6983	--	16.16	--	22.9	4.56	4.62	4.3	3.9	3.6	3.1	3.7	3.9
BTS 8092	NC	--	37.53	122	--	916	155	--	293.3	--	6977	--	15.76	--	23.3	4.62	4.44	4.1	4.0	4.1	3.9	3.8	3.8
Crystal 021	NC	--	38.07	124	--	935	159	--	295.3	--	7071	--	15.86	--	23.5	2.28	2.24	4.2	3.8	4.2	3.5	3.4	3.6
Crystal 022	NC	--	44.07	143	--	1047	178	--	315.8	--	7422	--	16.80	--	23.2	4.97	4.84	4.8	4.3	3.5	3.1	3.5	3.5
Crystal 025	NC	--	37.42	122	--	909	154	--	293.0	--	7062	--	15.73	--	24.0	4.84	4.70	3.5	3.5	2.4	2.5	3.8	3.7
Crystal 026	NC	--	37.63	122	--	913	155	--	293.7	--	7034	--	15.84	--	23.7	4.43	4.60	3.7	3.7	2.8	2.6	3.3	3.5
Crystal 029	NC	--	39.69	129	--	944	160	--	300.8	--	7062	--	16.17	--	23.2	4.59	4.63	4.3	3.9	2.9	2.7	3.9	4.1
Hilleshög HIL2320	NC	--	36.99	120	--	735	125	--	291.5	--	5721	--	15.58	--	19.5	4.78	4.94	4.7	4.1	4.5	4.5	3.8	4.2
Hilleshög HIL2366	NC	--	37.57	122	--	729	124	--	293.5	--	5656	--	15.66	--	19.2	5.01	4.98	5.8	4.8	4.6	4.6	4.0	4.1
Hilleshög HIL2367	NC	--	37.28	121	--	740	125	--	292.5	--	5760	--	15.64	--	19.6	4.75	4.92	5.1	4.3	4.3	4.4	4.1	4.2
Hilleshög HIL2368	NC	--	40.99	133	--	693	117	--	305.2	--	5136	--	16.25	--	16.8	4.66	4.67	5.3	4.5	4.4	4.1	2.9	3.2
SV 203	NC	--	37.75	123	--	829	141	--	294.1	--	6380	--	15.78	--	21.5	4.75	4.89	4.3	4.3	6.0	5.6	4.3	4.3
SX 1804	NC	--	37.60	122	--	885	150	--	293.6	--	6778	--	15.77	--	22.8	4.80	4.78	4.1	4.0	5.4	5.5	4.2	4.3
Aph Susc Checks		--	30.80		--	590		--	269.8	--	4984	--	14.75	--	18.0								
Mean of Approved Varieties		--	36.28		--	809		--	289.0	--	6325	--	15.55	--	21.6								

%Susc = % of susceptible varieties.

Created 11/10/2021

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

++ 2021 Revenue estimates based on a $45.65 beet payment at 17.5% sugar and 1.5% loss to molasses. 2020 Revenue estimates based on a $45.12 beet payment. Revenue does not consider hauling or production costs.

+++ 2020 Data from Grand ND, Climax and Perly MN.

Lack of Aphanomyces pressure at any of the OVT sites prevented collection of Aphanomyces Yield Data for 2021.

Table 4. ACSC Official Trial Disease Nurseries 2019-2021 (Varieties tested in 2021) Cercospora, Aphanomyces, Rhizoctonia & Fusarium

		< 4.5 Cercospora > 5.0					< 4.4 Aphanomyces > 5.0					< 3.82 Rhizoctonia > 5.0					< 3.0 Fusarium > 5.0					High Rzm
Code	Description	21 Mean	20 Mean	19 Mean	2 Yr Mean	3 Yr Mean	21 Mean	20 Mean	19 Mean	2 Yr Mean	3 Yr Mean	21 Mean	20 Mean	19 Mean	2 Yr Mean	3 Yr Mean	21 Mean	20 Mean	19 Mean	2 Yr Mean	3 Yr Mean	
	Previously Approved																					
532	BTS 8629	4.78	4.55	4.66	4.66	4.66	4.24	3.92	5.32	4.08	4.50	4.22	4.30	3.89	4.26	4.14	4.21	3.78	3.71	4.00	3.90	Hi Rzm
518	BTS 8882	4.92	4.71	4.18	4.81	4.60	3.25	4.33	5.17	3.79	4.25	4.26	4.26	4.27	4.26	4.26	3.25	2.11	2.91	2.68	2.76	Hi Rzm
504	BTS 8927	4.48	4.42	4.35	4.45	4.42	4.51	3.87	4.06	4.19	4.15	3.68	4.37	3.93	4.03	3.99	4.00	2.59	2.77	3.29	3.12	Hi Rzm
530	BTS 8938	4.71	4.66	4.35	4.68	4.57	4.07	3.86	3.75	3.96	3.89	3.83	3.90	3.47	3.87	3.74	4.51	3.66	3.06	4.09	3.75	Hi Rzm
553	BTS 8961	4.53	4.69	4.27	4.61	4.49	4.80	4.04	3.89	4.42	4.25	3.75	4.11	3.79	3.93	3.88	3.33	2.19	2.55	2.76	2.69	Hi Rzm
551	Crystal 572	4.75	4.46	4.68	4.61	4.63	4.47	4.28	4.98	4.38	4.58	3.88	4.21	4.14	4.05	4.08	3.34	2.36	2.39	2.85	2.70	Hi Rzm
549	Crystal 684	4.54	4.44	4.12	4.49	4.37	3.60	3.97	4.33	3.78	3.96	3.82	4.15	4.01	3.99	3.99	2.76	2.32	2.10	2.54	2.39	Hi Rzm
542	Crystal 793	4.13	4.31	4.04	4.22	4.16	3.74	3.87	3.72	3.80	3.77	4.36	4.84	4.18	4.60	4.46	2.80	2.61	2.71	2.71	2.71	Hi Rzm
502	Crystal 796	4.98	4.95	4.74	4.96	4.89	4.72	3.85	3.97	4.29	4.18	4.12	4.45	3.85	4.28	4.14	2.96	2.20	2.45	2.58	2.54	Hi Rzm
536	Crystal 803	3.86	3.93	3.88	3.89	3.89	3.89	3.96	4.45	3.92	4.10	4.39	5.00	4.54	4.69	4.64	3.52	2.52	2.70	3.02	2.91	Hi Rzm
527	Crystal 804	4.68	4.77	4.46	4.72	4.63	3.43	3.61	4.30	3.52	3.78	3.76	3.90	3.72	3.83	3.80	2.84	2.29	2.28	2.56	2.47	Hi Rzm
558	Crystal 912	5.13	4.75	4.62	4.94	4.83	3.95	3.67	3.91	3.81	3.84	3.77	3.54	3.58	3.66	3.63	4.11	3.61	3.37	3.86	3.69	Hi Rzm
513	Crystal 913	4.10	4.13	4.11	4.12	4.11	4.39	3.75	3.58	4.07	3.91	3.94	4.58	4.31	4.26	4.28	3.68	2.59	2.56	3.13	2.94	Hi Rzm
531	Hilleshög HIL2317	4.57	5.05	4.90	4.81	4.84	5.01	3.86	3.96	4.44	4.28	4.76	4.95	4.19	4.85	4.63	6.06	5.97	5.30	6.02	5.78	Hi Rzm
557	Hilleshög HIL9528	4.52	4.84	4.93	4.68	4.76	5.51	3.72	4.56	4.62	4.60	4.47	4.57	4.10	4.52	4.38	4.91	4.68	4.16	4.80	4.59	Hi Rzm
521	Hilleshög HIL9708	4.65	4.97	4.96	4.81	4.86	6.34	3.96	4.61	5.15	4.97	3.78	3.83	3.87	3.81	3.83	4.76	3.64	3.89	4.20	4.10	Rzm
569	Hilleshög HIL9920	4.75	4.82	4.95	4.78	4.84	4.65	3.65	5.05	4.15	4.45	4.70	5.12	4.68	4.91	4.83	5.45	6.28	5.42	5.87	5.72	Hi Rzm
525	Maribo MA504	5.07	5.35	5.34	5.21	5.25	6.97	5.06	6.17	6.01	6.06	4.91	4.83	4.69	4.87	4.81	4.76	4.25	4.61	4.51	4.54	Hi Rzm
512	Maribo MA717	4.68	5.11	5.11	4.89	4.97	6.75	3.77	4.42	5.26	4.98	4.31	4.61	4.15	4.46	4.36	5.11	4.62	4.81	4.87	4.85	Hi Rzm
519	Maribo MA902	4.63	4.96	4.91	4.80	4.83	6.96	4.01	5.31	5.48	5.43	3.80	3.93	3.97	3.86	3.90	4.50	4.01	3.71	4.26	4.08	Hi Rzm
506	SV 265	4.30	4.55	4.28	4.42	4.38	4.95	3.98	5.47	4.47	4.80	4.17	4.21	4.25	4.19	4.21	5.65	5.70	5.64	5.68	5.66	Hi Rzm
528	SV 268	5.18	4.78	4.82	4.98	4.93	4.93	4.49	5.08	4.71	4.83	4.38	5.24	4.21	4.81	4.61	6.21	4.04	4.92	5.12	5.06	Hi Rzm
563	SV 285	4.78	4.50	4.84	4.64	4.70	4.48	4.28	4.47	4.38	4.41	4.26	4.03	4.38	4.15	4.22	6.26	5.40	4.76	5.83	5.47	Hi Rzm
543	SV 375	4.71	4.78	4.11	4.74	4.53	4.77	4.04	5.03	4.41	4.62	4.22	4.54	4.05	4.38	4.27	5.86	5.25	4.97	5.56	5.36	Hi Rzm
568	SX 1888	5.03	4.67	4.89	4.85	4.87	4.12	3.99	4.65	4.06	4.25	4.25	4.17	4.19	4.21	4.20	5.74	5.54	5.51	5.64	5.60	Hi Rzm
533	SX 1898	4.76	4.73	4.68	4.74	4.72	4.97	3.76	4.74	4.37	4.49	4.34	4.16	4.21	4.25	4.24	5.67	5.41	5.14	5.54	5.41	Hi Rzm
Newly Approved																						
522	BTS 8018	2.31	2.41	--	2.36	--	4.52	3.87	--	4.20	--	3.83	4.16	--	3.99	--	3.22	2.47	--	2.85	--	Hi Rzm
514	BTS 8034	2.56	2.70	--	2.63	--	3.24	4.36	--	3.80	--	3.88	4.56	--	4.22	--	2.71	2.26	--	2.48	--	Hi Rzm
508	BTS 8073	4.56	4.68	--	4.62	--	4.30	3.45	--	3.87	--	3.67	4.11	--	3.89	--	3.63	2.58	--	3.11	--	Hi Rzm
561	BTS 8092	4.62	4.26	--	4.44	--	4.11	3.85	--	3.98	--	3.81	3.81	--	3.81	--	4.07	3.70	--	3.88	--	Hi Rzm
555	Crystal 021	2.28	2.20	--	2.24	--	4.19	3.46	--	3.83	--	3.38	3.88	--	3.63	--	4.18	2.85	--	3.52	--	Hi Rzm
534	Crystal 022	4.97	4.71	--	4.84	--	4.79	3.81	--	4.30	--	3.53	3.49	--	3.51	--	3.50	2.60	--	3.05	--	Hi Rzm
501	Crystal 025	4.84	4.56	--	4.70	--	3.52	3.40	--	3.46	--	3.76	3.72	--	3.74	--	2.42	2.51	--	2.47	--	Hi Rzm
535	Crystal 026	4.43	4.76	--	4.60	--	3.74	3.75	--	3.74	--	3.34	3.57	--	3.45	--	2.79	2.31	--	2.55	--	Hi Rzm
565	Crystal 029	4.59	4.67	--	4.63	--	4.30	3.60	--	3.95	--	3.87	4.31	--	4.09	--	2.88	2.42	--	2.65	--	Hi Rzm
511	Hilleshög HIL2320	4.78	5.11	4.92	4.94	4.94	4.66	3.55	4.58	4.11	4.26	3.80	4.64	4.04	4.22	4.16	4.50	4.56	4.37	4.53	4.48	Hi Rzm
545	Hilleshög HIL2366	5.01	4.94	--	4.98	--	5.81	3.81	--	4.81	--	3.98	4.24	--	4.11	--	4.65	4.55	--	4.60	--	Hi Rzm
556	Hilleshög HIL2367	4.75	5.08	--	4.92	--	5.13	3.51	--	4.32	--	4.10	4.26	--	4.18	--	4.27	4.44	--	4.35	--	Hi Rzm
509	Hilleshög HIL2368	4.66	4.69	--	4.67	--	5.25	3.70	--	4.47	--	2.92	3.52	--	3.22	--	4.44	3.86	--	4.15	--	Hi Rzm
559	SV 203	4.75	5.03	--	4.89	--	4.35	4.34	--	4.34	--	4.34	4.29	--	4.31	--	5.99	5.26	--	5.62	--	Hi Rzm
520	SX 1804	4.80	4.76	--	4.78	--	4.07	4.02	--	4.04	--	4.19	4.38	--	4.28	--	5.37	5.56	--	5.46	--	Hi Rzm

Created 11/11/2021

Green highlighted ratings indicate specialty or good resistance. Red highlighted ratings indicate level of concern for some fields.

-- indicates data not available

Table 5
Root Aphid Ratings
American Crystal Sugar, Betaseed and Magno Seed from 2019 - 2021

	Moorhead, MN[X] (1=Exc -4=Poor)					Shakopee, MN[Y] (1=Exc -4=Poor)					Longmont, CO[Z] (% Infested Plants)				
Variety	2019*	2020*	2021**	2 Yr Mean	3 Yr Mean	2019*	2020*	2021	2 Yr Mean	3 Yr Mean	2019	2020	2021	2 Yr Mean	3 Yr Mean
BTS 8018								1.00					67.94		
BTS 8034								1.32					68.72		
BTS 8073								1.19					80.81		
BTS 8092								1.21					61.48		
BTS 8629								1.46			3.60	10.20	82.76	46.48	32.19
BTS 8882								1.08			2.20	2.60	48.36	25.48	17.72
BTS 8927								1.16				7.90	76.97	42.44	42.44
BTS 8938								1.32				7.30	76.66	41.98	41.98
BTS 8961								1.00				9.20	51.05	30.13	30.13
Crystal 021								1.22					69.71		
Crystal 022								1.00					68.23		
Crystal 025								1.15					71.77		
Crystal 026								1.00					62.89		
Crystal 029								1.00					67.44		
Crystal 572								1.08			0.00	9.60	61.07	35.33	23.56
Crystal 684								1.28			2.10	14.40	67.74	41.07	28.08
Crystal 793								1.08			7.40	8.60	84.86	46.73	33.62
Crystal 796								1.00			1.60	3.30	70.75	37.03	25.22
Crystal 803								1.16			1.70	17.80	71.36	44.58	30.29
Crystal 804								1.24			2.80	13.10	57.64	35.37	24.51
Crystal 912								1.24				3.30	64.72	34.01	34.01
Crystal 913								1.12				1.40	62.18	31.79	31.79
Hilleshög HIL2317								3.41				34.40	76.15	55.28	55.28
Hilleshög HIL2320								3.33				49.20	80.33	64.77	64.77
Hilleshög HIL2366								3.72					73.41		
Hilleshög HIL2367								3.60					77.92		
Hilleshög HIL2368								3.54					73.23		
Hilleshög HIL9528								3.35			52.20	68.20	68.62	68.41	63.01
Hilleshög HIL9708								3.38			49.80	71.10	72.26	71.68	64.39
Hilleshög HIL9920								3.58			49.50	44.40	74.56	59.48	56.15
Maribo MA504								3.60			13.50	40.00	71.90	55.95	41.80
Maribo MA717								3.68			35.80	71.60	68.33	69.96	58.58
Maribo MA902								3.75				62.50	73.70	68.10	68.10
SV 203								2.32					70.81		
SV 265								3.65			28.80	83.10	70.81	76.95	60.90
SV 268								1.88			27.50	20.20	67.80	44.00	38.50
SV 285								2.28			4.90	28.20	66.81	47.50	33.30
SV 375								2.96			18.50	43.90	68.54	56.22	43.65
SX 1804								2.62					75.84		
SX 1888								2.92			29.40	69.50	83.66	76.58	60.85
SX 1898								2.21				43.20	54.21	48.70	48.70
Root Aphid Res Chk#2								1.13			3.60	19.80	80.06	49.93	34.49
Root Aphid Res Chk#3								1.36			0.00	9.60	70.65	40.12	26.75
Root Aphid Susc Chk#4								3.48			41.50	64.30	71.31	67.80	59.04
Root Aphid Susc Chk#5								3.60			52.20	68.20	76.10	72.15	65.50

Created 11/11/2021

[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, Betaseed

[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

** Trial in process

Table 6. Planting & Harvest Dates, Previous Crop and Disease Levels for 2021 ACSC Official Trial Sites *

Location	District / Trial Type	Cooperator	Planting Date	Harvest Date	Preceding Crop	Soil Type	Diseases Present @ Aph	Rhc	Rzm	Fus	Maggot	Rt Aphid	Comments
Casselton ND	Mhd/Hlb	Todd Weber Farms	5/4	9/13	Fallow	Medium/Light	N	L	N	N	N	N	
Glyndon MN	Mhd/Hlb	Menholt Farms	5/2	9/16	Wheat	Medium/Light	N	L	N	N	N	N	Moisture stress
Georgetown MN	Mhd/Hlb	Hoff Farms	5/4	9/22	Fallow	Medium	L	L	N	N	N	L	Moisture stress
Hendrum MN	Mhd/Hlb	Mark Maring	5/2	10/7	Wheat	Medium	N	N	N	N	N	L	Severe moisture stress
Hillsboro ND	Mhd/Hlb	CCK Farms	5/5	9/14	Soybean	Medium	L	L-M	N	N	N	L	Scattered small Aph and Rhizoc patches
Caledonia ND	Mhd/Hlb	Cotton Farms	5/8	Abandon	Wheat	Medium	N	L-M	N	N	N	N	Not harvested due to poor stand establishment
Grand Forks ND	EGF/Crk	Drees Farming Association	5/1	9/24	Wheat	Medium/Light	N	L	N	N	N	N	
Scandia MN	EGF/Crk	Deboer Farms	4/30	10/6	Wheat	Medium	N	L	N	L	N	N	Moisture stress; Fus in exp demo
Climax MN	EGF/Crk	Larson Farms	4/22	9/23	Wheat	Medium/Light	N	M	N	N	N	L	Moisture stress; scattered small to medium Rhizoc patches
Forest River MN	EGF/Crk	Forest River Farms Partnership	4/29	9/30	Wheat	Medium	N	L	N	N	N	L	Gaps and stunting in ranges 5-10 of commercial OVT
St. Thomas ND	Dtn	Kennelly Farms	4/28	Abandon	Beans	Medium/Light	N	L	N	N	L-M	N	Not harvested due to poor stand establishment
Hallock MN	Dtn	Prosser Kusnia Beets	4/27	10/4	Wheat	Medium/Heavy	N	L-M	N	N	N	L	Severe moisture stress; scattered small Rhizoc patches
Bathgate ND	Dtn	Shady Bend Farm	4/26	10/2	Wheat	Medium	N	L	N	N	N	N	Moisture stress

Location	District / Trial Type	Cooperator	Planting Date	Rating Date	Preceding Crop	Soil Type	Diseases Present @ Aph	Rhc	Rzm	Fus	Maggot	Rt Aphid	Comments
Moorhead Fus-N MN	Fus Nurs	Nelson Farms	6/15	Multiple	Wheat	Medium/Heavy	NA	NA	NA	V	NA	NA	Replanted due to poor stand establishment
Sabin Fus-S MN	Fus Nurs	Krabbenhoft & Sons Farm	6/15	Multiple	Soybeans	Medium	NA	NA	NA	M-V	NA	NA	Replanted due to poor stand establishment; not rated due to erratic stands on replant
Mhd Rhc-E MN	Rhc Nurs	Jon Hickel	5/6	8/10	Wheat	Heavy	NA	M	NA	L	NA	NA	
Mhd Rhc-W MN	Rhc Nurs	Jon Hickel	5/7	9/8	Wheat	Heavy	NA	M	NA	L	NA	NA	
NWROC MN	Rhc Nurs	Maureen Aubol	5/8	Abandon	NA	Medium	NA	L-M	NA	NA	M-S	NA	Not inoculated or rated due to erratic stands and abundance of root maggot damage
East Lansing MI	Rhc Nurs	Mitch McGrath	5/14	8/25	NA	NA	NA	V	NA	NA	NA	NA	Ratings not used due to high severity and lack of separation among checks
Shakopee MN	Aphanomyces	Patrick O'Boyle	5/5	8/25	NA	NA	M-V	L	NA	NA	NA	NA	Disease pressure higher earlier in season
Glyndon MN	Aphanomyces	Dennis Simmons	5/2	Abandon	Wheat	Medium	L	L	NA	L-M	NA	NA	Abandoned due to lack of Aph pressure
Georgetown MN	Aphanomyces	Hoff Farms	5/4	Abandon	Fallow	Medium	L	L	N	N	N	L	Abandoned due to lack of Aph pressure
Hillsboro ND	Aphanomyces	CCK Farms	9/14	Abandon	Soybeans	Medium	L	L	N	N	N	L	Abandoned due to lack of Aph pressure
Longmont CO	Root Aphids	Kara Guffey			NA	NA	NA	NA	NA	NA	NA		
Foxhome MN	Cercospora	NDSU/Kevin Etzler	5/6	Multiple	Wheat	Medium	NA	L	NA	NA	NA	NA	
East Lansing MI	Cercospora	Mitch McGrath	5/14	Multiple	NA	NA	NA	NA	NA	NA	NA	NA	Ratings not used due to lack of correlation with Randolph and Foxhome sites
Randolph MN	Cercospora	Patrick O'Boyle	5/1	Multiple	NA	NA	NA	NA	NA	NA	NA	NA	

Created 11/04/2021

* Fertilizer applied in accordance with cooperative recommendations.

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

Table 7. Seed Treatments Used on Varieties in Official Variety Trials in 2021

Description	Years in Trial	Years ** Comm.	Fungicide Seed Treatment (Damping Off)	(Rhizoctonia)	(Aphanomyces)	Insecticide (Springtails & Maggots)	Priming (Emergence)
ACSC Commercial							
BTS 8629	6	4	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8882	4	2	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8927	3	1	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8938	3	1	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8961	3	1	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
Crystal 572	7	5	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 684	6	3	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 793	5	3	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 796	5	2	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 803	4	1	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 804	4	1	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 913	3	1	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Hilleshög HIL2317	3	1	Apron XL Maxim	Vibrance	Tach 20	Cruiser Maxx	XBEET
Hilleshög HIL9528	8	6	Apron XL Maxim	Vibrance	Tach 20	Cruiser Maxx	XBEET
Hilleshög HIL9708	7	4	Apron XL Maxim	Vibrance	Tach 20	Cruiser Maxx	XBEET
Hilleshög HIL9920	5	3	Apron XL Maxim	Vibrance	Tach 20	Cruiser Maxx	XBEET
Maribo MA504	7	5	Apron XL Maxim	Vibrance	Tach 20	Cruiser Maxx	XBEET
Maribo MA717	5	3	Apron XL Maxim	Vibrance	Tach 20	Cruiser Maxx	XBEET
Maribo MA902	3	1	Apron XL Maxim	Vibrance	Tach 20	Cruiser Maxx	XBEET
SV 265	6	4	Apron XL Thiram	Metlock/Rizolex/Zeltera	Int Sol	Nipsit	XBEET
SV 268	6	4	Apron XL Thiram	Metlock/Rizolex/Zeltera	Int Sol	Nipsit	XBEET
SV 285	4	1	Apron XL Thiram	Metlock/Rizolex/Zeltera	Int Sol	Nipsit	XBEET
SV 375	5	2	Apron XL Thiram	Metlock/Rizolex/Zeltera	Int Sol	Nipsit	XBEET
SX 1888	4	2	Apron XL Thiram	Zeltera	Int Sol	Nipsit	XBEET
SX 1898	3	1	Apron XL Thiram	Zeltera	Int Sol	Nipsit	XBEET
Crystal 355RR(Check)	9	6	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
BTS 8572 (Check)	7	5	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Ultipro
BTS 8337 (Check)	9	7	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 578RR (Check)	7	4	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
AP CHK MOD SUS RR#5	6	4	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
AP CHK MOD RR#4	10	8	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Root Aphid Susc Chk#5	8	6	Apron XL Maxim	Vibrance	Tach 20	Cruiser Maxx	XBEET
ACSC Experimental							
BTS 8018	2	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8034	2	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8073	2	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8092	2	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8100	1	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8122	1	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8133	1	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8140	1	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8156	1	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8164	1	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
BTS 8187	1	NC	Allegiance Thiram	Vibrance	Tach 35	Poncho Beta	Ultipro
Crystal 021	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 022	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 025	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 026	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 029	2	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 130	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 132	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 134	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 137	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 138	1	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Crystal 912	3	NC	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Hilleshög HIL2320	3	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2366	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2367	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2368	2	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2385	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2386	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2387	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2388	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Hilleshög HIL2389	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Maribo MA930	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Maribo MA931	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
Maribo MA932	1	NC	Apron XL Maxim	Vibrance	Tach 45	Cruiser Maxx	XBEET
SV 203	2	NC	Apron XL Thiram	Zeltera	Int Sol	NipsIt	XBEET
SV 211	1	NC	Apron XL Thiram	Zeltera	Int Sol	NipsIt	XBEET
SV 213	1	NC	Apron XL Thiram	Zeltera	Int Sol	NipsIt	XBEET
SV 214	1	NC	Apron XL Thiram	Zeltera	Int Sol	NipsIt	XBEET
SV 215	1	NC	Apron XL Thiram	Zeltera	Int Sol	NipsIt	XBEET
SX 1804	2	NC	Apron XL Thiram	Metlock/Rizolex/Kabina	Tach 20	NipsIt	XBEET
SX 1815	1	NC	Apron XL Thiram	Metlock/Rizolex/Kabina	Tach 20	NipsIt	XBEET
SX 1816	1	NC	Apron XL Thiram	Metlock/Rizolex/Kabina	Tach 20	NipsIt	XBEET
SX 1817	1	NC	Apron XL Thiram	Metlock/Rizolex/Kabina	Tach 20	NipsIt	XBEET
SX 1818	1	NC	Apron XL Thiram	Metlock/Rizolex/Kabina	Tach 20	NipsIt	XBEET
SX 1819	1	NC	Apron XL Thiram	Metlock/Rizolex/Kabina	Tach 20	NipsIt	XBEET
Crystal 355RR(Check)	9	6	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
BTS 8572 (Check)	7	5	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	Ultipro
BTS 8337 (Check)	9	7	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
Crystal 578RR (Check)	7	4	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
BTS 8815 (Check)	4	2	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
AP CHK MOD SUS RR#5	6	4	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro
AP CHK MOD RR#4	10	8	Allegiance Thiram	Kabina	Tach 45	Poncho Beta	XBEET
Root Aphid Susc Chk#5	8	6	Apron XL Maxim	Vibrance	Tach 20	Cruiser Maxx	XBEET
AP CHK MOD SUS RR#5	6	4	Allegiance Thiram	Systiva	Tach 35	Poncho Beta	Ultipro

Abbreviations Tach (Tachigaren) Int Sol (Intego Solo)

Created 11/11/2021

Table 8.

2021 Performance of Varieties - ACSC RR Official Trial 11

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	322.9	97	11076	117	1.13	46.49	94	1590	113	17.28	34.40	136	1518	424	0	80.7
BTS 8882	112	322.3	97	10856	115	1.22	46.33	93	1554	111	17.34	33.81	148	1706	442	0	80.8
BTS 8927	101	343.3	103	10313	109	1.04	52.48	106	1572	112	18.21	30.16	119	1474	372	0	70.3
BTS 8938	113	333.2	100	10608	112	1.10	49.53	100	1574	112	17.76	31.89	123	1495	407	0	67.7
BTS 8961	110	328.5	98	10652	112	1.17	48.14	97	1556	111	17.60	32.51	143	1661	414	0	77.2
Crystal 572	125	337.9	101	10200	108	1.13	50.88	102	1530	109	18.02	30.32	114	1538	425	3	80.7
Crystal 684	124	320.8	96	10770	114	1.21	45.89	92	1533	109	17.25	33.70	149	1703	429	0	80.4
Crystal 793	107	339.3	102	10805	114	1.08	51.29	103	1625	116	18.04	32.02	120	1527	390	0	79.7
Crystal 796	108	328.1	98	10820	114	1.18	48.03	97	1578	112	17.59	33.09	139	1650	425	0	82.0
Crystal 803	115	336.8	101	10672	113	1.13	50.56	102	1597	114	17.97	31.79	118	1588	412	3	81.3
Crystal 804	114	324.7	97	11041	117	1.15	47.03	95	1591	113	17.39	34.17	154	1610	411	0	79.1
Crystal 913	118	339.5	102	10493	111	1.08	51.35	103	1579	113	18.05	31.07	126	1511	387	0	77.8
Hilleshög HIL2317	120	334.5	100	9750	103	1.12	49.88	100	1451	103	17.84	29.22	142	1643	378	0	74.6
Hilleshög HIL9528	109	320.3	96	9741	103	1.13	45.74	92	1392	99	17.14	30.38	163	1557	400	0	74.9
Hilleshög HIL9708	123	326.9	98	9647	102	1.11	47.67	96	1402	100	17.45	29.60	163	1553	387	0	79.4
Hilleshög HIL9920	117	335.4	101	10041	106	1.14	50.17	101	1497	107	17.91	30.02	148	1680	385	0	75.9
Maribo MA504	106	320.3	96	9831	104	1.18	45.75	92	1401	100	17.20	30.77	162	1612	429	0	78.7
Maribo MA717	121	317.4	95	10012	106	1.16	44.88	90	1414	101	17.03	31.59	161	1631	410	0	74.2
Maribo MA902	119	326.9	98	9808	104	1.12	47.68	96	1427	102	17.47	30.07	164	1567	391	0	83.7
SV 265	105	326.9	98	9725	103	1.07	47.66	96	1416	101	17.42	29.80	127	1570	370	0	76.2
SV 268	116	333.2	100	10462	110	1.13	49.52	100	1552	111	17.79	31.47	118	1637	397	0	81.7
SV 285	111	335.8	101	10211	108	1.11	50.28	101	1524	109	17.90	30.51	116	1609	387	0	81.8
SV 375	102	336.3	101	10313	109	1.09	50.43	102	1541	110	17.91	30.78	115	1599	381	0	81.1
SX 1888	104	328.0	98	9829	104	1.17	47.99	97	1434	102	17.57	30.03	127	1638	428	0	75.6
SX 1898	122	335.6	101	9932	105	1.13	50.21	101	1479	105	17.91	29.75	121	1632	400	0	76.8
Crystal 355RR(Check)	126	330.5	99	8826	93	1.27	48.74	98	1292	92	17.79	26.89	134	1703	481	0	81.0
BTS 8572 (Check)	127	333.2	100	9539	101	1.19	49.52	100	1412	101	17.85	28.79	124	1600	449	0	74.1
BTS 8337 (Check)	128	340.4	102	9584	101	1.20	51.62	104	1447	103	18.22	28.30	127	1683	437	0	74.6
Crystal 578RR (Check)	129	330.5	99	9951	105	1.16	48.71	98	1460	104	17.68	30.25	148	1642	405	0	82.7
AP CHK MOD SUS RR#5	130	332.6	100	10055	106	1.15	49.35	99	1485	106	17.78	30.37	138	1649	405	0	78.4
AP CHK MOD RR#4	131	328.2	98	9628	102	1.13	48.06	97	1399	100	17.54	29.56	154	1630	384	0	79.0
Root Aphid Susc Chk#5	132	320.9	96	9895	104	1.13	45.91	92	1414	101	17.17	30.85	167	1567	400	0	75.7
Experimental Trial (Comm status)																	
BTS 8018	232	338.0	101	10817	114	1.08	50.94	103	1622	116	17.97	32.16	120	1526	388	0	83.1
BTS 8034	222	323.2	97	11041	117	1.17	46.59	94	1587	113	17.34	34.28	152	1710	399	0	83.3
BTS 8073	207	332.4	100	10393	110	1.14	49.30	99	1533	109	17.76	31.44	118	1560	428	0	80.3
BTS 8092	236	332.2	100	10914	115	1.07	49.22	99	1611	115	17.67	32.98	127	1492	384	0	80.3
BTS 8100	212	339.2	102	10254	108	1.15	51.28	103	1544	110	18.10	30.39	123	1682	397	0	83.2
BTS 8122	226	353.2	106	9818	104	1.03	55.39	112	1535	109	18.69	27.91	109	1530	356	0	76.7
BTS 8133	227	322.1	97	11165	118	1.19	46.29	93	1601	114	17.30	34.75	150	1747	401	0	83.8
BTS 8140	243	337.0	101	10196	108	1.14	50.63	102	1528	109	17.98	30.35	118	1598	416	0	83.3
BTS 8156	223	330.2	99	10585	112	1.15	48.65	98	1551	111	17.67	32.24	144	1720	382	0	85.7
BTS 8164	211	330.4	99	10086	106	1.22	48.69	98	1480	105	17.74	30.68	147	1683	447	0	79.3
BTS 8187	220	344.3	103	9911	105	1.14	52.78	106	1514	108	18.34	28.91	118	1578	421	0	76.2
Crystal 021	208	330.0	99	11043	117	1.14	48.59	98	1620	115	17.64	33.60	142	1670	390	0	76.0
Crystal 022	241	340.7	102	10221	108	1.08	51.73	104	1543	110	18.12	30.19	119	1515	395	0	78.8
Crystal 025	244	333.2	100	10368	109	1.16	49.52	100	1531	109	17.82	31.34	136	1636	416	8	75.7
Crystal 026	209	327.9	98	10971	116	1.21	47.97	97	1602	114	17.61	33.56	152	1753	417	0	80.9
Crystal 029	240	335.6	101	10162	107	1.13	50.24	101	1512	108	17.90	30.48	118	1576	413	0	82.5
Crystal 130	230	338.1	101	10812	114	1.09	50.96	103	1620	115	17.98	32.18	123	1580	382	0	82.6
Crystal 132	218	340.8	102	10141	107	1.08	51.74	104	1529	109	18.12	29.99	123	1483	402	0	76.4
Crystal 134	214	347.6	104	10203	108	1.02	53.76	108	1574	112	18.38	29.43	115	1503	346	0	76.7
Crystal 137	203	330.7	99	11075	117	1.16	48.80	98	1628	116	17.70	33.66	139	1727	391	0	81.2
Crystal 138	205	336.6	101	10448	110	1.12	50.54	102	1561	111	17.94	31.18	116	1552	415	0	77.6
Crystal 912	242	328.2	98	11422	121	1.13	48.05	97	1665	119	17.54	34.96	160	1491	420	0	79.2
Hilleshög HIL2320	217	324.3	97	9781	103	1.19	46.93	95	1411	101	17.40	30.24	161	1639	429	0	82.2
Hilleshög HIL2366	215	331.3	99	10032	106	1.12	48.97	99	1481	106	17.68	30.34	150	1553	397	0	85.2
Hilleshög HIL2367	237	327.3	98	9901	104	1.19	47.80	96	1443	103	17.55	30.32	149	1617	441	0	82.0
Hilleshög HIL2368	233	337.7	101	8924	94	1.15	50.84	102	1339	95	18.02	26.51	142	1557	423	0	82.2
Hilleshög HIL2385	201	336.2	101	9457	100	1.12	50.40	102	1413	101	17.91	28.24	131	1548	407	0	82.3
Hilleshög HIL2386	238	332.3	100	10129	107	1.18	49.25	99	1499	107	17.79	30.54	149	1620	433	0	82.6
Hilleshög HIL2387	213	332.7	100	9420	99	1.12	49.37	99	1389	99	17.75	28.51	136	1576	400	0	82.1
Hilleshög HIL2388	225	331.3	99	9782	103	1.10	48.97	99	1442	103	17.66	29.61	149	1531	393	0	82.2
Hilleshög HIL2389	234	334.1	100	10003	106	1.11	49.80	100	1483	106	17.82	30.13	124	1607	385	0	85.1
Maribo MA930	210	326.4	98	10388	110	1.26	47.53	96	1508	107	17.58	31.93	153	1642	484	0	86.0
Maribo MA931	219	325.6	98	9940	105	1.19	47.30	95	1439	103	17.46	30.63	160	1640	426	0	78.9
Maribo MA932	231	328.4	98	10163	107	1.16	48.11	97	1486	106	17.58	31.01	156	1619	413	0	81.9
SV 203	239	337.8	101	9853	104	1.11	50.87	102	1478	105	18.00	29.31	119	1655	381	0	78.2
SV 211	224	335.1	100	9661	102	1.12	50.08	101	1436	102	17.87	28.99	120	1652	387	0	79.0
SV 213	206	333.5	100	9789	103	1.15	49.62	100	1450	103	17.83	29.50	123	1605	423	0	75.5
SV 214	245	321.8	96	8492	90	1.26	46.18	93	1213	86	17.35	26.52	118	1669	491	0	81.7
SV 215	221	331.3	99	9712	103	1.18	48.97	99	1427	102	17.74	29.48	136	1673	424	0	71.2
SX 1804	228	334.4	100	10164	107	1.12	49.88	100	1512	108	17.83	30.51	122	1622	394	0	80.4
SX 1815	229	338.7	102	10271	108	1.10	51.12	103	1545	110	18.03	30.45	117	1613	384	0	82.0
SX 1816	202	328.3	98	10404	110	1.18	48.08	97	1518	108	17.60	31.81	140	1679	421	0	72.4
SX 1817	216	330.5	99	10218	108	1.17	48.72	98	1503	107	17.70	31.04	126	1660	420	0	81.4
SX 1818	235	332.5	100	10527	111	1.12	49.33	99	1555	111	17.74	31.81	115	1634	392	0	79.6
SX 1819	204	332.6	100	10082	106	1.15	49.35	99	1493	106	17.78	30.38	120	1634	412	0	79.3
Crystal 355RR(Check)	246	332.1	100	8917	94	1.24	49.19	99	1311	93	17.84	27.06	137	1717	451	0	81.8
BTS 8572 (Check)	247	336.2	101	9173	97	1.17	50.39	101	1367	97	17.97	27.45	121	1597	436	8	73.6
BTS 8337 (Check)	248	337.6	101	9400	99	1.23	50.80	102	1408	100	18.10	27.99	133	1726	445	0	74.9
Crystal 578RR (Check)	249	328.7	99	10410	110	1.19	48.21	97	1524	109	17.63	31.73	152	1685	420	0	81.9
BTS 8815 (Check)	250	336.9	101	9768	103	1.15	50.61	102	1461	104	17.99	29.13	145	1719	384	0	70.8
AP CHK MOD SUS RR#5	251	335.7	101	10181	107	1.16	50.26	101	1521	108	17.94	30.40	144	1660	405	0	78.6
AP CHK MOD RR#4	252	329.0	99	9791	103	1.10	48.30	97	1435	102	17.56	29.79	155	1681	352	0	79.2
Root Aphid Susc Chk#5	253	327.9	98	9422	99	1.15	47.97	97	1377	98	17.54	28.78	158	1593	406	0	76.0
AP CHK MOD SUS RR#5	254	332.9	100	10239	108	1.16	49.44	100	1516	108	17.80	30.85	145	1647	405	0	80.1
Comm Benchmark Mean		333.7		9475		1.21	49.65		1403		17.89	28.56	133	1657	443		78.1
Comm Trial Mean		330.4		10159		1.14	48.68		1491		17.66	30.87	138	1606	408		78.0
Coeff. of Var. (%)		3.1		5.8		8.1	6.1		7.8		2.7	5.0	18.3	4.6	14.1		8.1
Mean LSD (0.05)		5.1		344		0.04	1.50		63		0.25	0.97	14	35	25		2.6
Mean LSD (0.01)		6.8		452		0.05	1.98		83		0.33	1.28	18	47	33		3.4
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2021 Data from 11 Sites   Bolters based upon 60,000 seed per acre.   Created 11/03/2021

%Bnch = percentage of four benchmark varieties.

Na, K, AmN, Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status.   Trial # = 21ACSExpB

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and does not consider hauling costs.

2021 Performance of Varieties - ACSC RR Official Trial

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	304.2	97	13113	119	1.06	41.00	93	1768	115	16.27	43.22	138	1550	360	0	73.7
BTS 8882	112	297.2	95	13361	121	1.16	38.97	89	1746	113	16.01	44.99	154	1776	371	0	74.0
BTS 8927	101	320.6	102	12848	116	0.98	45.81	104	1836	119	17.01	40.04	106	1461	334	0	58.5
BTS 8938	113	311.4	99	12588	114	1.07	43.12	98	1742	113	16.64	40.47	136	1498	380	0	59.3
BTS 8961	110	303.1	97	12570	114	1.13	40.71	93	1686	109	16.28	41.47	147	1690	373	0	69.7
Crystal 572	125	315.1	100	12408	112	1.12	44.21	101	1739	113	16.86	39.23	114	1615	396	0	75.4
Crystal 684	124	294.9	94	12997	118	1.19	38.28	87	1686	109	15.93	44.13	160	1780	390	0	79.9
Crystal 793	107	313.4	100	13276	120	1.06	43.70	100	1846	120	16.72	42.40	122	1549	363	0	75.8
Crystal 796	108	310.8	99	12988	117	1.11	42.95	98	1794	116	16.65	41.70	139	1734	353	0	72.5
Crystal 803	115	310.9	99	12657	114	1.12	42.99	98	1746	113	16.67	40.89	121	1616	393	0	76.5
Crystal 804	114	303.2	97	13324	120	1.14	40.73	93	1784	116	16.30	44.06	164	1676	377	0	66.1
Crystal 913	118	313.0	100	12932	117	1.01	43.61	99	1803	117	16.66	41.36	128	1573	317	0	65.3
Hilleshög HIL2317	120	318.7	102	11946	108	1.04	45.27	103	1699	110	16.98	37.45	137	1683	309	0	65.0
Hilleshög HIL9528	109	309.7	99	11845	107	1.09	42.62	97	1630	106	16.58	38.17	155	1642	357	0	63.2
Hilleshög HIL9708	123	304.0	97	11525	104	1.06	40.95	93	1551	101	16.26	37.95	161	1555	350	0	72.1
Hilleshög HIL9920	117	314.4	100	12167	110	1.05	43.99	100	1704	110	16.76	38.61	139	1681	315	0	66.8
Maribo MA504	106	299.1	95	12168	110	1.13	39.52	90	1614	105	16.09	40.68	154	1617	388	0	66.5
Maribo MA717	121	303.5	97	11949	108	1.15	40.82	93	1606	104	16.33	39.42	171	1686	382	0	62.3
Maribo MA902	119	310.7	99	11494	104	1.03	42.91	98	1588	103	16.56	36.86	135	1570	331	0	79.4
SV 265	105	316.1	101	11837	107	1.06	44.51	101	1667	108	16.87	37.46	112	1679	336	0	67.7
SV 268	116	319.7	102	13255	120	1.07	45.56	104	1887	122	17.05	41.42	115	1667	346	0	74.7
SV 285	111	319.2	102	12481	113	1.03	45.40	104	1773	115	16.99	39.19	117	1672	315	0	78.1
SV 375	102	320.5	102	12533	113	1.05	45.78	104	1794	116	17.08	39.18	116	1646	335	0	74.8
SX 1888	104	316.0	101	12152	110	1.14	44.47	101	1709	111	16.94	38.35	132	1753	370	0	66.6
SX 1898	122	318.0	101	12527	113	1.07	45.07	103	1773	115	16.97	39.53	130	1699	329	0	69.4
Crystal 355RR(Check)	126	312.3	99	9867	89	1.21	43.39	99	1363	88	16.83	31.98	136	1749	425	0	69.4
BTS 8572 (Check)	127	314.4	100	11630	105	1.08	44.01	100	1632	106	16.80	36.91	117	1632	357	0	64.5
BTS 8337 (Check)	128	319.4	102	10880	98	1.14	45.48	104	1544	100	17.11	34.18	130	1738	373	0	63.4
Crystal 578RR (Check)	129	309.4	99	11867	107	1.08	42.54	97	1630	106	16.55	38.31	146	1669	342	0	73.3
AP CHK MOD SUS RR#5	130	304.4	97	11888	107	1.14	41.06	94	1604	104	16.35	39.19	158	1773	351	0	70.5
AP CHK MOD RR#4	131	300.2	96	11432	103	1.16	39.83	91	1516	98	16.17	38.09	180	1782	361	0	70.2
Root Aphid Susc Chk#5	132	306.1	98	12031	109	1.09	41.57	95	1637	106	16.38	39.13	138	1627	359	0	66.0
Experimental Trial (Comm status)																	
BTS 8018	232	322.6	103	12572	114	1.09	46.46	106	1797	117	17.21	39.26	101	1567	408	0	72.3
BTS 8034	222	304.1	97	12464	113	1.06	40.96	93	1677	109	16.27	40.86	139	1692	340	0	70.3
BTS 8073	207	306.8	98	11574	105	1.06	41.78	95	1567	102	16.40	37.92	90	1567	392	0	71.2
BTS 8092	236	310.4	99	11034	100	0.98	42.85	98	1512	98	16.50	35.65	107	1515	335	0	61.5
BTS 8100	212	320.2	102	12139	110	1.06	45.74	104	1726	112	17.07	37.96	104	1745	338	0	70.7
BTS 8122	226	330.8	105	11007	100	0.99	48.88	111	1619	105	17.53	33.41	99	1590	327	0	65.2
BTS 8133	227	310.9	99	12854	116	1.02	42.96	98	1774	115	16.55	41.61	122	1709	313	0	70.6
BTS 8140	243	324.0	103	11543	104	1.02	46.85	107	1665	108	17.21	35.60	93	1614	344	0	66.9
BTS 8156	223	310.5	99	12344	112	1.09	42.87	98	1693	110	16.61	39.86	148	1729	349	0	67.3
BTS 8164	211	320.6	102	11397	103	1.06	45.86	105	1620	105	17.07	35.75	113	1689	347	0	65.6
BTS 8187	220	316.3	101	10868	98	1.06	44.57	102	1529	99	16.87	34.30	102	1633	368	0	60.7
Crystal 021	208	307.8	98	12355	112	1.07	42.06	96	1689	110	16.45	40.31	121	1691	353	0	51.8
Crystal 022	241	317.8	101	12435	112	0.99	45.02	103	1758	114	16.88	39.22	101	1516	349	0	66.3
Crystal 025	244	308.4	98	11683	106	1.12	42.24	96	1594	103	16.52	38.14	114	1750	379	0	65.2
Crystal 026	209	317.0	101	12184	110	1.07	44.78	102	1723	112	16.90	38.53	117	1766	330	0	66.0
Crystal 029	240	311.0	99	11566	105	1.05	42.98	98	1598	104	16.59	37.22	101	1650	354	0	66.7
Crystal 130	230	320.4	102	12678	115	0.93	45.81	104	1808	117	16.94	39.58	95	1526	294	0	72.6
Crystal 132	218	318.3	101	12262	111	1.02	45.19	103	1737	113	16.93	38.53	104	1503	369	0	61.8
Crystal 134	214	328.0	104	11663	105	0.89	48.05	110	1704	110	17.29	35.57	89	1483	282	0	66.7
Crystal 137	203	312.0	99	12276	111	1.06	43.29	99	1701	110	16.64	39.49	125	1791	314	0	72.4
Crystal 138	205	317.4	101	11815	107	1.02	44.89	102	1662	108	16.88	37.48	103	1541	362	0	63.4
Crystal 912	242	309.1	98	12942	117	1.06	42.46	97	1768	115	16.51	42.09	142	1487	388	0	66.6
Hilleshög HIL2320	217	304.0	97	11288	102	1.16	40.93	93	1517	98	16.37	37.22	136	1697	423	0	69.1
Hilleshög HIL2366	215	308.9	98	11375	103	1.05	42.41	97	1553	101	16.50	36.86	149	1557	360	0	73.3
Hilleshög HIL2367	237	304.1	97	11268	102	1.15	40.97	93	1513	98	16.36	37.07	130	1705	411	0	64.1
Hilleshög HIL2368	233	321.1	102	10185	92	1.07	46.00	105	1447	94	17.11	31.98	115	1608	374	0	63.4
Hilleshög HIL2385	201	320.4	102	10969	99	0.99	45.81	104	1563	101	17.01	34.25	100	1488	353	0	72.5
Hilleshög HIL2386	238	313.4	100	11537	104	1.10	43.71	100	1596	103	16.75	37.05	132	1639	383	0	69.4
Hilleshög HIL2387	213	310.3	99	10610	96	1.04	42.81	98	1454	94	16.54	34.42	100	1571	365	0	75.1
Hilleshög HIL2388	225	324.6	103	11497	104	0.99	47.01	107	1661	108	17.20	35.52	109	1523	341	0	67.7
Hilleshög HIL2389	234	315.4	100	11330	102	1.02	44.31	101	1586	103	16.76	36.24	106	1676	322	0	74.9
Maribo MA930	210	310.3	99	12448	113	1.13	42.82	98	1706	111	16.64	40.47	111	1689	404	0	72.8
Maribo MA931	219	301.8	96	10783	97	1.08	40.27	92	1437	93	16.17	35.85	125	1655	372	0	60.0
Maribo MA932	231	313.1	100	11318	102	1.05	43.63	99	1570	102	16.70	36.27	117	1653	349	0	71.2
SV 203	239	325.3	104	11600	105	1.04	47.21	108	1678	109	17.31	35.68	104	1682	338	0	60.1
SV 211	224	322.0	103	10824	98	1.01	46.28	106	1549	100	17.10	33.76	91	1656	326	0	59.3
SV 213	206	318.5	101	12343	112	1.10	45.24	103	1746	113	17.01	39.05	112	1663	386	0	62.5
SV 214	245	306.4	98	9852	89	1.17	41.66	95	1329	86	16.50	32.29	113	1701	441	0	74.8
SV 215	221	313.6	100	11510	104	1.15	43.78	100	1605	104	16.83	36.74	110	1762	402	0	64.1
SX 1804	228	317.2	101	12028	109	1.04	44.85	102	1695	110	16.88	38.16	100	1667	343	0	69.3
SX 1815	229	320.2	102	12045	109	1.03	45.74	104	1716	111	17.04	37.62	105	1632	345	0	63.4
SX 1816	202	318.4	101	11974	108	1.06	45.22	103	1690	110	16.97	37.75	112	1680	350	0	59.8
SX 1817	216	314.6	100	11924	108	1.02	44.06	100	1666	108	16.74	38.04	112	1689	321	0	65.9
SX 1818	235	313.6	100	11960	108	1.00	43.76	100	1663	108	16.67	38.30	87	1682	313	0	64.4
SX 1819	204	330.7	105	11958	108	1.04	48.85	111	1765	114	17.58	36.22	93	1702	337	0	72.5
Crystal 355RR(Check)	246	306.5	98	10664	96	1.19	41.69	95	1446	94	16.53	34.73	125	1806	421	0	64.1
BTS 8572 (Check)	247	305.9	97	11141	101	1.16	41.49	95	1507	98	16.46	36.60	102	1697	434	0	61.8
BTS 8337 (Check)	248	329.7	105	10708	97	1.11	48.54	111	1582	103	17.59	32.44	103	1791	364	0	65.7
Crystal 578RR (Check)	249	313.4	100	11731	106	1.05	43.70	100	1634	106	16.71	37.62	127	1784	311	0	66.0
BTS 8815 (Check)	250	310.2	99	11006	100	1.12	42.80	98	1521	99	16.63	35.44	143	1805	355	0	54.7
AP CHK MOD SUS RR#5	251	314.0	100	11656	105	1.05	43.89	100	1623	105	16.74	37.23	145	1642	342	0	63.9
AP CHK MOD RR#4	252	308.4	98	11084	100	1.04	42.26	96	1507	98	16.46	35.89	126	1761	304	0	54.4
Root Aphid Susc Chk#5	253	313.5	100	10821	98	1.08	43.75	100	1500	97	16.74	34.85	152	1593	372	0	57.1
AP CHK MOD SUS RR#5	254	314.5	100	11656	105	1.07	44.03	100	1627	105	16.78	37.27	125	1719	342	0	58.8
Comm Benchmark Mean		313.9		11061		1.13	43.86		1542		16.82	35.35	132	1697	374		67.7
Comm Trial Mean		310.4		12267		1.09	42.84		1691		16.61	39.56	138	1657	357		69.7
Coeff. of Var. (%)		3.0		4.0		7.4	6.3		6.5		2.6	3.4	15.9	4.8	13.2		10.6
Mean LSD (0.05)		11.1		598		0.10	3.25		131		0.51	1.67	27	96	58		9.2
Mean LSD (0.01)		14.7		790		0.13	4.29		173		0.68	2.21	36	127	76		12.2
Sig Lvl		**		**		**	**		**		**	**	**	**	*		**

2021 Data from Casselton ND Bolters based upon 60,000 seed per acre. Created 10/29/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status. Trial # = 218301

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 10.

2021 Performance of Varieties - ACSC RR Official Trial

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	307.5	98	11446	122	1.14	41.99	95	1565	119	16.52	37.21	134	1527	428	0	86.5
BTS 8882	112	309.7	98	10475	112	1.15	42.63	97	1440	110	16.64	33.85	123	1657	409	0	82.3
BTS 8927	101	322.5	102	10323	110	1.02	46.36	105	1485	113	17.15	32.02	137	1462	355	0	78.4
BTS 8938	113	320.0	102	10932	117	1.15	45.64	103	1561	119	17.15	34.20	120	1500	449	0	72.9
BTS 8961	110	312.6	99	10932	117	1.11	43.49	98	1519	116	16.74	34.98	133	1653	375	0	83.9
Crystal 572	125	322.2	102	10165	108	1.12	46.30	105	1458	111	17.23	31.61	107	1558	413	0	84.1
Crystal 684	124	310.1	98	11085	118	1.17	42.76	97	1525	116	16.68	35.80	146	1681	411	0	83.6
Crystal 793	107	328.6	104	11192	119	1.00	48.15	109	1640	125	17.42	34.06	113	1491	337	0	84.6
Crystal 796	108	313.8	100	10788	115	1.19	43.84	99	1505	114	16.88	34.40	134	1640	434	0	87.2
Crystal 803	115	321.7	102	10978	117	1.09	46.13	104	1576	120	17.18	34.11	110	1578	389	0	85.7
Crystal 804	114	311.7	99	11264	120	1.13	43.20	98	1561	119	16.71	36.14	147	1600	394	0	85.4
Crystal 913	118	315.9	100	10547	113	1.07	44.44	101	1484	113	16.86	33.39	133	1575	359	0	83.1
Hilleshög HIL2317	120	314.8	100	9464	101	1.20	44.13	100	1323	101	16.94	30.15	132	1675	436	0	78.9
Hilleshög HIL9528	109	305.2	97	9905	106	1.18	41.31	94	1338	102	16.44	32.48	155	1603	432	0	77.4
Hilleshög HIL9708	123	309.5	98	9741	104	1.10	42.56	96	1341	102	16.57	31.42	150	1600	374	0	82.8
Hilleshög HIL9920	117	316.9	101	9821	105	1.19	44.75	101	1383	105	17.03	31.03	147	1702	418	0	77.1
Maribo MA504	106	303.8	96	10096	108	1.16	40.91	93	1360	103	16.35	33.25	136	1631	416	0	86.7
Maribo MA717	121	303.9	96	10245	109	1.20	40.93	93	1379	105	16.40	33.68	159	1599	452	0	79.2
Maribo MA902	119	303.2	96	9404	100	1.17	40.73	92	1261	96	16.33	31.05	168	1609	418	0	89.1
SV 265	105	320.9	102	10383	111	1.14	45.90	104	1484	113	17.18	32.43	118	1684	391	0	84.1
SV 268	116	321.3	102	10538	112	1.14	46.02	104	1511	115	17.20	32.77	104	1694	393	0	87.5
SV 285	111	321.7	102	10346	110	1.16	46.16	104	1484	113	17.25	32.10	112	1673	415	0	84.4
SV 375	102	315.2	100	10282	110	1.15	44.25	100	1443	110	16.92	32.61	123	1660	409	0	85.9
SX 1888	104	308.3	98	9525	102	1.26	42.21	96	1305	99	16.68	30.88	130	1666	490	0	84.6
SX 1898	122	319.2	101	9783	104	1.18	45.41	103	1391	106	17.14	30.66	130	1657	430	0	80.2
Crystal 355RR(Check)	126	307.8	98	8429	90	1.23	42.06	95	1150	87	16.62	27.42	124	1715	449	0	83.9
BTS 8572 (Check)	127	315.6	100	9468	101	1.19	44.35	100	1331	101	16.98	30.02	117	1599	458	0	84.4
BTS 8337 (Check)	128	324.0	103	9798	105	1.22	46.82	106	1417	108	17.42	30.25	121	1682	452	0	77.3
Crystal 578RR (Check)	129	312.6	99	9786	104	1.19	43.47	98	1361	104	16.82	31.32	146	1684	423	0	90.4
AP CHK MOD SUS RR#5	130	310.3	99	9832	105	1.17	42.81	97	1358	103	16.69	31.67	139	1653	419	0	81.0
AP CHK MOD RR#4	131	311.5	99	9668	103	1.11	43.16	98	1340	102	16.69	31.05	148	1586	387	0	81.5
Root Aphid Susc Chk#5	132	305.1	97	9890	106	1.21	41.27	93	1336	102	16.46	32.42	163	1650	440	0	80.7
Experimental Trial (Comm status)																	
BTS 8018	232	324.4	103	11564	123	0.96	46.90	106	1677	128	17.21	35.10	106	1449	312	0	87.9
BTS 8034	222	309.8	98	11040	118	1.10	42.67	97	1523	116	16.60	35.47	135	1682	344	0	90.0
BTS 8073	207	321.4	102	11121	119	1.08	46.04	104	1591	121	17.16	34.43	118	1479	386	0	86.5
BTS 8092	236	323.5	103	11328	121	1.09	46.65	106	1622	123	17.25	35.33	130	1438	401	0	92.4
BTS 8100	212	323.1	103	10504	112	1.12	46.55	105	1521	116	17.32	31.96	128	1619	381	0	90.2
BTS 8122	226	341.4	108	10212	109	0.97	51.84	117	1546	118	18.05	29.66	98	1470	309	0	79.9
BTS 8133	227	305.6	97	11176	119	1.19	41.47	94	1515	115	16.47	36.54	151	1703	399	0	89.7
BTS 8140	243	321.5	102	10507	112	1.10	46.07	104	1503	114	17.17	32.68	134	1551	377	0	85.7
BTS 8156	223	311.8	99	10424	111	1.05	43.24	98	1446	110	16.64	33.55	121	1620	325	0	89.8
BTS 8164	211	310.5	99	9763	104	1.28	42.88	97	1347	102	16.80	31.44	150	1705	463	0	87.8
BTS 8187	220	325.6	103	10310	110	1.17	47.26	107	1498	114	17.46	31.36	127	1546	433	0	82.1
Crystal 021	208	313.4	100	11156	119	1.06	43.74	99	1559	119	16.74	35.43	136	1645	316	0	87.8
Crystal 022	241	323.4	103	10121	108	1.08	46.62	106	1447	110	17.25	31.38	109	1519	377	0	84.9
Crystal 025	244	319.3	101	10033	107	1.12	45.44	103	1432	109	17.09	31.51	128	1584	381	0	84.0
Crystal 029	240	316.3	100	10686	114	1.13	44.56	101	1496	114	16.94	33.55	122	1536	414	0	83.0
Crystal 130	230	326.1	104	11249	120	0.96	47.41	107	1626	124	17.26	34.61	93	1444	314	0	87.9
Crystal 132	218	319.5	101	9998	107	1.12	45.48	103	1422	108	17.09	31.38	142	1450	415	0	81.7
Crystal 134	214	331.5	105	10461	112	1.03	48.96	111	1538	117	17.61	31.59	104	1466	358	0	78.0
Crystal 137	203	317.3	101	11319	121	1.05	44.83	101	1600	122	16.92	35.63	130	1630	317	0	82.8
Crystal 138	205	321.0	102	10830	116	1.09	45.90	104	1547	118	17.14	33.65	112	1509	389	0	89.0
Crystal 912	242	320.6	102	11619	124	1.17	45.81	104	1658	126	17.21	36.36	168	1480	433	0	80.6
Hilleshög HIL2320	217	313.2	99	9707	104	1.19	43.68	99	1366	104	16.85	31.02	158	1606	420	0	86.3
Hilleshög HIL2366	215	310.3	99	9611	103	1.13	42.81	97	1318	100	16.65	30.77	150	1525	406	0	77.6
Hilleshög HIL2367	237	306.8	97	9713	104	1.22	41.83	95	1324	101	16.56	31.59	149	1602	444	0	90.8
Hilleshög HIL2368	233	320.7	102	9191	98	1.21	45.84	104	1309	100	17.24	28.43	126	1571	457	0	87.5
Hilleshög HIL2385	201	315.2	100	8913	95	1.24	44.24	100	1248	95	16.98	28.38	131	1580	479	0	91.9
Hilleshög HIL2386	238	312.9	99	9639	103	1.20	43.56	99	1346	102	16.85	30.66	140	1615	434	0	88.6
Hilleshög HIL2387	213	312.8	99	9470	101	1.16	43.54	99	1316	100	16.78	30.82	140	1559	420	0	83.5
Hilleshög HIL2388	225	310.0	98	9199	98	1.15	42.73	97	1266	96	16.65	29.74	138	1545	412	0	85.3
Hilleshög HIL2389	234	316.6	101	9862	105	1.10	44.66	101	1397	106	16.95	31.00	108	1550	385	0	81.3
Maribo MA930	210	302.8	96	9732	104	1.28	40.64	92	1308	99	16.42	32.28	151	1569	503	0	87.2
Maribo MA931	219	315.0	100	10433	111	1.34	44.20	100	1465	111	17.10	33.00	177	1668	516	0	82.4
Maribo MA932	231	310.5	99	9748	104	1.23	42.89	97	1333	101	16.74	31.43	168	1565	465	0	82.2
SV 203	239	325.9	103	9517	102	1.17	47.33	107	1380	105	17.47	29.13	118	1620	422	0	86.9
SV 211	224	322.9	103	9214	98	1.10	46.49	105	1331	101	17.24	28.93	123	1623	362	0	83.5
SV 213	206	322.7	102	9713	104	1.19	46.43	105	1395	106	17.34	30.12	110	1570	450	0	88.0
SV 214	245	304.2	97	8169	87	1.39	41.06	93	1102	84	16.59	26.93	125	1621	580	0	87.9
SV 215	221	319.7	101	9605	103	1.21	45.53	103	1368	104	17.18	30.13	124	1642	446	0	75.1
SX 1804	228	325.9	103	9812	105	1.15	47.34	107	1435	109	17.44	30.03	118	1650	393	0	83.7
SX 1815	229	322.7	102	9963	106	1.11	46.41	105	1435	109	17.25	31.01	107	1563	396	0	86.5
SX 1816	202	315.5	100	10100	108	1.25	44.34	100	1422	108	17.00	32.13	139	1684	451	0	76.7
SX 1817	216	314.2	100	9850	105	1.15	43.97	100	1389	106	16.88	30.93	121	1578	409	0	83.6
SX 1818	235	315.1	100	10376	111	1.06	44.24	100	1453	110	16.82	32.81	104	1573	356	0	82.2
SX 1819	204	308.0	98	9677	103	1.17	42.15	95	1315	100	16.58	31.42	107	1585	440	0	89.0
Crystal 355RR(Check)	246	309.1	98	8681	93	1.24	42.46	96	1188	90	16.70	28.15	129	1672	454	0	87.5
BTS 8572 (Check)	247	319.2	101	9575	102	1.16	45.39	103	1363	104	17.11	29.99	116	1582	422	0	77.5
BTS 8337 (Check)	248	318.6	101	9117	97	1.24	45.21	102	1295	99	17.18	28.60	129	1692	447	0	77.9
Crystal 578RR (Check)	249	313.1	99	10109	108	1.19	43.63	99	1412	107	16.85	32.27	152	1622	425	0	83.0
BTS 8815 (Check)	250	322.3	102	9314	99	1.17	46.32	105	1342	102	17.30	28.92	143	1675	393	0	77.5
AP CHK MOD SUS RR#5	251	318.7	101	10078	108	1.13	45.25	102	1427	109	17.06	31.35	130	1607	386	0	82.1
AP CHK MOD RR#4	252	313.6	100	9477	101	1.10	43.79	99	1318	100	16.78	30.20	156	1574	368	0	90.0
Root Aphid Susc Chk#5	253	311.8	99	8888	95	1.18	43.24	98	1240	94	16.77	28.40	147	1616	410	0	82.3
AP CHK MOD SUS RR#5	254	313.4	100	9798	105	1.15	43.75	99	1379	105	16.81	31.64	131	1627	390	0	84.9
Comm Benchmark Mean		315.0		9370		1.21	44.18		1315		16.96	29.75	127	1670	445		84.0
Comm Trial Mean		314.0		10204		1.15	43.88		1425		16.85	32.51	133	1623	414		83.0
Coeff. of Var. (%)		2.3		3.8		6.1	4.8		5.5		2.0	3.2	16.9	4.1	10.1		6.9
Mean LSD (0.05)		9.1		488		0.09	2.66		100		0.41	1.34	28	82	53		6.5
Mean LSD (0.01)		12.0		645		0.12	3.51		132		0.54	1.77	37	109	71		8.6
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2021 Data from Glyndon MN   Bolters based upon 60,000 seed per acre.   Created 10/29/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status.   Trial # = 218302

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 11 .

2021 Performance of Varieties - ACSC RR Official Trial

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	312.4	96	11207	116	1.19	43.42	91	1556	111	16.80	35.82	154	1575	449	0	86.0
BTS 8882	112	314.7	96	10796	112	1.23	44.08	93	1509	107	16.96	34.33	163	1798	419	0	88.0
BTS 8927	101	335.1	103	10940	113	0.98	50.07	105	1637	116	17.75	32.68	115	1575	304	0	77.3
BTS 8938	113	330.1	101	10977	114	0.99	48.61	102	1615	115	17.49	33.21	116	1587	307	0	72.8
BTS 8961	110	323.1	99	10965	113	1.17	46.55	98	1579	112	17.31	33.90	165	1723	385	0	85.7
Crystal 572	125	323.6	99	9860	102	1.25	46.70	98	1420	101	17.43	30.51	136	1725	457	0	82.2
Crystal 684	124	317.7	97	10756	111	1.29	44.98	95	1519	108	17.18	33.91	161	1821	460	0	83.6
Crystal 793	107	328.8	101	10736	111	1.14	48.23	102	1575	112	17.59	32.73	144	1698	391	0	85.7
Crystal 796	108	325.1	100	10829	112	1.21	47.16	99	1565	111	17.47	33.45	146	1790	406	0	86.4
Crystal 803	115	327.4	100	10718	111	1.24	47.81	101	1562	111	17.60	32.77	139	1765	437	0	85.8
Crystal 804	114	317.0	97	10907	113	1.20	44.76	94	1541	110	17.06	34.37	191	1723	408	0	86.2
Crystal 913	118	338.8	104	10392	108	1.15	51.17	108	1566	111	18.10	30.68	139	1651	406	0	85.7
Hilleshög HIL2317	120	338.1	104	9881	102	1.20	50.96	107	1484	105	18.09	29.32	159	1815	383	0	74.7
Hilleshög HIL9528	109	328.3	101	9960	103	1.14	48.09	101	1458	104	17.56	30.38	167	1670	377	0	79.6
Hilleshög HIL9708	123	329.5	101	10255	106	1.13	48.44	102	1506	107	17.62	31.20	149	1693	374	0	89.1
Hilleshög HIL9920	117	331.7	102	9875	102	1.26	49.06	103	1461	104	17.83	29.78	171	1856	413	0	82.3
Maribo MA504	106	315.5	97	10410	108	1.23	44.33	93	1466	104	17.02	32.94	199	1739	417	0	84.7
Maribo MA717	121	320.0	98	10185	105	1.20	45.65	96	1455	103	17.20	31.88	168	1725	406	0	77.1
Maribo MA902	119	328.0	101	10287	106	1.09	47.98	101	1505	107	17.47	31.31	142	1668	347	0	87.4
SV 265	105	333.8	102	10260	106	1.16	49.70	105	1523	108	17.85	30.85	127	1779	372	0	83.0
SV 268	116	318.9	98	10152	105	1.26	45.34	95	1447	103	17.20	31.76	153	1727	462	0	86.8
SV 285	111	334.0	102	10196	105	1.15	49.74	105	1524	108	17.85	30.44	125	1756	378	0	88.6
SV 375	102	324.1	99	10181	105	1.16	46.85	99	1468	104	17.36	31.50	126	1775	385	0	87.2
SX 1888	104	323.6	99	9932	103	1.16	46.71	98	1427	101	17.33	30.74	137	1689	405	0	82.1
SX 1898	122	325.1	100	10214	106	1.21	47.15	99	1484	105	17.47	31.42	142	1742	425	0	83.2
Crystal 355RR(Check)	126	324.0	99	9144	95	1.22	46.81	99	1317	94	17.42	28.28	131	1860	404	0	90.4
BTS 8572 (Check)	127	322.4	99	9848	102	1.22	46.35	98	1420	101	17.33	30.45	129	1713	442	0	84.3
BTS 8337 (Check)	128	335.4	103	9784	101	1.20	50.17	106	1464	104	17.97	29.15	134	1825	397	0	80.5
Crystal 578RR (Check)	129	323.2	99	9891	102	1.15	46.59	98	1426	101	17.31	30.60	153	1716	380	0	93.0
AP CHK MOD SUS RR#5	130	329.5	101	10131	105	1.11	48.44	102	1493	106	17.59	30.72	151	1723	350	0	83.1
AP CHK MOD RR#4	131	324.2	99	10533	109	1.09	46.88	99	1522	108	17.31	32.53	138	1759	329	0	83.8
Root Aphid Susc Chk#5	132	322.7	99	10161	105	1.15	46.44	98	1453	103	17.30	31.69	177	1692	383	0	82.8
Experimental Trial (Comm status)																	
BTS 8018	232	319.1	98	10969	113	1.05	45.36	96	1581	112	17.01	34.21	126	1661	322	0	87.3
BTS 8034	222	317.8	97	12417	128	1.10	44.96	95	1768	126	16.99	38.97	155	1759	321	0	88.0
BTS 8073	207	321.1	98	10522	109	1.24	45.96	97	1516	108	17.27	32.64	128	1704	449	0	80.6
BTS 8092	236	326.0	100	11425	118	1.01	47.41	100	1677	119	17.31	34.83	118	1557	321	0	83.4
BTS 8100	212	326.4	100	10615	110	1.16	47.53	100	1558	111	17.47	32.32	114	1797	373	0	89.4
BTS 8122	226	349.2	107	10572	109	1.06	54.31	114	1661	118	18.50	30.01	109	1664	331	0	78.4
BTS 8133	227	327.6	100	10732	111	1.09	47.88	101	1574	112	17.46	32.59	132	1846	295	0	90.3
BTS 8140	243	328.7	101	10911	113	1.15	48.21	102	1612	115	17.56	32.84	113	1669	396	0	88.0
BTS 8156	223	323.3	99	10798	112	1.04	46.62	98	1558	111	17.20	33.33	128	1798	271	0	90.4
BTS 8164	211	321.1	98	10051	104	1.24	45.97	97	1442	103	17.30	31.28	129	1796	420	0	84.8
BTS 8187	220	324.5	99	9787	101	1.22	46.96	99	1423	101	17.41	29.85	125	1766	415	0	78.4
Crystal 021	208	321.7	99	11641	120	1.18	46.14	97	1660	118	17.25	36.21	136	1778	382	0	84.1
Crystal 022	241	331.5	102	10950	113	1.10	49.05	103	1616	115	17.69	33.07	110	1667	362	0	88.1
Crystal 025	244	318.8	98	11346	117	1.22	45.27	95	1608	114	17.13	35.57	130	1742	419	0	75.9
Crystal 029	240	315.1	97	9824	102	1.15	44.19	93	1391	99	16.90	30.94	121	1693	387	0	85.1
Crystal 130	230	329.9	101	11291	117	1.05	48.57	102	1673	119	17.54	33.99	118	1668	323	0	84.0
Crystal 132	218	323.7	99	10745	111	1.12	46.73	98	1555	111	17.30	33.05	130	1653	376	0	77.0
Crystal 134	214	338.8	104	10420	108	1.00	51.20	108	1578	112	17.95	30.85	112	1596	302	0	77.9
Crystal 137	203	323.1	99	11757	122	1.09	46.57	98	1685	120	17.23	36.39	126	1814	307	0	88.5
Crystal 138	205	329.6	101	11183	116	1.11	48.48	102	1661	118	17.60	33.80	110	1673	368	0	84.5
Crystal 912	242	317.9	97	12311	127	1.10	45.00	95	1743	124	17.00	38.70	149	1577	370	0	85.1
Hilleshög HIL2320	217	333.5	102	10223	106	1.13	49.62	105	1530	109	17.81	30.51	136	1740	361	0	80.4
Hilleshög HIL2366	215	332.2	102	10501	109	1.08	49.26	104	1565	111	17.69	31.49	127	1621	348	0	90.3
Hilleshög HIL2367	237	331.6	102	10594	110	1.16	49.08	103	1572	112	17.74	31.92	131	1719	393	0	85.8
Hilleshög HIL2368	233	339.8	104	9648	100	1.12	51.50	108	1472	105	18.09	28.29	133	1634	377	0	87.2
Hilleshög HIL2385	201	336.5	103	10510	109	1.21	50.52	106	1571	112	18.02	31.38	128	1702	423	0	84.0
Hilleshög HIL2386	238	322.6	99	10374	107	1.19	46.40	98	1501	107	17.28	31.87	151	1728	400	0	79.4
Hilleshög HIL2387	213	332.7	102	10371	107	1.04	49.40	104	1540	109	17.63	30.96	122	1668	315	0	89.5
Hilleshög HIL2388	225	323.0	99	9783	101	1.18	46.52	98	1406	100	17.36	30.41	160	1640	411	0	85.8
Hilleshög HIL2389	234	325.6	100	10427	108	1.13	47.28	100	1518	108	17.44	32.09	129	1697	373	0	88.2
Maribo MA930	210	310.9	95	10155	105	1.40	42.91	90	1424	101	16.89	32.22	182	1760	539	0	93.9
Maribo MA931	219	328.9	101	10152	105	1.19	48.27	102	1492	106	17.62	30.86	159	1756	385	0	90.2
Maribo MA932	231	324.6	99	10419	108	1.13	46.98	99	1514	108	17.38	32.02	161	1713	356	0	88.1
SV 203	239	334.5	103	10810	112	1.13	49.92	105	1620	115	17.85	32.25	116	1762	362	0	84.0
SV 211	224	328.4	101	10359	107	1.16	48.14	101	1527	109	17.56	31.32	129	1770	377	0	85.7
SV 213	206	317.1	97	10127	105	1.14	44.76	94	1440	102	17.00	31.82	125	1612	399	0	82.9
SV 214	245	313.0	96	8679	90	1.35	43.56	92	1232	88	16.97	27.48	127	1834	494	0	90.2
SV 215	221	325.5	100	10309	107	1.22	47.25	100	1515	108	17.48	31.47	132	1796	408	0	83.4
SX 1804	228	329.9	101	10438	108	1.15	48.58	102	1522	108	17.64	31.74	120	1729	378	0	87.2
SX 1815	229	338.8	104	10829	112	1.15	51.20	108	1638	116	18.06	31.81	131	1771	362	0	89.9
SX 1816	202	325.2	100	11118	115	1.21	47.15	99	1617	115	17.46	34.13	143	1828	381	0	79.5
SX 1817	216	325.8	100	10479	108	1.15	47.33	100	1523	108	17.42	31.97	123	1796	367	0	89.1
SX 1818	235	328.6	101	10866	112	1.09	48.18	101	1585	113	17.50	33.03	101	1700	354	0	86.5
SX 1819	204	324.6	99	10174	105	1.17	46.98	99	1476	105	17.38	31.24	117	1779	386	0	84.6
Crystal 355RR(Check)	246	324.2	99	7847	81	1.27	46.87	99	1122	80	17.49	24.44	123	1848	439	0	88.4
BTS 8572 (Check)	247	324.7	100	9499	98	1.18	47.00	99	1369	97	17.44	29.45	131	1704	407	0	78.0
BTS 8337 (Check)	248	327.6	100	10187	105	1.26	47.87	101	1488	106	17.60	30.95	123	1831	430	0	77.8
Crystal 578RR (Check)	249	328.6	101	11135	115	1.08	48.18	101	1649	117	17.51	33.64	129	1775	313	0	89.7
BTS 8815 (Check)	250	339.8	104	10790	112	1.05	51.52	109	1633	116	18.00	31.60	137	1755	294	0	82.7
AP CHK MOD SUS RR#5	251	334.8	103	10759	111	1.06	50.01	105	1601	114	17.77	32.02	138	1761	294	0	86.5
AP CHK MOD RR#4	252	323.5	99	10296	107	1.07	46.67	98	1487	106	17.23	31.79	119	1786	304	0	82.2
Root Aphid Susc Chk#5	253	324.7	100	9660	100	1.07	47.01	99	1414	101	17.30	29.50	141	1682	326	0	77.2
AP CHK MOD SUS RR#5	254	323.8	99	10853	112	1.06	46.78	99	1566	111	17.26	33.54	140	1737	297	0	81.1
Comm Benchmark Mean		326.3		9667		1.20	47.48		1407		17.51	29.62	137	1779	406		87.0
Comm Trial Mean		325.8		10324		1.17	47.35		1498		17.46	31.73	148	1730	396		84.0
Coeff. of Var. (%)		2.8		5.1		6.8	5.6		7.0		2.4	4.4	18.9	4.4	13.0		6.5
Mean LSD (0.05)		11.2		671		0.10	3.28		132		0.52	1.79	34	87	65		6.6
Mean LSD (0.01)		14.8		887		0.13	4.33		174		0.68	2.36	45	114	86		8.8
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2021 Data from Georgetown MN   Bolters based upon 60,000 seed per acre.   Created 10/29/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status.   Trial # = 218303

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 12 .

2021 Performance of Varieties - ACSC RR Official Trial

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	320.4	96	11116	110	1.05	45.75	92	1591	106	17.06	34.72	121	1508	375	0	90.1
BTS 8882	112	323.4	97	11138	110	1.19	46.63	94	1611	107	17.36	34.45	133	1742	408	0	89.8
BTS 8927	101	336.3	101	9786	97	1.01	50.41	102	1470	98	17.82	29.11	126	1501	331	0	79.7
BTS 8938	113	329.1	99	11001	109	1.03	48.33	97	1618	108	17.48	33.46	115	1511	358	0	80.5
BTS 8961	110	329.1	99	11439	113	1.09	48.32	97	1676	112	17.55	34.75	124	1656	355	0	84.4
Crystal 572	125	336.7	101	10087	100	1.06	50.53	102	1516	101	17.89	30.00	107	1547	374	0	91.4
Crystal 684	124	313.1	94	9990	99	1.12	43.61	88	1390	93	16.79	31.81	140	1707	362	0	89.1
Crystal 793	107	336.9	101	10984	109	1.00	50.60	102	1657	111	17.85	32.44	105	1496	335	0	85.7
Crystal 796	108	321.9	97	10532	104	1.13	46.22	93	1498	100	17.21	33.08	136	1677	382	0	87.0
Crystal 803	115	332.2	100	10793	107	1.14	49.22	99	1611	107	17.76	32.18	115	1652	399	0	88.5
Crystal 804	114	328.8	99	11093	110	1.03	48.24	97	1630	109	17.48	33.67	132	1603	326	0	85.7
Crystal 913	118	335.5	101	10428	103	0.97	50.19	101	1558	104	17.75	31.11	115	1467	321	0	90.1
Hilleshög HIL2317	120	319.2	96	9671	96	1.02	45.42	92	1363	91	16.98	30.53	156	1570	314	0	83.6
Hilleshög HIL9528	109	305.3	92	8943	88	1.01	41.32	83	1209	81	16.26	29.30	185	1533	311	0	87.0
Hilleshög HIL9708	123	316.6	95	9989	99	1.00	44.64	90	1414	94	16.83	31.36	162	1509	316	0	87.0
Hilleshög HIL9920	117	334.1	100	10636	105	1.08	49.78	100	1585	106	17.79	31.83	124	1700	346	0	84.4
Maribo MA504	106	320.6	96	10498	104	1.08	45.83	92	1488	99	17.11	33.03	157	1570	360	0	90.1
Maribo MA717	121	300.4	90	8837	87	0.93	39.89	80	1180	79	15.95	29.30	171	1500	263	0	81.3
Maribo MA902	119	317.4	95	9865	97	1.04	44.87	90	1391	93	16.91	31.20	161	1529	335	0	90.4
SV 265	105	303.3	91	8889	88	0.92	40.76	82	1195	80	16.08	29.33	151	1477	268	0	87.0
SV 268	116	327.2	98	10691	106	1.09	47.76	96	1567	105	17.46	32.48	113	1616	373	0	95.3
SV 285	111	329.3	99	10264	101	1.03	48.38	98	1510	101	17.48	31.30	118	1594	333	0	89.8
SV 375	102	326.1	98	9985	99	1.03	47.44	96	1456	97	17.35	30.35	117	1570	338	0	89.3
SX 1888	104	325.0	97	10152	100	1.08	47.10	95	1471	98	17.34	31.17	118	1590	373	0	87.5
SX 1898	122	327.5	98	9573	95	1.00	47.83	96	1402	94	17.37	29.18	116	1559	327	0	87.8
Crystal 355RR(Check)	126	330.8	99	9522	94	1.21	48.82	98	1396	93	17.75	29.01	130	1735	430	0	87.0
BTS 8572 (Check)	127	335.8	101	10356	102	1.04	50.28	101	1546	103	17.83	30.93	109	1555	357	0	79.2
BTS 8337 (Check)	128	336.2	101	9851	97	1.14	50.39	102	1471	98	17.95	29.38	122	1716	379	0	84.6
Crystal 578RR (Check)	129	331.0	99	10743	106	1.08	48.86	99	1583	106	17.63	32.50	134	1622	355	0	89.9
AP CHK MOD SUS RR#5	130	335.8	101	10695	106	1.08	50.29	101	1598	107	17.87	31.79	114	1666	357	0	88.0
AP CHK MOD RR#4	131	320.1	96	10452	103	1.09	45.68	92	1498	100	17.09	32.56	146	1668	349	0	90.6
Root Aphid Susc Chk#5	132	302.8	91	9463	94	1.02	40.60	82	1275	85	16.15	31.20	181	1566	310	0	83.3
Experimental Trial (Comm status)																	
BTS 8018	232	326.6	98	11747	116	1.01	47.57	96	1710	114	17.34	36.04	113	1548	356	0	87.9
BTS 8034	222	324.0	97	12423	123	1.04	46.77	94	1787	119	17.24	38.47	125	1752	331	0	91.0
BTS 8073	207	333.2	100	11242	111	1.05	49.53	100	1668	111	17.72	33.81	106	1537	400	0	84.0
BTS 8092	236	328.6	99	12377	122	1.02	48.16	97	1808	121	17.46	37.76	110	1503	375	0	90.2
BTS 8100	212	339.9	102	11100	110	1.03	51.46	104	1678	112	18.03	32.75	98	1624	355	0	92.2
BTS 8122	226	343.9	103	10335	102	0.99	52.66	106	1572	105	18.18	30.41	111	1548	341	0	84.8
BTS 8133	227	329.0	99	11773	116	1.10	48.28	97	1725	115	17.56	35.88	122	1784	369	0	89.5
BTS 8140	243	330.7	99	10419	103	1.08	48.78	98	1526	102	17.61	31.76	114	1634	396	0	91.8
BTS 8156	223	341.5	102	11992	119	1.07	51.94	105	1818	121	18.16	35.20	128	1704	361	0	92.6
BTS 8164	211	335.9	101	10822	107	1.07	50.32	101	1624	108	17.86	32.16	109	1659	384	0	86.7
BTS 8187	220	346.4	104	10696	106	1.08	53.39	108	1649	110	18.39	30.96	101	1649	395	0	81.6
Crystal 021	208	329.6	99	11752	116	1.08	48.45	98	1727	115	17.58	35.58	138	1691	363	0	83.2
Crystal 022	241	339.9	102	11451	113	1.00	51.48	104	1725	115	17.98	33.89	109	1543	349	0	86.7
Crystal 025	244	333.4	100	12063	119	1.05	49.59	100	1787	119	17.73	36.23	121	1605	375	86	80.9
Crystal 026	209	322.6	97	11305	112	1.12	46.38	94	1615	108	17.25	35.33	133	1770	385	0	87.9
Crystal 029	240	332.3	100	11419	113	1.06	49.26	99	1686	112	17.69	34.45	113	1603	387	0	91.0
Crystal 130	230	330.9	99	12178	120	0.99	48.83	98	1786	119	17.54	37.02	123	1556	330	0	89.9
Crystal 132	218	338.0	101	11245	111	0.99	50.90	103	1688	113	17.88	33.37	117	1457	358	0	87.1
Crystal 134	214	347.4	104	10823	107	0.94	53.70	108	1669	111	18.30	31.29	102	1510	317	0	83.6
Crystal 137	203	326.5	98	12060	119	1.09	47.53	96	1741	116	17.40	37.31	129	1767	358	0	88.7
Crystal 138	205	338.7	102	11220	111	1.03	51.13	103	1687	113	17.96	33.35	99	1543	373	0	83.6
Crystal 912	242	329.5	99	12637	125	1.00	48.40	98	1845	123	17.47	38.51	124	1490	356	0	88.7
Hilleshög HIL2320	217	314.0	94	9803	97	1.03	43.85	88	1367	91	16.73	31.24	147	1593	344	0	90.6
Hilleshög HIL2366	215	329.1	99	10851	107	0.98	48.29	97	1589	106	17.42	33.08	113	1524	341	0	89.5
Hilleshög HIL2367	237	327.9	98	10120	100	1.02	47.96	97	1477	99	17.41	30.93	127	1551	354	0	88.7
Hilleshög HIL2368	233	332.9	100	9615	95	1.03	49.42	100	1429	95	17.68	28.89	118	1511	378	0	94.9
Hilleshög HIL2385	201	327.1	98	9853	97	1.04	47.70	96	1438	96	17.40	30.01	112	1567	368	0	91.0
Hilleshög HIL2386	238	328.0	98	10507	104	1.06	47.96	97	1532	102	17.45	32.21	137	1674	364	0	85.9
Hilleshög HIL2387	213	331.1	99	9843	97	0.99	48.89	99	1451	97	17.54	29.78	140	1532	337	0	87.1
Hilleshög HIL2388	225	322.8	97	10260	101	0.97	46.43	94	1470	98	17.09	32.01	145	1480	333	0	92.6
Hilleshög HIL2389	234	324.8	97	10422	103	1.05	47.03	95	1506	100	17.30	32.19	124	1597	371	0	90.2
Maribo MA930	210	318.3	95	10721	106	1.25	45.12	91	1511	101	17.15	33.92	152	1730	484	0	91.4
Maribo MA931	219	321.8	96	10529	104	1.07	46.13	93	1509	101	17.18	32.77	135	1600	385	0	86.3
Maribo MA932	231	329.4	99	10239	101	1.04	48.38	98	1500	100	17.53	31.33	118	1561	380	0	88.3
SV 203	239	330.4	99	10346	102	1.07	48.70	98	1519	101	17.60	31.43	109	1672	377	0	90.2
SV 211	224	326.8	98	10079	100	1.05	47.60	96	1465	98	17.41	30.77	115	1663	357	0	90.2
SV 213	206	335.5	101	10453	103	0.98	50.20	101	1562	104	17.75	31.31	93	1509	344	0	90.2
SV 214	245	314.3	94	8225	81	1.24	43.95	89	1150	77	16.96	26.18	118	1725	488	0	87.1
SV 215	221	314.8	94	10056	99	1.03	44.10	89	1407	94	16.76	31.92	123	1570	360	0	84.0
SX 1804	228	319.6	96	10154	100	1.07	45.52	92	1441	96	17.04	31.86	129	1653	381	0	89.1
SX 1815	229	334.0	100	11315	112	0.98	49.75	100	1679	112	17.67	33.99	107	1562	332	0	90.2
SX 1816	202	330.1	99	11224	111	1.07	48.61	98	1643	110	17.58	34.08	112	1661	379	0	82.8
SX 1817	216	329.0	99	10936	108	1.03	48.27	97	1601	107	17.48	33.27	103	1635	355	0	89.5
SX 1818	235	326.4	98	11253	111	1.04	47.49	96	1636	109	17.35	34.57	109	1594	369	0	88.3
SX 1819	204	320.7	96	9946	98	1.04	45.84	92	1418	95	17.08	31.17	123	1580	364	0	83.6
Crystal 355RR(Check)	246	330.8	99	9571	95	1.15	48.81	98	1407	94	17.70	29.08	119	1736	415	0	89.5
BTS 8572 (Check)	247	334.2	100	9612	95	1.06	49.81	100	1427	95	17.76	28.97	123	1622	380	0	86.7
BTS 8337 (Check)	248	338.0	101	10247	101	1.16	50.91	103	1539	103	18.06	30.30	119	1742	422	0	87.9
Crystal 578RR (Check)	249	330.8	99	11043	109	1.09	48.82	98	1622	108	17.64	33.47	127	1690	382	0	89.1
BTS 8815 (Check)	250	338.2	101	10254	101	1.04	50.97	103	1536	102	17.94	30.47	129	1671	341	0	83.2
AP CHK MOD SUS RR#5	251	335.3	101	11189	111	1.10	50.13	101	1667	111	17.87	33.61	120	1649	402	0	86.3
AP CHK MOD RR#4	252	328.9	99	11447	113	1.05	48.25	97	1671	111	17.51	34.94	135	1699	342	0	91.8
Root Aphid Susc Chk#5	253	320.8	96	9752	96	1.06	45.86	92	1396	93	17.13	30.36	147	1562	379	0	87.1
AP CHK MOD SUS RR#5	254	330.1	99	10687	106	1.04	48.60	98	1571	105	17.55	32.57	118	1612	362	0	92.2
Comm Benchmark Mean		333.5		10118		1.12	49.59		1499		17.79	30.46	124	1657	380		85.2
Comm Trial Mean		324.6		10233		1.06	47.00		1482		17.29	31.52	133	1591	348		87.0
Coeff. of Var. (%)		3.1		7.2		6.8	6.3		9.2		2.9	6.4	19.9	4.0	12.2		6.2
Mean LSD (0.05)		11.8		914		0.09	3.45		164		0.59	2.51	33	77	53		6.2
Mean LSD (0.01)		15.6		1207		0.12	4.56		217		0.78	3.31	43	102	70		8.2
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2021 Data from Hendrum MN Bolters based upon 60,000 seed per acre. Created 11/01/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status. Trial # = 218304

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 13 .

2021 Performance of Varieties - ACSC RR Official Trial

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	260.2	96	8399	107	1.27	28.12	91	911	101	14.28	32.24	148	1797	451	0	84.8
BTS 8882	112	256.6	95	8148	104	1.34	27.08	87	862	96	14.17	31.68	171	1921	464	0	81.9
BTS 8927	101	282.7	105	8170	104	1.13	34.72	112	1004	111	15.27	28.88	131	1644	393	0	71.4
BTS 8938	113	270.1	100	8078	103	1.17	31.02	100	931	103	14.67	29.88	131	1678	412	0	67.8
BTS 8961	110	262.8	97	7816	100	1.33	28.89	93	863	96	14.47	29.61	159	1881	470	0	79.4
Crystal 572	125	274.5	102	7886	101	1.23	32.31	104	928	103	14.96	28.66	129	1718	450	0	81.4
Crystal 684	124	260.1	96	8495	108	1.30	28.10	91	924	102	14.30	32.51	161	1887	444	0	82.5
Crystal 793	107	276.9	103	8565	109	1.16	33.00	106	1022	113	15.00	30.95	125	1721	400	0	84.2
Crystal 796	108	260.5	96	8455	108	1.35	28.19	91	918	102	14.37	32.41	170	1912	476	0	82.2
Crystal 803	115	284.5	105	8734	111	1.21	35.24	114	1080	120	15.44	30.78	114	1730	435	0	78.4
Crystal 804	114	264.5	98	9169	117	1.23	29.37	95	1022	113	14.46	34.56	147	1782	427	0	83.7
Crystal 913	118	277.3	103	8176	104	1.18	33.13	107	979	109	15.04	29.54	120	1666	424	0	78.9
Hilleshög HIL2317	120	273.0	101	7703	98	1.24	31.87	103	901	100	14.89	28.16	154	1912	397	0	73.2
Hilleshög HIL9528	109	265.0	98	7673	98	1.24	29.53	95	856	95	14.49	28.94	171	1795	420	0	77.6
Hilleshög HIL9708	123	272.0	101	7424	95	1.24	31.59	102	861	96	14.84	27.32	163	1784	426	0	76.2
Hilleshög HIL9920	117	271.4	100	7799	100	1.27	31.40	101	905	100	14.83	28.69	154	1970	402	0	73.8
Maribo MA504	106	256.7	95	7354	94	1.32	27.11	87	780	86	14.17	28.59	184	1886	459	0	77.2
Maribo MA717	121	266.7	99	8108	103	1.28	30.03	97	912	101	14.62	30.38	152	1875	441	0	71.2
Maribo MA902	119	269.0	100	7633	97	1.28	30.70	99	872	97	14.73	28.31	176	1850	434	0	76.0
SV 265	105	265.0	98	7433	95	1.21	29.53	95	825	92	14.47	28.16	137	1850	401	0	74.7
SV 268	116	269.4	100	7908	101	1.25	30.83	99	903	100	14.73	29.32	131	1893	422	0	73.0
SV 285	111	281.5	104	8200	105	1.26	34.36	111	1005	112	15.34	29.00	127	1924	420	0	73.5
SV 375	102	271.7	101	8118	104	1.28	31.50	102	944	105	14.86	29.85	123	1909	439	0	78.8
SX 1888	104	272.3	101	8159	104	1.28	31.68	102	957	106	14.89	29.76	128	1892	440	0	79.4
SX 1898	122	273.2	101	8224	105	1.26	31.94	103	963	107	14.93	30.07	134	1925	420	0	74.0
Crystal 355RR(Check)	126	267.9	99	7635	97	1.35	30.37	98	870	97	14.74	28.48	137	1905	489	0	83.2
BTS 8572 (Check)	127	272.4	101	7688	98	1.32	31.69	102	893	99	14.94	28.29	132	1787	500	0	74.9
BTS 8337 (Check)	128	281.4	104	8316	106	1.27	34.33	111	1017	113	15.33	29.48	134	1893	429	0	78.0
Crystal 578RR (Check)	129	258.5	96	7705	98	1.30	27.63	89	825	92	14.23	29.73	179	1885	445	0	84.7
AP CHK MOD SUS RR#5	130	260.0	96	7868	100	1.32	28.06	91	850	94	14.31	30.31	163	1921	451	0	84.4
AP CHK MOD RR#4	131	254.0	94	7676	98	1.20	26.30	85	794	88	13.90	30.23	163	1843	381	0	84.2
Root Aphid Susc Chk#5	132	273.2	101	7651	98	1.27	31.92	103	896	99	14.93	27.95	167	1827	439	0	73.7
Experimental Trial (Comm status)																	
BTS 8018	232	277.6	103	9420	120	1.14	33.28	107	1131	126	15.02	33.62	131	1617	461	0	81.7
BTS 8034	222	260.9	97	9292	119	1.31	28.29	91	1020	113	14.36	35.23	174	1950	495	0	81.9
BTS 8073	207	270.6	100	8723	111	1.16	31.16	101	1019	113	14.67	31.98	127	1684	455	0	86.3
BTS 8092	236	262.3	97	9141	117	1.19	28.68	93	1006	112	14.29	34.61	173	1685	457	0	77.9
BTS 8100	212	272.8	101	8863	113	1.27	31.83	103	1034	115	14.91	32.50	140	1888	489	0	78.8
BTS 8122	226	296.1	110	7947	101	1.12	38.79	125	1040	115	15.90	26.87	125	1664	429	0	74.8
BTS 8133	227	253.0	94	9021	115	1.37	25.90	84	934	104	14.02	35.20	192	1982	527	0	83.5
BTS 8140	243	272.9	101	8276	106	1.22	31.86	103	961	107	14.87	30.60	135	1804	481	0	81.0
BTS 8156	223	247.6	92	8519	109	1.37	24.30	78	851	94	13.75	34.00	178	2106	496	0	85.2
BTS 8164	211	272.5	101	9002	115	1.28	31.73	102	1051	117	14.90	32.93	163	1832	505	0	74.7
BTS 8187	220	285.9	106	8760	112	1.14	35.75	115	1097	122	15.42	30.59	115	1708	443	0	82.0
Crystal 021	208	265.5	98	8933	114	1.28	29.65	96	1001	111	14.54	33.50	162	1870	485	0	75.6
Crystal 022	241	283.0	105	8937	114	1.20	34.88	112	1109	123	15.34	31.49	123	1631	507	0	78.4
Crystal 025	244	279.8	104	9210	118	1.11	33.92	109	1130	125	15.08	32.50	132	1734	395	0	79.7
Crystal 026	209	260.2	96	9521	122	1.30	28.09	91	1026	114	14.31	36.37	156	1889	506	0	76.5
Crystal 029	240	278.5	103	8641	110	1.17	33.54	108	1042	116	15.09	31.05	130	1732	456	0	81.2
Crystal 130	230	270.2	100	9106	116	1.18	31.03	100	1047	116	14.69	33.61	139	1774	460	0	85.5
Crystal 132	218	280.5	104	8992	115	1.13	34.12	110	1098	122	15.13	31.98	127	1604	448	0	77.7
Crystal 134	214	279.9	104	8219	105	1.09	33.94	109	1007	112	15.07	29.02	136	1654	411	0	75.9
Crystal 137	203	259.7	96	9122	116	1.37	27.93	90	993	110	14.37	34.47	182	2009	533	0	79.7
Crystal 138	205	272.6	101	8804	112	1.18	31.76	102	1028	114	14.79	32.24	138	1692	468	0	78.5
Crystal 912	242	269.4	100	9970	127	1.13	30.81	99	1147	127	14.57	36.87	178	1637	412	0	84.4
Hilleshög HIL2320	217	266.0	99	8430	108	1.24	29.79	96	961	107	14.51	31.38	171	1855	443	0	79.8
Hilleshög HIL2366	215	283.7	105	8316	106	1.16	35.07	113	1028	114	15.34	29.33	159	1769	435	0	89.5
Hilleshög HIL2367	237	277.1	103	8193	105	1.23	33.12	107	986	109	15.08	29.37	157	1768	476	0	81.0
Hilleshög HIL2368	233	278.5	103	7505	96	1.25	33.55	108	906	101	15.18	26.69	173	1811	486	0	79.9
Hilleshög HIL2385	201	277.5	103	8077	103	1.17	33.23	107	974	108	15.04	29.03	166	1748	435	0	80.3
Hilleshög HIL2386	238	283.9	105	8179	104	1.28	35.15	113	1017	113	15.47	28.83	171	1827	503	0	81.3
Hilleshög HIL2387	213	274.1	101	8349	107	1.18	32.22	104	987	109	14.88	30.53	153	1782	434	0	84.1
Hilleshög HIL2388	225	281.3	104	8695	111	1.19	34.36	111	1072	119	15.24	30.54	159	1787	439	0	83.1
Hilleshög HIL2389	234	283.0	105	8928	114	1.15	34.87	112	1098	122	15.30	31.64	122	1796	430	0	89.1
Maribo MA930	210	263.1	97	7883	101	1.31	28.92	93	870	97	14.46	29.86	176	1862	511	0	84.4
Maribo MA931	219	275.4	102	8541	109	1.20	32.61	105	1019	113	14.96	30.85	164	1776	451	0	78.7
Maribo MA932	231	272.2	101	8474	108	1.26	31.65	102	990	110	14.87	31.03	169	1817	485	0	83.1
SV 203	239	278.3	103	9061	116	1.21	33.48	108	1098	122	15.12	32.36	133	1920	438	0	76.5
SV 211	224	273.0	101	8378	107	1.27	31.89	103	990	110	14.91	30.35	141	1891	482	0	76.1
SV 213	206	268.1	99	8326	106	1.33	30.44	98	972	108	14.72	30.30	149	1853	532	0	66.8
SV 214	245	259.1	96	7189	92	1.37	27.73	89	774	86	14.33	27.51	140	1903	569	0	80.2
SV 215	221	268.3	99	8598	110	1.33	30.48	98	985	109	14.74	31.89	171	1908	510	0	69.2
SX 1804	228	268.7	100	8094	103	1.27	30.63	99	927	103	14.69	29.92	139	1882	482	0	77.5
SX 1815	229	281.9	104	8453	108	1.25	34.54	111	1040	115	15.33	29.82	133	1923	466	0	84.3
SX 1816	202	265.6	98	9057	116	1.29	29.69	96	1013	112	14.57	34.04	151	1901	498	0	75.4
SX 1817	216	269.5	100	8891	113	1.21	30.85	100	1021	113	14.68	32.83	128	1863	458	0	78.8
SX 1818	235	274.1	101	8765	112	1.21	32.21	104	1038	115	14.91	31.91	127	1846	460	0	76.9
SX 1819	204	275.0	102	8637	110	1.22	32.48	105	1020	113	14.97	31.37	127	1807	483	0	77.4
Crystal 355RR(Check)	246	262.7	97	7639	97	1.32	28.79	93	835	93	14.45	29.10	166	1917	511	0	79.1
BTS 8572 (Check)	247	280.3	104	7692	98	1.31	34.07	110	942	104	15.33	27.40	141	1714	568	0	76.7
BTS 8337 (Check)	248	280.3	104	8248	105	1.24	34.05	110	1003	111	15.25	29.30	159	1955	444	0	75.0
Crystal 578RR (Check)	249	257.0	95	7765	99	1.36	27.11	87	825	92	14.21	30.18	205	1991	513	0	80.7
BTS 8815 (Check)	250	271.4	100	8126	104	1.24	31.41	101	947	105	14.80	29.86	168	1955	439	0	71.0
AP CHK MOD SUS RR#5	251	267.5	99	7693	98	1.28	30.26	98	874	97	14.63	28.86	185	1893	467	0	78.9
AP CHK MOD RR#4	252	242.4	90	7118	91	1.26	22.78	73	676	75	13.38	29.14	230	1989	408	0	76.5
Root Aphid Susc Chk#5	253	283.6	105	7790	99	1.15	35.04	113	960	107	15.33	27.40	145	1753	440	0	68.1
AP CHK MOD SUS RR#5	254	270.7	100	8195	105	1.28	31.19	101	956	106	14.79	29.92	187	1771	496	0	76.6
Comm Benchmark Mean		270.1		7836		1.31	31.01		901		14.81	29.00	145	1868	466		80.2
Comm Trial Mean		268.9		8011		1.26	30.67		915		14.71	29.77	147	1839	434		78.1
Coeff. of Var. (%)		3.2		7.1		5.9	8.3		10.3		2.8	6.5	14.1	4.0	9.9		8.9
Mean LSD (0.05)		10.8		710		0.09	3.15		118		0.52	2.38	26	91	53		8.1
Mean LSD (0.01)		14.2		937		0.12	4.16		156		0.68	3.15	34	121	70		10.7
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2021 Data from Hillsboro ND Bolters based upon 60,000 seed per acre. Created 10/29/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status. Trial # = 218305

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 14.

2021 Performance of Varieties - ACSC RR Official Trial Grand

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	356.6	96	13548	117	0.97	56.37	94	2140	113	18.80	38.10	104	1457	329	0	78.8
BTS 8882	112	365.3	99	14200	123	0.98	58.91	98	2282	121	19.24	38.90	114	1638	282	0	81.5
BTS 8927	101	378.8	102	12615	109	0.85	62.88	104	2100	111	19.80	33.32	86	1393	260	0	69.8
BTS 8938	113	366.7	99	12644	109	0.91	59.33	98	2044	108	19.24	34.53	100	1453	282	0	75.6
BTS 8961	110	367.1	99	12484	108	0.96	59.45	99	2021	107	19.31	34.01	109	1597	280	0	79.2
Crystal 572	125	368.5	100	12653	109	0.98	59.87	99	2055	109	19.40	34.21	87	1476	329	0	83.9
Crystal 684	124	357.4	97	14000	121	1.03	56.62	94	2206	117	18.90	39.45	114	1616	327	0	81.7
Crystal 793	107	362.8	98	13122	113	0.97	58.18	97	2099	111	19.10	36.23	107	1502	311	0	77.5
Crystal 796	108	354.6	96	12756	110	0.97	55.78	93	2007	106	18.69	35.93	105	1558	294	0	85.6
Crystal 803	115	369.2	100	13274	115	0.91	60.08	100	2161	115	19.37	35.73	93	1505	269	0	84.2
Crystal 804	114	350.5	95	13943	120	1.02	54.58	91	2165	115	18.54	39.82	136	1567	330	0	80.1
Crystal 913	118	366.8	99	12603	109	0.90	59.38	99	2042	108	19.25	34.30	106	1459	273	0	78.5
Hilleshög HIL2317	120	375.8	102	12463	108	0.93	62.00	103	2051	109	19.71	33.20	104	1579	262	0	76.2
Hilleshög HIL9528	109	362.2	98	12244	106	0.97	58.03	96	1954	104	19.07	33.91	107	1548	303	0	70.6
Hilleshög HIL9708	123	366.1	99	12018	104	0.95	59.17	98	1939	103	19.26	33.00	108	1501	299	0	77.5
Hilleshög HIL9920	117	367.7	99	12588	109	0.99	59.62	99	2041	108	19.37	34.15	119	1669	279	0	74.5
Maribo MA504	106	354.1	96	12921	112	1.03	55.64	92	2031	108	18.74	36.44	113	1624	328	0	78.3
Maribo MA717	121	341.4	92	12384	107	1.05	51.91	86	1879	100	18.11	36.16	122	1611	339	0	75.8
Maribo MA902	119	354.0	96	12090	104	1.04	55.62	92	1900	101	18.74	34.24	119	1569	345	0	85.4
SV 265	105	365.3	99	12542	108	0.88	58.92	98	2021	107	19.14	34.27	85	1473	263	0	81.8
SV 268	116	369.3	100	12842	111	0.95	60.08	100	2092	111	19.43	34.92	89	1589	285	0	82.0
SV 285	111	372.3	101	12095	104	0.93	60.98	101	1979	105	19.55	32.58	87	1541	281	0	81.1
SV 375	102	369.2	100	13124	113	0.93	60.07	100	2131	113	19.40	35.76	97	1520	284	0	82.3
SX 1888	104	365.2	99	11788	102	0.94	58.89	98	1900	101	19.20	32.35	89	1539	289	0	75.5
SX 1898	122	370.4	100	12138	105	0.97	60.41	100	1986	105	19.50	32.72	89	1592	298	0	79.3
Crystal 355RR(Check)	126	370.5	100	11210	97	1.04	60.45	100	1828	97	19.58	30.37	98	1601	351	0	81.6
BTS 8572 (Check)	127	370.8	100	11661	101	1.00	60.53	100	1905	101	19.54	31.51	98	1538	329	0	73.5
BTS 8337 (Check)	128	374.7	101	11500	99	1.05	61.67	102	1892	100	19.78	30.60	96	1630	350	0	70.8
Crystal 578RR (Check)	129	363.5	98	11969	103	1.03	58.39	97	1921	102	19.20	32.96	117	1683	305	0	82.6
AP CHK MOD SUS RR#5	130	371.5	100	12580	109	0.95	60.74	101	2054	109	19.53	34.07	103	1614	271	0	78.5
AP CHK MOD RR#4	131	372.5	101	12282	106	0.93	61.05	101	2002	106	19.54	33.13	110	1537	265	0	82.0
Root Aphid Susc Chk#5	132	352.3	95	12267	106	1.00	55.10	91	1918	102	18.62	34.87	114	1501	337	0	76.8
Experimental Trial (Comm status)																	
BTS 8018	232	370.3	100	12385	107	0.99	60.39	100	2023	107	19.51	33.40	105	1564	305	0	84.8
BTS 8034	222	348.2	94	12684	109	1.11	53.88	89	1971	104	18.54	36.28	132	1752	332	0	87.2
BTS 8073	207	358.4	97	12278	106	1.03	56.89	94	1949	103	18.96	34.29	110	1548	330	0	85.9
BTS 8092	236	371.0	100	12968	112	0.91	60.60	101	2123	113	19.47	34.90	110	1440	277	0	85.6
BTS 8100	212	375.0	101	11925	103	0.95	61.75	102	1964	104	19.68	31.83	116	1521	274	0	89.1
BTS 8122	226	381.6	103	11675	101	0.91	63.72	106	1949	103	20.01	30.61	86	1475	264	0	83.6
BTS 8133	227	350.1	95	12482	108	1.06	54.43	90	1944	103	18.58	35.65	133	1733	303	0	90.7
BTS 8140	243	374.5	101	11960	103	0.98	61.62	102	1969	104	19.70	31.94	96	1546	303	0	90.6
BTS 8156	223	358.9	97	11859	102	1.02	57.04	95	1883	100	18.96	33.10	117	1680	281	0	92.2
BTS 8164	211	365.1	99	12140	105	1.02	58.85	98	1960	104	19.28	33.21	117	1597	306	0	84.0
BTS 8187	220	376.6	102	11864	102	1.02	62.22	103	1961	104	19.85	31.52	97	1563	327	0	80.4
Crystal 021	208	358.1	97	13534	117	1.00	56.79	94	2149	114	18.92	37.76	111	1606	296	0	81.3
Crystal 022	241	374.7	101	12324	106	0.92	61.67	102	2030	108	19.67	32.89	92	1417	291	0	77.4
Crystal 025	244	362.1	98	12394	107	1.07	57.96	96	1985	105	19.18	34.26	113	1602	348	0	82.1
Crystal 026	209	357.2	97	12999	112	1.03	56.53	94	2059	109	18.90	36.38	126	1704	282	0	86.0
Crystal 029	240	360.0	97	12144	105	1.03	57.34	95	1935	103	19.01	33.77	103	1568	327	0	89.0
Crystal 130	230	376.4	102	12130	105	0.97	62.18	103	2008	106	19.80	32.15	95	1537	292	0	84.7
Crystal 132	218	376.9	102	12416	107	0.93	62.33	103	2055	109	19.81	32.93	97	1433	294	0	84.0
Crystal 134	214	379.1	102	12581	109	0.87	62.97	105	2089	111	19.80	33.23	90	1459	245	0	82.5
Crystal 137	203	362.3	98	12515	108	1.02	58.01	96	2008	106	19.14	34.48	109	1643	295	0	87.5
Crystal 138	205	366.2	99	12279	106	1.02	59.19	98	1984	105	19.32	33.58	104	1535	332	0	80.9
Crystal 912	242	353.7	96	13233	114	1.02	55.50	92	2078	110	18.71	37.44	123	1418	353	0	84.8
Hilleshög HIL2320	217	346.4	94	11402	98	1.09	53.37	89	1757	93	18.42	32.95	127	1628	349	0	83.2
Hilleshög HIL2366	215	363.4	98	11518	99	1.00	58.35	97	1850	98	19.16	31.72	106	1550	309	0	87.5
Hilleshög HIL2367	237	361.8	98	11687	101	1.03	57.87	96	1871	99	19.11	32.33	105	1566	324	0	82.9
Hilleshög HIL2368	233	366.7	99	10515	91	1.02	59.32	98	1702	90	19.38	28.69	112	1500	326	0	86.3
Hilleshög HIL2385	201	361.8	98	10751	93	1.11	57.88	96	1719	91	19.22	29.77	125	1521	389	0	84.0
Hilleshög HIL2386	238	351.9	95	12105	104	1.06	54.98	91	1893	100	18.66	34.38	121	1591	337	0	88.7
Hilleshög HIL2387	213	366.2	99	10524	91	0.96	59.19	98	1702	90	19.28	28.72	101	1479	300	0	84.8
Hilleshög HIL2388	225	360.8	98	11323	98	0.95	57.59	96	1811	96	19.01	31.37	118	1483	283	0	83.9
Hilleshög HIL2389	234	357.8	97	11310	98	1.04	56.71	94	1794	95	18.93	31.63	104	1615	319	0	92.2
Maribo MA930	210	364.5	99	12547	108	1.10	58.67	97	2021	107	19.31	34.43	117	1649	357	0	89.4
Maribo MA931	219	349.0	94	10981	95	1.13	54.13	90	1701	90	18.59	31.55	140	1640	376	0	84.4
Maribo MA932	231	353.7	96	12059	104	1.08	55.49	92	1893	100	18.76	34.10	135	1659	336	0	85.1
SV 203	239	368.3	100	11044	95	0.97	59.78	99	1795	95	19.42	29.98	92	1596	282	0	83.2
SV 211	224	366.3	99	11928	103	0.98	59.21	98	1931	102	19.31	32.53	96	1610	284	0	84.0
SV 213	206	368.3	100	10757	93	0.93	59.78	99	1748	93	19.37	29.22	90	1496	279	0	75.0
SV 214	245	358.9	97	10744	93	1.07	57.03	95	1709	91	19.01	29.90	96	1564	367	0	85.9
SV 215	221	367.5	99	11914	103	1.01	59.56	99	1933	102	19.39	32.43	130	1587	294	0	79.3
SX 1804	228	366.0	99	12419	107	0.95	59.11	98	2005	106	19.26	33.95	91	1519	282	0	87.5
SX 1815	229	375.0	101	11827	102	0.94	61.77	103	1951	103	19.70	31.48	95	1563	269	0	81.2
SX 1816	202	360.8	98	12708	110	1.04	57.60	96	2030	108	19.09	35.21	111	1605	324	0	78.5
SX 1817	216	366.2	99	12726	110	1.01	59.18	98	2060	109	19.33	34.72	102	1631	295	0	86.0
SX 1818	235	355.9	96	12573	109	1.00	56.16	93	1984	105	18.79	35.34	96	1590	301	0	84.4
SX 1819	204	370.6	100	12169	105	0.99	60.47	100	1985	105	19.52	32.88	95	1610	292	0	80.9
Crystal 355RR(Check)	246	374.6	101	10333	89	1.03	61.64	102	1702	90	19.76	27.57	99	1632	312	0	82.8
BTS 8572 (Check)	247	369.5	100	11003	95	0.98	60.15	100	1793	95	19.46	29.79	94	1506	306	0	73.8
BTS 8337 (Check)	248	371.3	100	11884	103	1.06	60.69	101	1943	103	19.64	32.00	92	1643	330	0	78.5
Crystal 578RR (Check)	249	364.1	98	13119	113	1.04	58.56	97	2108	112	19.23	36.08	103	1627	319	0	86.3
BTS 8815 (Check)	250	367.0	99	11910	103	1.07	59.43	99	1929	102	19.41	32.44	120	1715	310	0	75.4
AP CHK MOD SUS RR#5	251	368.5	100	11807	102	1.09	59.87	99	1920	102	19.53	32.01	118	1699	333	0	83.6
AP CHK MOD RR#4	252	364.2	98	12902	111	1.01	58.60	97	2076	110	19.21	35.46	125	1709	274	0	81.2
Root Aphid Susc Chk#5	253	358.3	97	10966	95	1.05	56.85	94	1744	92	18.96	30.58	130	1642	315	0	79.3
AP CHK MOD SUS RR#5	254	367.1	99	12699	110	1.01	59.45	99	2058	109	19.37	34.55	108	1601	305	0	85.5
Comm Benchmark Mean		369.9		11585		1.03	60.26		1887		19.53	31.36	102	1613	334		77.1
Comm Trial Mean		364.8		12580		0.97	58.77		2023		19.21	34.55	104	1552	301		78.8
Coeff. of Var. (%)		2.8		4.0		6.8	5.0		5.5		2.5	3.6	13.8	4.4	13.0		7.6
Mean LSD (0.05)		12.7		631		0.08	3.72		138		0.62	1.60	17	81	49		7.3
Mean LSD (0.01)		16.8		833		0.11	4.92		183		0.81	2.12	23	107	65		9.6
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2021 Data from Grand Forks ND Bolters based upon 60,000 seed per acre. Created 10/29/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status. Trial # = 218307

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 15.

2021 Performance of Varieties - ACSC RR Official Trial

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	341.4	96	11577	121	1.26	51.92	92	1742	115	18.32	34.30	143	1478	530	0	91.2
BTS 8882	112	340.8	95	10857	113	1.50	51.76	91	1635	108	18.54	32.12	165	1691	655	0	87.4
BTS 8927	101	371.3	104	10857	113	1.17	60.69	107	1774	117	19.75	29.15	116	1471	475	0	80.2
BTS 8938	113	356.4	100	11261	118	1.16	56.32	99	1777	117	18.97	31.69	106	1373	492	0	75.7
BTS 8961	110	354.1	99	11098	116	1.21	55.65	98	1742	115	18.93	31.25	128	1613	465	0	87.5
Crystal 572	125	360.1	101	10505	110	1.19	57.40	101	1682	111	19.19	29.10	114	1462	493	0	91.3
Crystal 684	124	347.8	97	11520	120	1.22	53.78	95	1788	118	18.61	33.13	139	1651	454	0	86.9
Crystal 793	107	368.1	103	11524	120	1.24	59.75	106	1863	123	19.65	31.35	119	1505	517	0	88.8
Crystal 796	108	352.7	99	11604	121	1.26	55.22	98	1807	119	18.91	33.00	132	1574	510	0	87.9
Crystal 803	115	364.4	102	11058	115	1.19	58.66	104	1774	117	19.41	30.41	114	1554	469	0	90.0
Crystal 804	114	352.6	99	11409	119	1.15	55.20	98	1774	117	18.78	32.55	143	1510	438	0	85.5
Crystal 913	118	370.9	104	11220	117	1.11	60.57	107	1827	120	19.65	30.39	122	1452	431	0	86.6
Hilleshög HIL2317	120	357.2	100	10247	107	1.24	56.54	100	1634	108	19.09	28.59	143	1612	482	0	82.1
Hilleshög HIL9528	109	329.3	92	9710	101	1.26	48.37	85	1439	95	17.71	29.57	176	1508	512	0	87.3
Hilleshög HIL9708	123	348.9	98	10031	105	1.17	54.13	96	1558	103	18.64	28.47	146	1562	441	0	89.1
Hilleshög HIL9920	117	362.7	101	10015	105	1.28	58.15	103	1607	106	19.41	27.74	130	1606	518	0	85.6
Maribo MA504	106	338.0	95	9507	99	1.39	50.92	90	1425	94	18.29	28.01	158	1617	588	0	86.1
Maribo MA717	121	333.4	93	10512	110	1.28	49.58	88	1570	103	17.94	31.67	164	1631	499	0	81.0
Maribo MA902	119	355.0	99	10035	105	1.16	55.92	99	1586	104	18.91	28.09	154	1529	433	0	90.5
SV 265	105	328.3	92	9260	97	1.21	48.08	85	1356	89	17.62	28.16	138	1469	498	0	90.0
SV 268	116	354.6	99	10484	109	1.25	55.79	99	1657	109	18.97	29.66	119	1643	490	0	90.4
SV 285	111	350.9	98	10547	110	1.18	54.70	97	1646	108	18.72	30.02	121	1552	456	0	91.3
SV 375	102	355.9	100	9635	101	1.11	56.18	99	1517	100	18.90	27.23	120	1550	403	0	89.6
SX 1888	104	344.5	96	10012	104	1.31	52.82	93	1523	100	18.54	29.15	133	1618	534	0	84.3
SX 1898	122	359.6	101	10149	106	1.21	57.24	101	1609	106	19.20	28.21	114	1602	472	0	87.5
Crystal 355RR(Check)	126	351.7	98	8765	91	1.52	54.93	97	1373	90	19.11	24.54	132	1670	684	0	90.0
BTS 8572 (Check)	127	357.1	100	9735	102	1.27	56.52	100	1548	102	19.13	27.09	119	1596	515	0	84.7
BTS 8337 (Check)	128	363.1	102	9125	95	1.37	58.27	103	1465	96	19.52	25.16	122	1648	576	0	84.6
Crystal 578RR (Check)	129	357.8	100	10704	112	1.27	56.72	100	1689	111	19.14	30.43	127	1593	511	0	91.9
AP CHK MOD SUS RR#5	130	361.0	101	9896	103	1.17	57.65	102	1596	105	19.23	27.05	124	1565	449	0	86.0
AP CHK MOD RR#4	131	356.2	100	9170	96	1.25	56.26	99	1440	95	19.05	25.99	140	1522	510	0	83.6
Root Aphid Susc Chk#5	132	345.4	97	10909	114	1.21	53.09	94	1675	110	18.49	31.56	135	1493	493	0	86.5
Experimental Trial (Comm status)																	
BTS 8018	232	359.2	101	11310	118	1.23	57.14	101	1798	118	19.27	31.29	130	1503	441	0	92.2
BTS 8034	222	345.2	97	12226	128	1.30	53.08	94	1863	123	18.50	35.63	138	1640	448	0	93.0
BTS 8073	207	359.7	101	11383	119	1.31	57.26	101	1817	120	19.32	31.64	119	1587	484	0	86.3
BTS 8092	236	355.8	100	12035	126	1.15	56.15	99	1887	124	18.96	34.01	121	1482	390	0	91.8
BTS 8100	212	364.3	102	11045	115	1.26	58.61	104	1775	117	19.51	30.56	119	1613	438	0	93.8
BTS 8122	226	380.6	106	11078	116	1.15	63.29	112	1827	120	20.19	29.33	111	1487	393	0	87.9
BTS 8133	227	334.0	93	12364	129	1.41	49.87	88	1857	122	18.16	36.85	160	1796	480	0	88.7
BTS 8140	243	357.7	100	11561	121	1.32	56.70	100	1838	121	19.16	32.35	115	1582	482	0	88.3
BTS 8156	223	362.8	102	11064	115	1.17	58.19	103	1764	116	19.33	30.80	110	1623	377	0	94.1
BTS 8164	211	344.2	96	11254	117	1.53	52.80	93	1718	113	18.77	32.64	163	1678	600	0	88.7
BTS 8187	220	375.8	105	10728	112	1.18	61.90	109	1750	115	19.96	28.83	116	1518	413	0	90.6
Crystal 021	208	354.5	99	11880	124	1.27	55.77	99	1858	122	18.98	33.66	133	1618	437	0	86.7
Crystal 022	241	365.0	102	10625	111	1.31	58.79	104	1709	113	19.55	29.13	149	1473	501	0	86.7
Crystal 025	244	353.8	99	10524	110	1.27	55.59	98	1629	107	18.95	30.15	133	1675	423	0	86.3
Crystal 026	209	346.4	97	12472	130	1.40	53.44	94	1918	126	18.76	35.99	144	1776	484	0	90.6
Crystal 029	240	366.4	103	10767	112	1.22	59.21	105	1761	116	19.61	28.87	102	1550	441	0	95.3
Crystal 130	230	369.5	103	10980	115	1.30	60.11	106	1767	116	19.78	29.94	125	1662	456	0	87.1
Crystal 132	218	370.7	104	10807	113	1.20	60.44	107	1751	115	19.75	29.25	111	1522	423	0	92.2
Crystal 134	214	375.8	105	11307	118	1.11	61.92	109	1861	123	19.95	29.93	109	1525	354	0	82.8
Crystal 137	203	339.6	95	12045	126	1.44	51.49	91	1834	121	18.37	35.51	144	1710	533	0	93.4
Crystal 138	205	347.3	97	12243	128	1.42	53.69	95	1881	124	18.78	35.07	122	1581	552	0	88.3
Crystal 912	242	361.6	101	13143	137	1.24	57.81	102	2086	137	19.33	36.46	160	1466	453	0	87.9
Hilleshög HIL2320	217	340.4	95	10248	107	1.42	51.71	91	1562	103	18.44	30.08	151	1589	543	0	94.9
Hilleshög HIL2366	215	345.4	97	11301	118	1.31	53.14	94	1737	114	18.63	32.43	155	1549	473	0	95.7
Hilleshög HIL2367	237	335.3	94	10648	111	1.49	50.23	89	1612	106	18.32	31.35	153	1617	590	0	87.5
Hilleshög HIL2368	233	364.6	102	9877	103	1.21	58.69	104	1589	105	19.48	26.96	120	1537	426	0	89.5
Hilleshög HIL2385	201	346.1	97	10311	108	1.08	53.34	94	1582	104	18.42	29.67	122	1437	361	0	88.3
Hilleshög HIL2386	238	354.3	99	11630	121	1.29	55.72	98	1838	121	19.01	32.48	127	1565	473	0	90.6
Hilleshög HIL2387	213	362.1	101	9301	97	1.32	57.95	102	1476	97	19.40	26.23	112	1613	492	0	89.1
Hilleshög HIL2388	225	340.3	95	10155	106	1.16	51.67	91	1560	103	18.20	29.53	148	1496	388	0	90.2
Hilleshög HIL2389	234	346.8	97	10090	105	1.18	53.56	95	1547	102	18.53	29.37	126	1555	404	0	94.1
Maribo MA930	210	345.7	97	11577	121	1.40	53.22	94	1771	117	18.64	33.62	143	1547	543	0	92.2
Maribo MA931	219	340.6	95	11328	118	1.27	51.76	91	1732	114	18.30	33.03	142	1594	437	0	87.1
Maribo MA932	231	343.4	96	11416	119	1.30	52.58	93	1742	115	18.50	33.15	142	1626	453	0	88.7
SV 203	239	354.9	99	10533	110	1.27	55.88	99	1672	110	19.04	29.33	122	1672	425	0	88.3
SV 211	224	346.1	97	10080	105	1.34	53.33	94	1554	102	18.64	29.06	116	1639	488	0	89.8
SV 213	206	352.6	99	10248	107	1.28	55.24	98	1591	105	18.89	29.15	111	1622	447	0	87.5
SV 214	245	341.9	96	8738	91	1.40	52.13	92	1343	88	18.49	25.49	110	1624	533	0	90.2
SV 215	221	355.3	99	10570	110	1.31	56.01	99	1661	109	19.10	29.59	116	1633	467	0	80.9
SX 1804	228	352.4	99	11277	118	1.22	55.15	97	1762	116	18.87	32.01	116	1556	425	0	91.4
SX 1815	229	360.9	101	11295	118	1.18	57.62	102	1786	118	19.23	31.54	110	1564	400	0	87.9
SX 1816	202	341.6	96	11519	120	1.44	52.05	92	1772	117	18.56	33.36	127	1622	560	0	81.3
SX 1817	216	338.5	95	10581	110	1.47	51.15	90	1606	106	18.38	31.27	137	1636	576	0	89.1
SX 1818	235	352.9	99	11502	120	1.36	55.31	98	1789	118	19.01	32.72	121	1620	504	0	91.8
SX 1819	204	350.2	98	10914	114	1.26	54.54	96	1709	113	18.77	31.13	119	1569	442	0	90.6
Crystal 355RR(Check)	246	359.5	101	8950	93	1.35	57.20	101	1416	93	19.27	24.95	115	1687	478	0	91.8
BTS 8572 (Check)	247	364.1	102	9107	95	1.24	58.53	103	1471	97	19.49	24.96	115	1576	443	0	79.7
BTS 8337 (Check)	248	364.7	102	9185	96	1.42	58.73	104	1492	98	19.63	24.93	130	1727	516	0	84.8
Crystal 578RR (Check)	249	341.4	96	11087	116	1.42	51.97	92	1696	112	18.51	32.37	149	1584	547	0	91.8
BTS 8815 (Check)	250	361.7	101	10946	114	1.27	57.85	102	1743	115	19.35	30.34	124	1644	425	0	86.7
AP CHK MOD SUS RR#5	251	355.0	99	11467	120	1.40	55.91	99	1801	119	19.18	32.15	147	1616	522	0	92.6
AP CHK MOD RR#4	252	360.0	101	10892	114	1.15	57.37	101	1746	115	19.23	29.91	139	1607	355	0	92.2
Root Aphid Susc Chk#5	253	347.4	97	10211	107	1.29	53.73	95	1571	103	18.64	29.61	149	1544	468	0	84.8
AP CHK MOD SUS RR#5	254	348.5	98	10466	109	1.38	54.05	95	1611	106	18.82	30.14	155	1693	494	0	86.7
Comm Benchmark Mean		357.4		9582		1.36	56.61		1519		19.23	26.81	125	1627	572		87.8
Comm Trial Mean		352.9		10404		1.24	55.27		1628		18.89	29.53	133	1560	500		86.9
Coeff. of Var. (%)		3.4		6.9		13.7	6.4		8.5		2.9	6.4	18.4	4.6	23.1		5.4
Mean LSD (0.05)		14.9		870		0.21	4.37		164		0.67	2.36	30	88	141		5.6
Mean LSD (0.01)		19.7		1149		0.27	5.77		216		0.88	3.12	39	116	186		7.4
Sig Lvl		**		**		*	**		**		**	**	**	**	ns		**

2021 Data from Scandia MN | Bolters based upon 60,000 seed per acre. | Created 10/29/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,
Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status. | Trial # = 218308

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 16.

2021 Performance of Varieties - ACSC RR Official Trial Climax

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	297.2	96	9774	113	1.10	38.97	91	1278	107	15.97	33.00	159	1272	460	0	71.7
BTS 8882	112	299.1	96	9899	114	1.24	39.51	92	1307	110	16.20	33.10	162	1445	517	0	72.5
BTS 8927	101	323.2	104	9296	108	1.02	46.60	109	1346	113	17.18	28.61	127	1263	410	0	57.5
BTS 8938	113	313.5	101	9496	110	1.11	43.73	102	1326	111	16.77	30.23	142	1305	462	0	56.2
BTS 8961	110	304.1	98	10008	116	1.15	40.99	96	1352	113	16.36	32.92	162	1397	457	0	62.7
Crystal 572	125	311.0	100	9377	108	1.11	43.00	101	1295	109	16.67	30.20	141	1295	467	28	68.8
Crystal 684	124	303.9	98	9865	114	1.17	40.94	96	1320	111	16.37	32.64	155	1432	471	0	69.0
Crystal 793	107	315.0	102	9264	107	1.04	44.17	103	1299	109	16.79	29.39	125	1286	421	0	68.7
Crystal 796	108	300.8	97	9953	115	1.22	40.01	94	1325	111	16.26	33.08	159	1408	512	0	68.4
Crystal 803	115	308.3	99	8871	103	1.20	42.23	99	1216	102	16.60	28.74	155	1349	512	0	62.7
Crystal 804	114	301.4	97	9735	113	1.16	40.20	94	1300	109	16.22	32.20	177	1351	477	0	69.2
Crystal 913	118	309.5	100	8966	104	1.14	42.58	100	1232	103	16.61	29.00	168	1274	480	0	63.4
Hilleshög HIL2317	120	315.4	102	8823	102	1.05	44.30	104	1243	104	16.83	27.92	161	1347	395	0	68.9
Hilleshög HIL9528	109	301.1	97	8844	102	1.09	40.11	94	1179	99	16.13	29.28	191	1248	443	0	66.5
Hilleshög HIL9708	123	302.1	97	8836	102	1.09	40.40	94	1182	99	16.21	29.29	194	1274	438	0	67.2
Hilleshög HIL9920	117	321.5	104	9425	109	1.08	46.09	108	1351	113	17.17	29.34	150	1353	421	0	68.0
Maribo MA504	106	301.1	97	8368	97	1.07	40.11	94	1113	93	16.13	27.80	198	1281	418	0	64.0
Maribo MA717	121	311.6	100	9356	108	1.10	43.18	101	1292	108	16.68	30.15	157	1333	442	0	69.4
Maribo MA902	119	303.7	98	8683	100	1.09	40.88	96	1167	98	16.28	28.60	201	1312	423	0	72.7
SV 265	105	307.5	99	9030	104	1.12	41.98	98	1230	103	16.49	29.41	147	1352	453	0	60.5
SV 268	116	314.0	101	9452	109	1.07	43.89	103	1327	111	16.78	30.03	128	1389	414	0	69.3
SV 285	111	312.6	101	9023	104	1.03	43.49	102	1260	106	16.68	28.82	125	1293	414	0	72.5
SV 375	102	316.0	102	9564	111	1.09	44.48	104	1345	113	16.90	30.34	127	1330	446	0	67.3
SX 1888	104	304.0	98	8858	102	1.11	40.97	96	1193	100	16.32	29.14	143	1340	453	0	68.9
SX 1898	122	317.5	102	9367	108	1.09	44.90	105	1328	111	16.96	29.42	123	1367	439	0	71.4
Crystal 355RR(Check)	126	309.4	100	8203	95	1.30	42.53	99	1126	94	16.77	26.54	164	1445	564	0	71.6
BTS 8572 (Check)	127	305.8	99	8410	97	1.25	41.48	97	1143	96	16.53	27.42	154	1383	546	0	60.8
BTS 8337 (Check)	128	316.6	102	9176	106	1.24	44.64	104	1293	108	17.06	28.99	156	1421	525	0	69.3
Crystal 578RR (Check)	129	309.1	100	8793	102	1.09	42.44	99	1208	101	16.55	28.48	152	1330	437	0	70.7
AP CHK MOD SUS RR#5	130	308.5	99	9010	104	1.14	42.26	99	1235	104	16.56	29.21	154	1348	473	0	65.3
AP CHK MOD RR#4	131	295.8	95	7855	91	1.17	38.57	90	1020	86	15.95	26.58	206	1403	457	0	60.8
Root Aphid Susc Chk#5	132	303.9	98	8832	102	1.12	40.92	96	1196	100	16.32	28.91	189	1309	454	0	67.6
Experimental Trial (Comm status)																	
BTS 8018	232	305.4	98	8766	101	1.04	41.34	97	1189	100	16.31	28.66	141	1237	426	0	68.3
BTS 8034	222	301.5	97	9937	115	1.23	40.19	94	1324	111	16.31	32.99	161	1381	528	0	63.7
BTS 8073	207	309.3	100	9466	109	1.10	42.48	99	1299	109	16.58	30.71	133	1290	463	0	55.6
BTS 8092	236	307.6	99	9470	110	1.07	41.98	98	1296	109	16.44	30.74	121	1248	457	0	63.2
BTS 8100	212	311.0	100	8778	102	1.24	42.99	101	1217	102	16.79	28.20	159	1449	515	0	62.5
BTS 8122	226	320.4	103	8186	95	1.05	45.77	107	1168	98	17.07	25.61	116	1328	417	0	53.0
BTS 8133	227	299.5	97	10198	118	1.22	39.57	93	1345	113	16.20	34.11	167	1490	493	0	66.6
BTS 8140	243	315.5	102	9138	106	1.12	44.33	104	1286	108	16.89	29.00	116	1331	474	0	62.7
BTS 8156	223	311.8	101	10272	119	1.20	43.21	101	1423	119	16.81	33.02	167	1440	487	0	67.9
BTS 8164	211	303.5	98	10166	118	1.20	40.78	95	1365	114	16.38	33.56	173	1398	497	0	63.1
BTS 8187	220	321.4	104	8375	97	1.12	46.06	108	1201	101	17.17	26.06	131	1340	462	0	51.6
Crystal 021	208	308.3	99	9220	107	1.15	42.18	99	1262	106	16.54	29.85	172	1350	473	0	57.1
Crystal 022	241	318.4	103	8491	98	1.03	45.19	106	1209	101	16.95	26.61	120	1261	421	0	51.0
Crystal 025	244	312.8	101	8930	103	1.20	43.52	102	1242	104	16.84	28.55	153	1365	513	0	51.8
Crystal 026	209	310.2	100	9825	114	1.14	42.76	100	1347	113	16.65	31.80	158	1456	440	0	62.2
Crystal 029	240	311.8	101	8916	103	1.18	43.22	101	1241	104	16.75	28.51	135	1312	518	0	57.1
Crystal 130	230	308.2	99	9227	107	1.12	42.16	99	1261	106	16.51	30.04	154	1367	446	0	57.6
Crystal 132	218	314.2	101	8124	94	1.06	43.94	103	1135	95	16.78	25.92	125	1225	453	0	54.6
Crystal 134	214	320.7	103	8483	98	0.98	45.85	107	1211	102	17.01	26.53	139	1238	377	0	60.9
Crystal 137	203	309.5	100	10089	117	1.17	42.53	99	1384	116	16.65	32.67	159	1427	469	0	55.8
Crystal 138	205	314.4	101	8919	103	1.15	44.01	103	1253	105	16.85	28.31	131	1339	484	0	47.9
Crystal 912	242	305.2	98	9667	112	1.08	41.28	97	1311	110	16.33	31.65	175	1199	457	0	53.9
Hilleshög HIL2320	217	314.1	101	8908	103	1.12	43.91	103	1251	105	16.80	28.29	178	1275	459	0	59.0
Hilleshög HIL2366	215	312.4	101	8629	100	1.04	43.41	101	1202	101	16.64	27.62	170	1214	422	0	69.4
Hilleshög HIL2367	237	312.0	101	8776	102	1.13	43.28	101	1218	102	16.71	28.15	165	1326	463	0	67.6
Hilleshög HIL2368	233	317.0	102	7365	85	1.07	44.77	105	1041	87	16.90	23.19	164	1186	451	0	64.2
Hilleshög HIL2385	201	315.5	102	8593	99	1.12	44.31	104	1209	101	16.87	27.22	147	1287	471	0	64.4
Hilleshög HIL2386	238	312.6	101	8948	104	1.20	43.45	102	1245	104	16.82	28.62	206	1312	506	0	66.0
Hilleshög HIL2387	213	309.8	100	8188	95	1.09	42.61	100	1129	95	16.56	26.45	163	1285	440	0	63.0
Hilleshög HIL2388	225	311.3	100	9042	105	1.04	43.07	101	1255	105	16.59	29.04	179	1199	424	0	65.5
Hilleshög HIL2389	234	320.7	103	9404	109	1.11	45.84	107	1344	113	17.12	29.30	140	1355	450	0	73.2
Maribo MA930	210	316.3	102	9462	109	1.20	44.57	104	1333	112	17.02	29.95	156	1352	513	0	70.7
Maribo MA931	219	313.8	101	8720	101	1.09	43.81	102	1220	102	16.77	27.76	169	1286	440	0	62.2
Maribo MA932	231	311.5	100	9686	112	1.11	43.12	101	1347	113	16.65	31.02	164	1275	462	0	66.8
SV 203	239	312.4	101	8915	103	1.04	43.40	101	1240	104	16.64	28.45	133	1289	417	0	67.3
SV 211	224	309.3	100	9099	105	1.14	42.48	99	1252	105	16.59	29.37	143	1393	465	0	65.2
SV 213	206	310.0	100	9215	107	1.14	42.69	100	1268	106	16.62	29.68	146	1311	481	0	62.3
SV 214	245	301.9	97	7870	91	1.21	40.32	94	1051	88	16.31	26.12	127	1340	537	0	67.2
SV 215	221	311.3	100	9009	104	1.14	43.08	101	1250	105	16.69	28.87	150	1345	471	0	58.6
SX 1804	228	312.0	101	9153	106	1.15	43.29	101	1276	107	16.72	29.23	144	1325	485	0	61.8
SX 1815	229	317.1	102	9003	104	1.09	44.80	105	1269	106	16.94	28.46	125	1343	444	0	64.6
SX 1816	202	303.2	98	9337	108	1.17	40.69	95	1254	105	16.31	30.80	198	1364	472	0	56.6
SX 1817	216	316.7	102	8996	104	1.15	44.67	104	1272	107	16.97	28.35	135	1379	473	0	66.0
SX 1818	235	321.6	104	9790	113	1.09	46.12	108	1404	118	17.17	30.48	142	1384	428	0	62.2
SX 1819	204	308.1	99	8938	103	1.29	42.12	98	1225	103	16.67	28.89	154	1417	564	0	58.8
Crystal 355RR(Check)	246	309.7	100	8744	101	1.20	42.60	100	1205	101	16.67	28.17	179	1388	497	0	67.5
BTS 8572 (Check)	247	305.0	98	7454	86	1.22	41.24	96	1004	84	16.48	24.54	161	1345	527	0	54.3
BTS 8337 (Check)	248	317.8	102	8770	101	1.30	45.02	105	1242	104	17.19	27.58	159	1416	575	0	59.9
Crystal 578RR (Check)	249	308.4	99	9614	111	1.15	42.22	99	1319	111	16.56	31.14	194	1332	469	0	66.2
BTS 8815 (Check)	250	311.3	100	8620	100	1.16	43.09	101	1193	100	16.74	27.73	170	1420	460	0	50.5
AP CHK MOD SUS RR#5	251	304.1	98	9117	105	1.18	40.95	96	1228	103	16.38	30.02	162	1375	492	0	58.5
AP CHK MOD RR#4	252	300.6	97	7750	90	1.10	39.92	93	1030	86	16.13	25.86	187	1339	431	0	59.7
Root Aphid Susc Chk#5	253	304.5	98	8036	93	1.07	41.08	96	1087	91	16.29	26.34	182	1266	429	0	67.9
AP CHK MOD SUS RR#5	254	307.4	99	9123	106	1.15	41.91	98	1243	104	16.49	29.69	157	1295	493	0	66.4
Comm Benchmark Mean		310.2		8646		1.22	42.77		1193		16.73	27.86	157	1395	518		68.1
Comm Trial Mean		308.3		9138		1.13	42.20		1251		16.54	29.65	158	1342	459		67.0
Coeff. of Var. (%)		2.4		5.7		6.2	5.2		7.5		2.2	4.8	14.1	3.5	10.2		8.0
Mean LSD (0.05)		9.2		654		0.09	2.71		117		0.45	1.82	28	59	59		6.6
Mean LSD (0.01)		12.2		865		0.12	3.58		155		0.59	2.40	36	79	78		8.7
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2021 Data from Climax MN — Bolters based upon 60,000 seed per acre. — Created 10/29/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status. — Trial # = 218309

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 17.

2021 Performance of Varieties - ACSC RR Official Trial Forest

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	329.9	99	10383	111	0.92	48.55	98	1540	110	17.43	31.25	96	1175	370	0	56.9
BTS 8882	112	323.7	97	11154	119	1.06	46.73	94	1621	116	17.25	34.22	118	1382	412	0	60.4
BTS 8927	101	346.4	104	10431	111	0.85	53.39	108	1612	116	18.19	30.01	92	1093	343	0	56.5
BTS 8938	113	339.4	102	9440	101	0.93	51.32	104	1440	103	17.89	27.57	89	1159	381	0	46.8
BTS 8961	110	330.8	99	9457	101	1.08	48.82	99	1407	101	17.62	28.32	118	1350	437	0	55.9
Crystal 572	125	340.3	102	10394	111	0.94	51.59	104	1581	113	17.96	30.47	85	1197	382	0	62.0
Crystal 684	124	317.3	95	10222	109	1.04	44.87	91	1456	104	16.90	31.95	110	1353	407	0	62.3
Crystal 793	107	344.2	103	10956	117	0.90	52.73	106	1683	121	18.10	31.71	90	1194	346	0	60.2
Crystal 796	108	344.3	103	10156	108	0.99	52.76	106	1559	112	18.20	29.43	102	1337	379	0	67.8
Crystal 803	115	335.3	101	10443	112	0.91	50.12	101	1568	113	17.67	31.00	98	1261	334	0	65.7
Crystal 804	114	319.0	96	10256	110	1.05	45.36	92	1462	105	17.00	32.10	137	1343	404	0	61.2
Crystal 913	118	340.6	102	10857	116	0.92	51.70	104	1653	119	17.94	31.71	100	1220	352	0	56.4
Hilleshög HIL2317	120	340.3	102	9660	103	0.91	51.59	104	1470	105	17.92	28.23	99	1202	350	0	55.8
Hilleshög HIL9528	109	327.1	98	9727	104	0.91	47.72	96	1422	102	17.27	29.68	119	1173	349	0	63.3
Hilleshög HIL9708	123	325.8	98	9217	98	0.94	47.34	96	1349	97	17.24	28.07	127	1163	377	0	61.4
Hilleshög HIL9920	117	334.7	100	9809	105	0.92	49.96	101	1467	105	17.66	29.26	132	1266	325	0	55.7
Maribo MA504	106	327.0	98	10030	107	0.96	47.69	96	1470	105	17.30	30.52	113	1230	372	0	61.6
Maribo MA717	121	321.5	96	9386	100	1.03	46.08	93	1353	97	17.10	29.02	116	1288	412	0	56.9
Maribo MA902	119	333.4	100	10326	110	0.85	49.56	100	1541	111	17.52	30.85	113	1099	329	0	75.8
SV 265	105	330.5	99	10031	107	0.89	48.72	98	1486	107	17.42	30.20	97	1178	342	0	51.6
SV 268	116	332.1	100	10300	110	0.97	49.19	99	1540	110	17.57	30.69	92	1294	373	0	64.2
SV 285	111	334.7	100	10377	111	0.97	49.94	101	1551	111	17.69	30.92	92	1178	400	0	69.7
SV 375	102	355.9	107	10970	117	0.87	56.18	113	1740	125	18.66	30.66	78	1187	327	0	62.2
SX 1888	104	328.4	99	9738	104	1.00	48.10	97	1430	103	17.41	29.56	101	1274	397	0	53.7
SX 1898	122	342.5	103	9568	102	0.97	52.24	105	1465	105	18.10	27.83	80	1241	392	0	56.6
Crystal 355RR(Check)	126	330.0	99	9342	100	1.16	48.57	98	1383	99	17.66	28.12	119	1358	496	0	63.2
BTS 8572 (Check)	127	327.0	98	9264	99	1.00	47.70	96	1344	96	17.37	28.57	105	1280	397	0	49.8
BTS 8337 (Check)	128	339.9	102	9137	98	1.07	51.47	104	1387	100	18.07	26.88	115	1338	428	0	50.9
Crystal 578RR (Check)	129	336.5	101	9701	104	0.96	50.47	102	1461	105	17.79	28.75	134	1295	348	0	65.8
AP CHK MOD SUS RR#5	130	337.7	101	9811	105	1.01	50.83	103	1490	107	17.89	28.80	112	1283	396	0	54.1
AP CHK MOD RR#4	131	338.2	101	9919	106	0.92	50.97	103	1498	107	17.84	29.31	115	1246	342	0	63.8
Root Aphid Susc Chk#5	132	329.6	99	9605	103	0.93	48.45	98	1418	102	17.40	28.98	106	1189	364	0	62.9
Experimental Trial (Comm status)																	
BTS 8018	232	346.3	104	11377	122	0.83	53.17	107	1753	126	18.19	32.75	94	1213	269	0	86.1
BTS 8034	222	338.2	101	10678	114	0.85	50.88	103	1613	116	17.79	31.46	117	1294	253	0	75.9
BTS 8073	207	327.9	98	10221	109	0.99	48.04	97	1499	108	17.39	31.16	104	1335	349	0	80.5
BTS 8092	236	328.7	99	10378	111	0.91	48.28	97	1526	110	17.36	31.52	123	1184	322	0	77.3
BTS 8100	212	346.9	104	9801	105	0.92	53.32	108	1509	108	18.29	28.25	101	1393	288	0	82.6
BTS 8122	226	356.5	107	9648	103	0.84	55.96	113	1518	109	18.70	26.99	90	1218	275	0	75.8
BTS 8133	227	326.1	98	10380	111	0.94	47.54	96	1517	109	17.26	31.87	128	1403	287	0	84.8
BTS 8140	243	334.1	100	10077	108	0.94	49.77	100	1504	108	17.66	30.16	98	1303	321	0	87.8
BTS 8156	223	339.2	102	10195	109	0.88	51.19	103	1544	111	17.86	29.97	109	1301	271	0	91.6
BTS 8164	211	333.5	100	9412	101	1.01	49.60	100	1403	101	17.70	28.14	142	1350	349	0	72.1
BTS 8187	220	351.4	105	10307	110	0.85	54.55	110	1604	115	18.44	29.33	86	1261	269	0	75.1
Crystal 021	208	331.2	99	10878	116	0.90	48.99	99	1611	116	17.48	32.77	123	1376	261	0	69.7
Crystal 022	241	334.0	100	9397	100	0.93	49.74	100	1399	100	17.64	28.20	118	1214	324	0	79.2
Crystal 025	244	333.2	100	9643	103	0.99	49.52	100	1434	103	17.67	28.92	140	1315	345	0	77.0
Crystal 026	209	337.9	101	9901	106	1.01	50.82	103	1492	107	17.91	29.29	131	1437	325	0	72.4
Crystal 029	240	338.2	101	10070	108	0.92	50.89	103	1518	109	17.85	29.74	105	1307	304	0	83.2
Crystal 130	230	337.2	101	10731	115	0.92	50.60	102	1616	116	17.80	31.73	112	1335	298	0	83.0
Crystal 132	218	336.3	101	9400	100	0.96	50.39	102	1410	101	17.79	27.99	136	1233	339	0	76.1
Crystal 134	214	350.1	105	10424	111	0.84	54.19	109	1619	116	18.37	29.74	112	1260	255	0	79.1
Crystal 137	203	341.9	103	10389	111	0.88	51.94	105	1584	114	18.00	30.38	118	1314	264	0	77.3
Crystal 138	205	333.6	100	9934	106	0.92	49.63	100	1483	106	17.62	29.70	105	1243	319	0	77.0
Crystal 912	242	324.5	97	9819	105	0.91	47.10	95	1424	102	17.15	30.33	128	1164	326	0	78.7
Hilleshög HIL2320	217	327.2	98	9207	98	1.04	47.86	97	1352	97	17.41	28.08	151	1340	370	0	84.1
Hilleshög HIL2366	215	329.3	99	9253	99	1.01	48.44	98	1365	98	17.50	28.05	139	1338	357	0	88.9
Hilleshög HIL2367	237	326.0	98	9455	101	1.02	47.53	96	1384	99	17.34	28.93	125	1303	378	0	78.1
Hilleshög HIL2368	233	330.5	99	8424	90	0.98	48.78	98	1247	89	17.52	25.49	124	1235	358	0	78.1
Hilleshög HIL2385	201	338.5	102	8822	94	0.97	50.98	103	1335	96	17.92	25.96	112	1266	358	0	79.0
Hilleshög HIL2386	238	333.4	100	9294	99	1.02	49.58	100	1384	99	17.70	27.87	128	1278	383	0	82.3
Hilleshög HIL2387	213	323.0	97	9470	101	0.97	46.68	94	1371	98	17.12	29.33	134	1315	327	0	83.4
Hilleshög HIL2388	225	323.6	97	8847	95	1.03	46.87	95	1284	92	17.22	27.34	151	1264	383	0	83.3
Hilleshög HIL2389	234	332.6	100	9747	104	0.89	49.36	100	1452	104	17.54	29.23	98	1265	291	0	83.8
Maribo MA930	210	321.5	96	9153	98	1.12	46.27	93	1321	95	17.19	28.49	161	1301	436	0	85.4
Maribo MA931	219	321.2	96	9520	102	1.08	46.20	93	1373	99	17.14	29.61	160	1347	388	0	75.9
Maribo MA932	231	325.3	98	9555	102	1.11	47.34	96	1391	100	17.36	29.39	133	1328	423	0	78.0
SV 203	239	339.2	102	9696	104	0.91	51.19	103	1469	105	17.90	28.52	100	1334	292	0	76.1
SV 211	224	334.1	100	9324	100	0.91	49.76	100	1392	100	17.64	27.90	111	1283	297	0	76.0
SV 213	206	342.8	103	9579	102	0.91	52.17	105	1463	105	18.08	27.86	101	1257	314	0	79.7
SV 214	245	312.5	94	8472	91	1.16	43.79	88	1185	85	16.77	27.18	116	1455	437	0	78.9
SV 215	221	327.6	98	8886	95	1.01	47.97	97	1303	94	17.40	27.07	129	1362	353	0	63.4
SX 1804	228	336.0	101	9487	101	0.89	50.31	102	1424	102	17.71	28.25	104	1287	290	0	75.4
SX 1815	229	328.2	98	9482	101	0.91	48.15	97	1394	100	17.34	28.91	103	1227	318	0	84.1
SX 1816	202	320.5	96	9609	103	1.01	46.01	93	1381	99	17.04	29.97	130	1364	347	0	63.5
SX 1817	216	330.4	99	9516	102	1.01	48.76	98	1410	101	17.54	28.71	121	1325	366	0	79.2
SX 1818	235	333.2	100	10085	108	0.89	49.51	100	1501	108	17.56	30.26	88	1307	288	0	79.7
SX 1819	204	331.8	100	9579	102	0.94	49.13	99	1424	102	17.55	28.76	95	1331	315	0	71.8
Crystal 355RR(Check)	246	335.1	101	9060	97	1.06	50.03	101	1355	97	17.82	26.99	120	1408	377	0	83.5
BTS 8572 (Check)	247	336.1	101	9354	100	0.98	50.31	102	1403	101	17.80	27.86	108	1323	345	0	70.5
BTS 8337 (Check)	248	333.3	100	8922	95	1.08	49.54	100	1330	95	17.75	26.71	126	1408	383	0	65.3
Crystal 578RR (Check)	249	328.9	99	10108	108	1.08	48.32	98	1487	107	17.52	30.77	149	1416	375	0	75.1
BTS 8815 (Check)	250	340.9	102	9140	98	0.98	51.65	104	1387	99	18.03	26.83	137	1459	297	0	60.6
AP CHK MOD SUS RR#5	251	348.6	105	10079	108	0.93	53.79	109	1561	112	18.38	28.82	107	1327	306	0	76.6
AP CHK MOD RR#4	252	334.1	100	9918	106	0.89	49.77	100	1480	106	17.63	29.63	136	1323	267	0	76.3
Root Aphid Susc Chk#5	253	323.0	97	9263	99	0.99	46.68	94	1344	96	17.16	28.60	138	1306	354	0	75.3
AP CHK MOD SUS RR#5	254	336.4	101	10086	108	0.94	50.41	102	1516	109	17.78	29.93	122	1345	304	0	79.1
Comm Benchmark Mean		333.4		9361		1.05	49.55		1394		17.72	28.08	118	1318	417		57.5
Comm Trial Mean		333.9		10002		0.96	49.71		1495		17.66	29.83	106	1245	377		59.7
Coeff. of Var. (%)		2.9		6.5		8.6	5.8		8.4		2.6	5.5	16.8	6.9	12.6		13.9
Mean LSD (0.05)		12.6		844		0.11	3.69		163		0.60	2.12	23	106	61		10.6
Mean LSD (0.01)		16.7		1116		0.14	4.88		215		0.79	2.80	30	140	80		14.0
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2021 Data from Forest River ND   Bolters based upon 60,000 seed per acre.   Created 10/29/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status.   Trial # = 218310

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 18.

2021 Performance of Varieties - ACSC RR Official Trial

Description @	Code	Rec/T lbs.	Rec/T %Bnch	Rec/A lbs.	Rec/A %Bnch	Loss Mol %	Rev/T $ ++	Rev/T %Bnch	Rev/A $ ++	Rev/A %Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	365.3	98	9887	134	1.55	58.92	97	1591	133	19.79	27.18	187	1875	631	0	78.7
BTS 8882	112	368.1	99	8635	117	1.62	59.75	98	1408	117	20.08	23.49	209	2010	640	0	85.9
BTS 8927	101	379.1	102	7931	108	1.51	62.97	104	1317	110	20.43	20.63	179	1840	622	0	69.7
BTS 8938	113	367.8	99	9322	127	1.62	59.65	98	1512	126	20.01	25.36	205	1874	680	0	67.8
BTS 8961	110	366.3	99	9311	127	1.63	59.23	98	1506	126	19.95	25.40	210	1982	663	0	82.4
Crystal 572	125	384.5	104	8666	118	1.51	64.54	106	1457	121	20.80	22.40	150	1843	631	0	85.8
Crystal 684	124	359.7	97	8880	121	1.66	57.28	94	1410	118	19.70	24.82	222	2052	664	0	81.8
Crystal 793	107	385.1	104	8296	113	1.52	64.74	107	1399	117	20.80	21.53	179	1867	609	0	84.7
Crystal 796	108	365.2	98	9600	131	1.50	58.89	97	1542	129	19.81	26.40	184	1873	603	0	89.1
Crystal 803	115	378.0	102	8838	120	1.53	62.65	103	1473	123	20.46	23.02	155	1896	630	28	86.3
Crystal 804	114	365.8	98	8694	118	1.56	59.07	97	1404	117	19.84	23.83	198	1907	628	0	80.7
Crystal 913	118	384.9	104	8625	117	1.53	64.68	107	1456	121	20.81	22.29	163	1829	637	0	81.7
Hilleshög HIL2317	120	363.5	98	7648	104	1.53	58.41	96	1229	102	19.72	20.94	197	2039	574	0	80.0
Hilleshög HIL9528	109	337.5	91	8280	113	1.51	50.79	84	1255	105	18.40	24.45	227	1865	585	0	82.7
Hilleshög HIL9708	123	355.5	96	7788	106	1.58	56.06	92	1229	102	19.30	21.63	321	1933	600	0	84.6
Hilleshög HIL9920	117	357.6	96	7685	104	1.55	56.67	93	1211	101	19.42	21.82	257	2017	567	0	82.2
Maribo MA504	106	341.9	92	6838	93	1.67	52.08	86	1042	87	18.77	19.92	265	1959	679	0	83.7
Maribo MA717	121	341.2	92	8643	118	1.59	51.87	85	1315	110	18.62	25.34	267	2036	592	0	81.3
Maribo MA902	119	351.8	95	8166	111	1.63	54.95	91	1272	106	19.15	23.18	317	1933	637	0	87.8
SV 265	105	358.7	97	7063	96	1.38	56.98	94	1114	93	19.21	19.86	193	1818	512	0	79.8
SV 268	116	372.2	100	8608	117	1.41	60.95	100	1415	118	20.03	23.12	150	1866	537	0	90.7
SV 285	111	373.7	101	8099	110	1.47	61.38	101	1334	111	20.20	21.69	150	1935	570	0	86.9
SV 375	102	375.5	101	8276	113	1.45	61.93	102	1369	114	20.27	21.82	140	1924	563	0	84.5
SX 1888	104	358.1	96	7839	107	1.66	56.83	94	1245	104	19.58	21.88	185	2049	676	0	75.0
SX 1898	122	375.6	101	8189	111	1.46	61.96	102	1361	113	20.26	21.68	157	1935	559	0	78.5
Crystal 355RR(Check)	126	374.7	101	6484	88	1.65	61.68	102	1067	89	20.38	17.40	183	2014	676	0	82.0
BTS 8572 (Check)	127	372.5	100	7451	101	1.69	61.04	101	1219	102	20.34	19.99	171	1927	734	0	73.9
BTS 8337 (Check)	128	371.8	100	7713	105	1.56	60.84	100	1261	105	20.12	20.72	169	1981	622	0	78.4
Crystal 578RR (Check)	129	366.5	99	7774	106	1.59	59.27	98	1250	104	19.88	21.37	226	1971	625	0	83.2
AP CHK MOD SUS RR#5	130	377.0	102	8649	118	1.55	62.35	103	1428	119	20.34	23.07	180	1913	623	0	80.4
AP CHK MOD RR#4	131	373.0	100	7152	97	1.51	61.19	101	1168	97	20.12	19.30	223	1939	571	0	80.0
Root Aphid Susc Chk#5	132	336.9	91	8246	112	1.54	50.60	83	1229	102	18.39	24.76	340	1891	563	0	78.2
Experimental Trial (Comm status)																	
BTS 8018	232	388.7	105	7843	107	1.58	65.86	108	1328	111	20.98	20.21	175	1869	690	0	81.2
BTS 8034	222	355.5	96	8429	115	1.71	55.97	92	1319	110	19.50	23.79	263	2150	685	0	83.3
BTS 8073	207	376.7	101	7329	100	1.64	62.28	103	1206	101	20.44	19.59	180	1955	706	0	79.9
BTS 8092	236	368.6	99	9053	123	1.53	59.88	99	1467	122	19.94	24.54	181	1876	642	0	74.0
BTS 8100	212	382.2	103	7963	108	1.51	63.92	105	1330	111	20.58	20.85	169	2098	570	0	78.5
BTS 8122	226	402.7	108	8264	112	1.35	70.03	115	1435	120	21.44	20.60	141	1832	534	0	75.9
BTS 8133	227	360.1	97	10305	140	1.59	57.34	94	1642	137	19.59	28.46	203	2098	620	0	82.9
BTS 8140	243	377.7	102	7787	106	1.53	62.59	103	1287	107	20.46	20.50	160	1974	621	0	82.0
BTS 8156	223	366.6	99	8352	114	1.59	59.29	98	1357	113	19.93	22.61	210	2143	612	0	85.3
BTS 8164	211	367.8	99	7866	107	1.66	59.66	98	1285	107	20.05	21.19	223	2103	672	0	80.8
BTS 8187	220	376.9	101	7524	102	1.68	62.35	103	1226	102	20.54	20.13	206	1892	749	0	75.3
Crystal 021	208	376.6	101	9494	129	1.57	62.25	103	1569	131	20.41	25.07	203	2049	617	0	77.4
Crystal 022	241	389.7	105	7844	107	1.51	66.15	109	1326	111	20.97	20.26	166	1917	622	0	82.9
Crystal 025	244	378.5	102	8058	110	1.58	62.84	104	1337	111	20.49	21.32	199	1980	654	0	71.6
Crystal 026	209	363.5	98	10013	136	1.70	58.37	96	1613	134	19.86	27.49	264	2137	676	0	84.3
Crystal 029	240	390.4	105	7700	105	1.53	66.37	109	1299	108	21.08	19.70	161	1851	656	0	88.2
Crystal 130	230	381.4	103	8488	115	1.57	63.67	105	1418	118	20.58	22.43	198	2008	639	0	82.9
Crystal 132	218	392.2	106	7341	100	1.39	66.89	110	1244	104	21.00	18.73	146	1716	594	0	72.9
Crystal 134	214	397.5	107	7807	106	1.47	68.47	113	1338	112	21.29	19.68	159	1875	596	0	76.5
Crystal 137	203	379.2	102	9396	128	1.56	63.05	104	1561	130	20.56	24.54	204	2125	586	0	87.3
Crystal 138	205	387.1	104	7952	108	1.50	65.37	108	1335	111	20.83	20.57	144	1858	643	0	77.7
Crystal 912	242	362.0	97	9140	124	1.75	57.91	95	1461	122	19.86	25.21	267	1964	760	0	79.1
Hilleshög HIL2320	217	344.4	93	8045	109	1.68	52.66	87	1221	102	18.85	23.50	278	2062	674	0	87.0
Hilleshög HIL2366	215	360.6	97	8885	121	1.55	57.49	95	1416	118	19.54	24.62	252	1905	625	0	88.9
Hilleshög HIL2367	237	356.7	96	8305	113	1.64	56.34	93	1307	109	19.41	23.45	242	2033	665	0	85.1
Hilleshög HIL2368	233	363.7	98	7429	101	1.62	58.42	96	1192	99	19.79	20.46	240	1942	677	0	86.1
Hilleshög HIL2385	201	373.7	101	7937	108	1.35	61.41	101	1305	109	19.98	21.42	185	1877	517	0	84.9
Hilleshög HIL2386	238	371.6	100	9448	128	1.50	60.78	100	1536	128	20.06	25.47	198	1941	598	0	87.3
Hilleshög HIL2387	213	368.4	99	7949	108	1.57	59.82	99	1282	107	19.99	21.58	206	2012	624	0	84.1
Hilleshög HIL2388	225	370.1	100	8666	118	1.46	60.32	99	1405	117	19.93	23.40	214	1871	570	0	80.1
Hilleshög HIL2389	234	377.6	102	8676	118	1.41	62.56	103	1440	120	20.30	22.85	179	1956	530	0	86.4
Maribo MA930	210	371.2	100	9744	132	1.66	60.66	100	1598	133	20.20	26.17	210	2050	688	0	91.4
Maribo MA931	219	353.6	95	8357	114	1.48	55.42	91	1311	109	19.16	23.60	236	1982	564	0	80.2
Maribo MA932	231	354.1	95	8545	116	1.53	55.56	92	1340	112	19.23	24.10	311	2015	555	0	86.2
SV 203	239	367.6	99	7344	100	1.46	59.58	98	1187	99	19.85	19.92	177	2026	550	0	69.0
SV 211	224	386.9	104	7376	100	1.39	65.32	108	1247	104	20.67	19.13	140	2017	516	0	74.4
SV 213	206	362.7	98	6914	94	1.65	58.13	96	1093	91	19.80	19.24	206	2028	692	0	57.3
SV 214	245	367.8	99	6345	86	1.45	59.64	98	1025	85	19.82	17.37	125	1969	587	0	69.1
SV 215	221	366.5	99	6974	95	1.61	59.26	98	1123	94	19.88	19.08	188	2100	639	0	52.4
SX 1804	228	381.8	103	8636	117	1.48	63.80	105	1437	120	20.52	22.78	170	2007	579	0	79.2
SX 1815	229	379.3	102	8331	113	1.45	63.07	104	1387	116	20.39	21.95	152	1978	568	0	84.0
SX 1816	202	366.2	99	8543	116	1.48	59.15	97	1389	116	19.81	22.95	184	2026	556	0	66.4
SX 1817	216	367.3	99	8420	114	1.63	59.49	98	1355	113	20.01	22.90	179	2073	667	0	80.1
SX 1818	235	371.3	100	8586	117	1.53	60.68	100	1402	117	20.10	23.10	166	2043	611	0	77.3
SX 1819	204	367.9	99	8729	119	1.52	59.66	98	1409	118	19.88	23.83	173	1969	614	0	78.7
Crystal 355RR(Check)	246	362.5	98	6928	94	1.73	58.08	96	1106	92	19.89	19.07	217	2109	723	0	78.8
BTS 8572 (Check)	247	384.7	104	6900	94	1.52	64.68	107	1155	96	20.73	18.08	132	1933	648	86	69.1
BTS 8337 (Check)	248	366.5	99	7167	97	1.67	59.24	98	1157	96	20.00	19.56	210	2082	688	0	77.6
Crystal 578RR (Check)	249	371.8	100	8427	115	1.57	60.83	100	1380	115	20.10	22.78	212	2034	625	0	81.3
BTS 8815 (Check)	250	374.4	101	7932	108	1.55	61.61	101	1301	108	20.26	21.25	195	2110	592	0	61.5
AP CHK MOD SUS RR#5	251	377.1	102	8284	113	1.50	62.41	103	1369	114	20.38	21.92	200	1994	586	0	74.3
AP CHK MOD RR#4	252	380.7	103	8004	109	1.45	63.48	105	1333	111	20.51	20.91	207	1990	540	0	80.6
Root Aphid Susc Chk#5	253	358.3	96	8169	111	1.65	56.83	94	1295	108	19.56	22.71	268	2025	662	0	78.6
AP CHK MOD SUS RR#5	254	360.0	97	8146	111	1.62	57.31	94	1298	108	19.64	22.49	217	2077	642	0	84.0
Comm Benchmark Mean		371.4		7356		1.62	60.71		1199		20.18	19.87	187	1973	664		79.4
Comm Trial Mean		365.8		8227		1.55	59.07		1328		19.84	22.51	205	1931	616		81.5
Coeff. of Var. (%)		4.5		8.6		8.3	8.1		11.3		4.0	6.4	23.6	4.6	12.5		7.7
Mean LSD (0.05)		19.7		843		0.16	5.76		177		0.91	1.80	60	111	99		7.4
Mean LSD (0.01)		26.0		1112		0.22	7.61		233		1.21	2.38	79	147	131		9.8
Sig Lvl		**		**		*	**		**		**	**	**	**	**		**

2021 Data from Hallock MN Bolters based upon 60,000 seed per acre. Created 10/29/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status. Trial # = 218312

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 19.

2021 Performance of Varieties - ACSC RR Official Trial

Description @	Code	Rec/T lbs.	%Bnch	Rec/A lbs.	%Bnch	Loss Mol %	Rev/T $ ++	%Bnch	Rev/A $ ++	%Bnch	Sugar %	Yield T/A	Na ppm	K ppm	AmN ppm	Bolter per Ac	Emerg. %
Commercial Trial																	
BTS 8629	103	358.2	98	11076	118	0.93	56.85	96	1748	115	18.84	31.13	110	1488	285	0	87.2
BTS 8882	112	351.4	96	10832	115	1.02	54.85	92	1686	111	18.59	30.86	113	1724	293	0	86.0
BTS 8927	101	374.7	102	10427	111	0.92	61.68	104	1714	112	19.65	27.78	98	1536	273	0	75.6
BTS 8938	113	364.0	99	10967	117	0.92	58.53	98	1765	116	19.11	30.06	96	1513	278	0	67.0
BTS 8961	110	362.0	99	11161	119	1.02	57.96	97	1786	117	19.13	30.91	113	1692	301	0	79.2
Crystal 572	125	378.1	103	10120	108	0.92	62.68	105	1679	110	19.83	26.77	91	1479	288	0	82.9
Crystal 684	124	346.6	94	10568	112	1.06	53.44	90	1627	107	18.39	30.55	129	1738	310	0	84.0
Crystal 793	107	374.5	102	11165	119	0.92	61.62	104	1840	121	19.64	29.80	93	1526	272	0	81.3
Crystal 796	108	362.4	99	11346	121	1.03	58.06	98	1820	119	19.14	31.24	121	1638	316	0	85.6
Crystal 803	115	371.1	101	11275	120	0.92	60.62	102	1839	121	19.48	30.42	91	1551	275	0	89.2
Crystal 804	114	356.8	97	11398	121	1.02	56.42	95	1797	118	18.86	32.03	119	1676	304	0	84.8
Crystal 913	118	381.4	104	10857	115	0.86	63.65	107	1803	118	19.94	28.62	87	1452	252	0	87.2
Hilleshög HIL2317	120	365.6	100	9913	105	0.93	59.01	99	1601	105	19.21	27.12	120	1598	252	0	79.8
Hilleshög HIL9528	109	355.1	97	9985	106	0.99	55.92	94	1576	103	18.74	28.05	136	1563	305	0	71.8
Hilleshög HIL9708	123	362.2	99	9586	102	0.91	58.01	98	1531	100	19.02	26.56	118	1517	262	0	86.7
Hilleshög HIL9920	117	375.3	102	10381	110	0.92	61.84	104	1711	112	19.68	27.52	101	1647	239	0	81.0
Maribo MA504	106	366.3	100	9975	106	0.97	59.21	100	1615	106	19.28	27.20	113	1555	296	0	85.0
Maribo MA717	121	351.0	96	10629	113	0.99	54.74	92	1662	109	18.55	30.24	127	1661	281	0	82.0
Maribo MA902	119	368.1	100	10027	107	0.98	59.76	101	1632	107	19.39	27.22	121	1567	298	0	88.2
SV 265	105	364.8	99	10137	108	0.87	58.77	99	1630	107	19.11	27.81	90	1494	246	0	79.3
SV 268	116	367.3	100	11056	118	0.96	59.52	100	1790	117	19.33	30.16	102	1634	271	0	88.6
SV 285	111	369.7	101	10899	116	0.94	60.21	101	1771	116	19.43	29.54	104	1574	275	0	86.4
SV 375	102	369.0	101	10749	114	0.90	59.99	101	1749	115	19.34	29.13	98	1528	253	0	88.6
SX 1888	104	362.2	99	9901	105	0.99	58.03	98	1588	104	19.10	27.24	108	1636	299	0	74.7
SX 1898	122	363.9	99	9753	104	1.01	58.52	98	1570	103	19.21	26.77	111	1645	308	0	75.1
Crystal 355RR(Check)	126	358.9	98	8465	90	1.08	57.05	96	1341	88	19.03	23.69	123	1683	344	0	90.2
BTS 8572 (Check)	127	365.4	100	9196	98	0.97	58.94	99	1487	98	19.25	25.19	109	1566	299	0	80.8
BTS 8337 (Check)	128	380.5	104	9886	105	0.97	63.38	107	1653	108	20.00	25.86	98	1658	279	0	80.5
Crystal 578RR (Check)	129	363.6	99	10075	107	0.96	58.42	98	1617	106	19.14	27.73	119	1611	272	0	84.6
AP CHK MOD SUS RR#5	130	363.4	99	10270	109	1.02	58.35	98	1648	108	19.19	28.34	120	1671	300	0	88.8
AP CHK MOD RR#4	131	363.0	99	9435	100	0.97	58.25	98	1507	99	19.12	26.13	125	1645	267	0	89.5
Root Aphid Susc Chk#5	132	350.9	96	9925	106	0.88	54.69	92	1549	102	18.43	28.29	125	1495	245	0	76.7
Experimental Trial (Comm status)																	
BTS 8018	232	369.4	101	10411	111	0.91	60.13	101	1703	112	19.38	28.01	110	1554	301	0	89.5
BTS 8034	222	347.0	95	9958	106	1.02	53.43	90	1537	101	18.39	28.76	143	1733	322	0	90.2
BTS 8073	207	369.7	101	10322	110	0.91	60.20	101	1695	111	19.40	27.69	102	1495	330	0	84.0
BTS 8092	236	365.3	99	10772	115	0.90	58.89	99	1741	114	19.16	29.31	125	1538	286	0	83.6
BTS 8100	212	364.6	99	9957	106	1.07	58.71	99	1609	106	19.31	27.16	116	1750	371	0	89.5
BTS 8122	226	383.1	104	8982	95	0.88	64.22	108	1498	98	20.05	23.54	111	1553	273	0	84.4
BTS 8133	227	348.1	95	11115	118	0.96	53.78	90	1728	113	18.38	31.80	125	1687	299	0	83.6
BTS 8140	243	367.5	100	9870	105	1.05	59.57	100	1598	105	19.44	26.86	119	1611	388	0	93.4
BTS 8156	223	356.7	97	10476	111	1.08	56.34	95	1667	109	18.95	29.16	158	1776	364	0	89.1
BTS 8164	211	354.5	97	9412	100	1.06	55.71	94	1484	97	18.80	26.41	135	1672	369	0	80.9
BTS 8187	220	381.9	104	9664	103	0.93	63.86	107	1620	106	20.04	25.15	105	1531	331	0	82.4
Crystal 021	208	356.0	97	10267	109	0.99	56.11	94	1625	107	18.80	28.85	125	1680	315	0	80.5
Crystal 022	241	369.3	101	10177	108	0.90	60.12	101	1665	109	19.38	27.37	106	1534	289	0	83.2
Crystal 025	244	362.6	99	10291	109	1.05	58.12	98	1652	108	19.19	28.34	131	1666	370	0	78.5
Crystal 026	209	357.6	97	10994	117	1.01	56.61	95	1748	115	18.91	30.72	133	1738	316	0	89.8
Crystal 029	240	366.9	100	9973	106	0.96	59.40	100	1618	106	19.31	27.08	109	1561	336	0	89.5
Crystal 130	230	366.5	100	10329	110	0.91	59.26	100	1684	110	19.24	27.98	103	1543	310	0	90.6
Crystal 132	218	373.6	102	10232	109	0.94	61.39	103	1680	110	19.63	27.50	113	1493	335	0	75.0
Crystal 134	214	372.2	101	9694	103	0.91	60.95	103	1591	104	19.51	26.06	113	1526	293	0	79.7
Crystal 137	203	367.2	100	10944	116	0.97	59.46	100	1780	117	19.33	29.63	109	1726	295	0	83.6
Crystal 138	205	367.2	100	10005	106	0.91	59.49	100	1626	107	19.27	27.17	102	1561	304	0	79.7
Crystal 912	242	353.2	96	11623	124	0.98	55.30	93	1828	120	18.64	32.79	143	1524	343	0	78.5
Hilleshög HIL2320	217	358.9	98	10133	108	0.98	57.02	96	1622	106	18.93	27.85	132	1619	325	0	89.8
Hilleshög HIL2366	215	365.7	100	9990	106	0.90	59.01	99	1623	106	19.18	27.21	126	1528	281	0	86.7
Hilleshög HIL2367	237	353.4	96	9978	106	1.00	55.35	93	1568	103	18.68	28.25	169	1591	329	0	87.1
Hilleshög HIL2368	233	373.6	102	8440	90	0.95	61.38	103	1395	91	19.64	22.45	129	1577	315	0	88.7
Hilleshög HIL2385	201	380.4	104	9414	100	0.92	63.40	107	1580	104	19.94	24.57	111	1503	318	0	84.0
Hilleshög HIL2386	238	367.1	100	9871	105	1.03	59.46	100	1605	105	19.40	26.86	131	1628	362	0	84.8
Hilleshög HIL2387	213	371.3	101	9247	98	0.94	60.71	102	1512	99	19.52	24.82	118	1533	334	0	84.4
Hilleshög HIL2388	225	368.4	100	10041	107	0.97	59.85	101	1645	108	19.40	27.01	127	1559	333	0	88.3
Hilleshög HIL2389	234	373.2	102	9471	101	0.97	61.26	103	1555	102	19.64	25.38	115	1617	324	0	84.4
Maribo MA930	210	365.2	99	10480	111	0.99	58.84	99	1691	111	19.26	28.59	118	1604	340	0	86.3
Maribo MA931	219	357.1	97	9881	105	1.06	56.45	95	1570	103	18.92	27.48	160	1683	360	0	78.9
Maribo MA932	231	367.5	100	10238	109	0.92	59.56	100	1664	109	19.31	27.81	111	1615	300	0	82.8
SV 203	239	370.8	101	9394	100	0.96	60.54	102	1537	101	19.50	25.46	110	1619	314	0	81.3
SV 211	224	367.7	100	9514	101	0.96	59.63	100	1542	101	19.36	25.95	110	1648	313	0	80.9
SV 213	206	361.1	98	9466	101	1.03	57.65	97	1526	100	19.10	26.04	105	1671	357	0	78.6
SV 214	245	360.2	98	8910	95	1.01	57.38	97	1427	94	19.03	24.61	115	1607	358	0	87.9
SV 215	221	367.8	100	9510	101	0.99	59.66	100	1547	101	19.39	25.73	114	1697	320	0	71.9
SX 1804	228	367.3	100	9992	106	0.91	59.51	100	1635	107	19.27	26.88	99	1561	296	0	81.6
SX 1815	229	365.4	100	10512	112	0.91	58.93	99	1697	111	19.19	28.77	107	1616	286	0	85.6
SX 1816	202	357.5	97	9459	101	1.03	56.57	95	1502	99	18.92	26.45	140	1731	335	0	75.8
SX 1817	216	360.7	98	10064	107	0.98	57.54	97	1614	106	19.04	27.68	131	1685	313	0	86.3
SX 1818	235	361.5	98	10192	108	0.97	57.76	97	1629	107	19.06	28.17	110	1633	326	0	82.4
SX 1819	204	371.8	101	10088	107	0.91	60.84	102	1653	108	19.50	26.98	103	1593	288	0	85.9
Crystal 355RR(Check)	246	371.4	101	9529	101	0.99	60.74	102	1561	102	19.56	25.63	108	1674	332	0	88.3
BTS 8572 (Check)	247	374.5	102	9176	98	0.98	61.64	104	1521	100	19.70	24.28	103	1565	346	0	82.4
BTS 8337 (Check)	248	363.8	99	9028	96	0.99	58.47	98	1450	95	19.20	24.83	118	1683	321	0	75.8
Crystal 578RR (Check)	249	358.7	98	9889	105	1.02	56.94	96	1566	103	18.96	27.72	123	1665	340	0	88.3
BTS 8815 (Check)	250	369.0	101	9339	99	0.96	60.01	101	1522	100	19.43	25.35	131	1712	297	0	75.8
AP CHK MOD SUS RR#5	251	366.0	100	9850	105	1.01	59.09	99	1598	105	19.30	26.80	131	1676	333	0	82.4
AP CHK MOD RR#4	252	356.6	97	8577	91	0.98	56.30	95	1366	90	18.82	23.89	153	1710	296	0	85.9
Root Aphid Susc Chk#5	253	362.0	99	9340	99	0.92	57.93	97	1503	99	19.04	25.74	133	1559	300	0	80.9
AP CHK MOD SUS RR#5	254	382.9	104	10287	109	0.97	64.18	108	1732	114	20.12	26.77	136	1598	318	0	84.0
Comm Benchmark Mean		367.1		9406		1.00	59.45		1525		19.36	25.62	112	1630	299		84.0
Comm Trial Mean		364.6		10357		0.96	58.72		1667		19.19	28.44	110	1592	282		82.8
Coeff. of Var. (%)		2.4		5.4		6.9	4.4		6.6		2.2	4.8	13.7	4.9	12.2		7.9
Mean LSD (0.05)		10.8		703		0.08	3.18		135		0.51	1.75	19	94	43		7.6
Mean LSD (0.01)		14.3		928		0.11	4.20		178		0.67	2.31	25	125	57		10.0
Sig Lvl		**		**		**	**		**		**	**	**	**	**		**

2021 Data from Bathgate ND Bolters based upon 60,000 seed per acre. Created 11/01/2021

%Bnch = percentage of four commercial and 2-year benchmark varieties. Na, K, AmN,

Bolter & Emergence not adjusted to commercial status.

@ Statistics and trial mean are from Commercial trial including benchmark and check means. Experimental trial data adjusted to commercial status. Trial # = 218313

++ Revenue estimates are based on a $45.65 beet payment at 17.5% sugar & 1.5% loss to molasses and do not consider hauling costs.

Table 20.
Calculation for Approval of Sugarbeet Varieties for ACSC Market for 2022

Description	Approval Status		Rec/Ton 2020	Rec/Ton 2021	Rec/Ton 2 Yr	Rec/Ton % Bench		Rev/Acre 2020	Rev/Acre 2021	Rev/Acre 2 Yr	Rev/Acre % Bench	R/T + $/A Bench	Cercospora Rating + 2019	Cercospora Rating + 2020	Cercospora Rating + 2021	Cercospora Rating + 2 Yr Mean	Cercospora Rating + 3 Yr Mean
Previously Approved (3 Yr)																	**<=5.30**
BTS 8629	Approved		317.4	322.9	320.2	95.9		1406	1590	1498	112.4	208.3	4.66	4.55	4.78	4.66	4.66
BTS 8882	Approved		314.8	322.3	318.6	95.5		1381	1554	1468	110.1	205.6	4.18	4.71	4.92	4.81	4.60
BTS 8927	Approved		347.7	343.3	345.5	103.5		1482	1572	1527	114.6	218.1	4.35	4.42	4.48	4.45	4.42
BTS 8938	Approved		329.2	333.2	331.2	99.2		1409	1574	1492	111.9	211.2	4.35	4.66	4.71	4.68	4.57
BTS 8961	Approved		321.4	328.5	325.0	97.4		1415	1556	1486	111.5	208.8	4.27	4.69	4.53	4.61	4.49
Crystal 572	Approved		340.6	337.9	339.3	101.7		1405	1530	1468	110.1	211.8	4.68	4.46	4.75	4.61	4.63
Crystal 684	Approved		316.7	320.8	318.8	95.5		1432	1533	1483	111.2	206.8	4.12	4.44	4.54	4.49	4.37
Crystal 793	Approved		335.2	339.3	337.3	101.1		1514	1625	1570	117.8	218.8	4.04	4.31	4.13	4.22	4.16
Crystal 796	Approved		321.7	328.1	324.9	97.4		1372	1578	1475	110.7	208.0	4.74	4.95	4.98	4.96	4.89
Crystal 803	Approved		333.6	336.8	335.2	100.4		1444	1597	1521	114.1	214.5	3.88	3.93	3.86	3.89	3.89
Crystal 804	Approved		312.5	324.7	318.6	95.5		1383	1591	1487	111.6	207.1	4.46	4.77	4.68	4.72	4.63
Crystal 912	Approved		322.7	328.2	325.5	97.5		1520	1665	1593	119.5	217.0	4.62	4.75	5.13	4.94	4.83
Crystal 913	Approved		332.9	339.5	336.2	100.7		1490	1579	1535	115.1	215.9	4.11	4.13	4.10	4.12	4.11
Hilleshög HIL2317	Approved		334.3	334.5	334.4	100.2		1385	1451	1418	106.4	206.6	4.90	5.05	4.57	4.81	4.84
Hilleshög HIL9528	Approved		323.5	320.3	321.9	96.5		1362	1392	1377	103.3	199.8	4.93	4.84	4.52	4.68	4.76
Hilleshög HIL9708	Approved		330.0	326.9	328.5	98.4		1369	1402	1386	104.0	202.4	4.96	4.97	4.65	4.81	4.86
Hilleshög HIL9920	Approved		333.4	335.4	334.4	100.2		1398	1497	1448	108.6	208.8	4.95	4.82	4.75	4.78	4.84
Maribo MA504	Approved		317.5	320.3	318.9	95.6		1368	1401	1385	103.9	199.5	5.34	5.35	5.07	5.21	5.25
Maribo MA717	Approved		329.0	317.4	323.2	96.8		1454	1414	1434	107.6	204.5	5.11	5.11	4.68	4.89	4.97
Maribo MA902	Approved		332.7	326.9	329.8	98.8		1393	1427	1410	105.8	204.6	4.91	4.96	4.63	4.80	4.83
SV 265	Approved		332.4	326.9	329.7	98.8		1396	1416	1406	105.5	204.3	4.28	4.55	4.30	4.42	4.38
SV 268	Approved		328.3	333.2	330.8	99.1		1317	1552	1435	107.6	206.8	4.82	4.78	5.18	4.98	4.93
SV 285	Approved		335.6	335.8	335.7	100.6		1373	1524	1449	108.7	209.3	4.84	4.50	4.78	4.64	4.70
SV 375	Approved		327.5	336.3	331.9	99.5		1352	1541	1447	108.5	208.0	4.11	4.78	4.71	4.74	4.53
SX 1888	Approved		327.9	328.0	328.0	98.3		1345	1434	1390	104.3	202.5	4.89	4.67	5.03	4.85	4.87
SX 1898	Approved		337.2	335.6	336.4	100.8		1510	1479	1495	112.1	213.0	4.68	4.73	4.76	4.74	4.72
Candidates for Approval (2 Yr)																**<=5.00**	
BTS 8018	Approved		332.8	338.0	335.4	100.5		1501	1622	1562	117.2	217.7	--	2.41	2.31	2.36	--
BTS 8034	Approved		327.3	323.2	325.3	97.5		1534	1587	1561	117.1	214.6	--	2.70	2.56	2.63	--
BTS 8073	Approved		337.0	332.4	334.7	100.3		1537	1533	1535	115.2	215.5	--	4.68	4.56	4.62	--
BTS 8092	Approved		329.9	332.2	331.1	99.2		1474	1611	1543	115.7	215.0	--	4.26	4.62	4.44	--
Crystal 021	Approved		326.6	330.0	328.3	98.4		1489	1620	1555	116.6	215.0	--	2.20	2.28	2.24	--
Crystal 022	Approved		348.5	340.7	344.6	103.3		1536	1543	1540	115.5	218.8	--	4.71	4.97	4.84	--
Crystal 025	Approved		332.8	333.2	333.0	99.8		1444	1531	1488	111.6	211.4	--	4.56	4.84	4.70	--
Crystal 026	Approved		329.1	327.9	328.5	98.4		1491	1602	1547	116.0	214.5	--	4.76	4.43	4.60	--
Crystal 029	Approved		333.7	335.6	334.7	100.3		1477	1512	1495	112.1	212.4	--	4.67	4.59	4.63	--
Hilleshög HIL2320	Approved		333.4	324.3	328.9	98.5		1468	1411	1440	108.0	206.6	4.92	5.11	4.78	4.94	4.94
Hilleshög HIL2366	Approved		328.2	331.3	329.8	98.8		1383	1481	1432	107.5	206.3	--	4.94	5.01	4.98	--
Hilleshög HIL2367	Approved		334.8	327.3	331.1	99.2		1440	1443	1442	108.2	207.4	--	5.08	4.75	4.92	--
Hilleshög HIL2368	Approved		345.2	337.7	341.5	102.3		1301	1339	1320	99.1	201.4	--	4.69	4.66	4.67	--
SV 203	Approved		333.5	337.8	335.7	100.6		1466	1478	1472	110.5	211.0	--	5.03	4.75	4.89	--
SX 1804	Approved		329.9	334.4	332.2	99.5		1393	1512	1453	109.0	208.5	--	4.76	4.80	4.78	--
Benchmark Varieties		2019	2020	2021			2019	2020	2021								
Crystal 101RR (Check)	Benchmark	309.5					1355										
Crystal 355RR(Check)	Benchmark	321.2	333.8	330.5			1379	1200	1292								
BTS 8572 (Check)	Benchmark	327.5	335.2	333.2			1459	1292	1412								
BTS 8337 (Check)	Benchmark	329.6	342.6	340.4			1452	1262	1447								
Crystal 578RR (Check)	Benchmark		323.5	330.5				1296	1460								
Benchmark mean		322.0	333.8	333.7	333.7	329.8	1411	1263	1403	1333	1359						

+ All Cercospora ratings 2019-2021 were adjusted to 1982 basis. Created 11-08-2021

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

2021 First-Year Experimental Varieties New Benchmark Comparison Projected Calculation for Approval of Sugarbeet Varieties for ACSC Market

Description	Approval ^ Likely	Rec/Ton % 2021	Rec/Ton % Bench	Rev/Acre % 2021	Rev/Acre % Bench	R/T + $/A Bench	CR Rating ^^ 2021
Candidates for Retesting (1 Yr)							
BTS 8100	On Track	339.2	101.3	1544	107.2	208.5	4.01
BTS 8122	On Track	353.2	105.5	1535	106.6	212.1	3.55
BTS 8133	Not On Track	322.1	96.2	1601	111.2	207.4	2.30
BTS 8140	On Track	337.0	100.6	1528	106.1	206.7	3.90
BTS 8156	On Track	330.2	98.6	1551	107.7	206.3	2.48
BTS 8164	Not On Track	330.4	98.7	1480	102.8	201.4	4.61
BTS 8187	On Track	344.3	102.8	1514	105.1	207.9	4.39
Crystal 130	On Track	338.1	101.0	1620	112.5	213.5	2.38
Crystal 132	On Track	340.8	101.8	1529	106.2	207.9	4.74
Crystal 134	On Track	347.6	103.8	1574	109.3	213.1	4.59
Crystal 137	On Track	330.7	98.8	1628	113.0	211.8	2.53
Crystal 138	On Track	336.6	100.5	1561	108.4	208.9	4.74
Hilleshög HIL2385	On Track	336.2	100.4	1413	98.1	198.5	4.72
Hilleshög HIL2386	On Track	332.3	99.2	1499	104.1	203.3	4.30
Hilleshög HIL2387	Not On Track	332.7	99.4	1389	96.4	195.8	4.84
Hilleshög HIL2388	Not On Track	331.3	98.9	1442	100.1	199.1	4.84
Hilleshög HIL2389	On Track	334.1	99.8	1483	103.0	202.7	4.85
Maribo MA930	Not On Track	326.4	97.5	1508	104.7	202.2	5.16
Maribo MA931	Not On Track	325.6	97.2	1439	99.9	197.2	5.00
Maribo MA932	Not On Track	328.4	98.1	1486	103.2	201.3	4.85
SV 211	On Track	335.1	100.1	1436	99.7	199.8	4.83
SV 213	Not On Track	333.5	99.6	1450	100.7	200.3	5.03
SV 214	Not On Track	321.8	96.1	1213	84.2	180.3	4.42
SV 215	Not On Track	331.3	98.9	1427	99.1	198.0	5.11
SX 1815	On Track	338.7	101.1	1545	107.3	208.4	4.78
SX 1816	On Track	328.3	98.0	1518	105.4	203.4	4.63
SX 1817	Not On Track	330.5	98.7	1503	104.4	203.1	5.15
SX 1818	On Track	332.5	99.3	1555	108.0	207.3	4.86
SX 1819	On Track	332.6	99.3	1493	103.7	203.0	4.71
Benchmarks							
BTS 8572 (Check)		336.2	100.4	1367	94.9		
BTS 8337 (Check)		337.6	100.8	1408	97.8		
Crystal 578RR (Check)		328.7	98.2	1524	105.8		
BTS 8815 (Check)		336.9	100.6	1461	101.5		
Benchmark Mean		334.9		1440			

^ Not on Track = not on track for approval. On Track = data is tracking for potential approval. Created 11-08-2021

^^ All Cercospora ratings 2021 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 2021 first year entries added Beta 8815 and dropped Crystal 355(Check)

Table

Calculation for Approval of Sugarbeet Varieties for ACSC Aphanomyces Specialty Market for 2022

Trial Yrs	Description	Approval Status	Aph. Root Rating 2019	2020	2021	2 Yr	3 Yr	Cercospora Rating + 2019	2020	2021	2 Yr	3 Yr
	Previously Approved (3 Yrs)						**<=4.70**					**<=5.30**
6	BTS 8629	Approved	5.32	3.92	4.24	4.08	4.49	4.66	4.55	4.78	4.67	4.66
3	BTS 8927	Approved	4.06	3.87	4.51	4.19	4.15	4.35	4.42	4.48	4.45	4.42
3	BTS 8938	Approved	3.75	3.86	4.07	3.97	3.89	4.35	4.66	4.71	4.69	4.57
3	BTS 8961	Approved	3.89	4.04	4.80	4.42	4.24	4.27	4.69	4.53	4.61	4.50
6	Crystal 684	Approved	4.33	3.97	3.60	3.79	3.97	4.12	4.44	4.54	4.49	4.37
5	Crystal 793	Approved	3.72	3.87	3.74	3.81	3.78	4.04	4.31	4.13	4.22	4.16
5	Crystal 796	Approved	3.97	3.85	4.72	4.29	4.18	4.74	4.95	4.98	4.97	4.89
4	Crystal 803	Approved	4.45	3.96	3.89	3.93	4.10	3.88	3.93	3.86	3.90	3.89
4	Crystal 804	Approved	4.30	3.61	3.43	3.52	3.78	4.46	4.77	4.68	4.73	4.64
3	Crystal 912	Approved	3.91	3.67	3.95	3.81	3.84	4.62	4.75	5.13	4.94	4.83
3	Crystal 913	Approved	3.58	3.75	4.39	4.07	3.91	4.11	4.13	4.10	4.12	4.11
3	Hilleshög HIL2317	Approved	3.96	3.86	5.01	4.44	4.28	4.90	5.05	4.57	4.81	4.84
8	Hilleshög HIL9528	Approved	4.56	3.72	5.51	4.62	4.60	4.93	4.84	4.52	4.68	4.76
7	Hilleshög HIL9708	NO	4.61	3.96	6.34	5.15	4.97	4.96	4.97	4.65	4.81	4.86
5	Hilleshög HIL9920	Approved	5.05	3.65	4.65	4.15	4.45	4.95	4.82	4.75	4.79	4.84
5	Maribo MA717	NO	4.42	3.77	6.75	5.26	4.98	5.11	5.11	4.68	4.90	4.97
6	SV 268	NO	5.08	4.49	4.93	4.71	4.83	4.82	4.78	5.18	4.98	4.93
4	SV 285	Approved	4.47	4.28	4.48	4.38	4.41	4.84	4.50	4.78	4.64	4.71
4	SX 1888	Approved	4.65	3.99	4.12	4.06	4.25	4.89	4.67	5.03	4.85	4.86
3	SX 1898	Approved	4.74	3.76	4.97	4.37	4.49	4.68	4.73	4.76	4.75	4.72
	Candidates for Approval					**<=4.40**					**<=5.00**	
2	BTS 8018	Approved	0.00	3.87	4.52	4.20		0.00	2.41	2.31	2.36	0.00
2	BTS 8034	Approved	0.00	4.36	3.24	3.80		0.00	2.70	2.56	2.63	0.00
2	BTS 8073	Approved	0.00	3.45	4.30	3.88		0.00	4.68	4.56	4.62	0.00
2	BTS 8092	Approved	0.00	3.85	4.11	3.98		0.00	4.26	4.62	4.44	0.00
4	BTS 8882	Approved	5.17	4.33	3.25	3.79	4.25	4.18	4.71	4.92	4.82	4.60
2	Crystal 021	Approved	0.00	3.46	4.19	3.83		0.00	2.20	2.28	2.24	0.00
2	Crystal 022	Approved	0.00	3.81	4.79	4.30		0.00	4.71	4.97	4.84	0.00
2	Crystal 025	Approved	0.00	3.40	3.52	3.46		0.00	4.56	4.84	4.70	0.00
2	Crystal 026	Approved	0.00	3.75	3.74	3.75		0.00	4.76	4.43	4.60	0.00
2	Crystal 029	Approved	0.00	3.60	4.30	3.95		0.00	4.67	4.59	4.63	0.00
7	Crystal 572	Approved	4.98	4.28	4.47	4.38	4.58	4.68	4.46	4.75	4.61	4.63
3	Hilleshög HIL2320	Approved	4.58	3.55	4.66	4.11	4.26	4.92	5.11	4.78	4.95	4.94
2	Hilleshög HIL2366	NO	0.00	3.81	5.81	4.81		0.00	4.94	5.01	4.98	0.00
2	Hilleshög HIL2367	Approved	0.00	3.51	5.13	4.32		0.00	5.08	4.75	4.92	0.00
2	Hilleshög HIL2368	NO	0.00	3.70	5.25	4.48		0.00	4.69	4.66	4.68	0.00
7	Maribo MA504	NO	6.17	5.06	6.97	6.02	6.07	5.34	5.35	5.07	5.21	5.25
3	Maribo MA902	NO	5.31	4.01	6.96	5.49	5.43	4.91	4.96	4.63	4.80	4.83
2	SV 203	Approved	0.00	4.34	4.35	4.35		0.00	5.03	4.75	4.89	0.00
6	SV 265	NO	5.47	3.98	4.95	4.47	4.80	4.28	4.55	4.30	4.43	4.38
5	SV 375	NO	5.03	4.04	4.77	4.41	4.61	4.11	4.78	4.71	4.75	4.53
2	SX 1804	Approved	0.00	4.02	4.07	4.05		0.00	4.76	4.80	4.78	0.00
	Approval Criteria new varieties					4.40					5.00	
	Criteria to Maintain Approval						4.70					5.30

+ All Cercospora ratings 2019-2021 were adjusted to 1982 basis. Created 11/10/2021

Aphanomyces approval criteria include: 1) Cercospora rating 2 year mean must not exceed 5.00 (1982 adjusted data), 2) Aph root rating 2 year mean <= 4.40. Three years of data may be considered for initial approval.

To maintain Aphanomyces approval, criteria include: 1) Cercospora 3 year mean must not exceed 5.30, 2) Aph root rating 3 year mean <= 4.70. Previously approved varieties not meeting current approval standards may be sold in 2022.

Table 240.

Calculation for Approval of Sugarbeet Varieties for ACSC Rhizoctonia Specialty Market for 2022

Approval Description	Status	Disease Index + 2019	2020	2021	2 Yr Mn	3 Yr Mn	Cercospora Rating 2019	2020	2021	2 Yr Mn	3 Yr Mn
Previously Approved (3 Yr)											
BTS 8938	Approved	3.47	3.90	3.83	3.87	3.73	4.35	4.66	4.71	4.69	4.57
Crystal 804	Approved	3.72	3.90	3.76	3.83	3.79	4.46	4.77	4.68	4.73	4.64
Crystal 912	Approved	3.58	3.54	3.77	3.66	3.63	4.62	4.75	5.13	4.94	4.83
Hilleshög HIL9708	Approved	3.87	3.83	3.78	3.81	3.83	4.96	4.97	4.65	4.81	4.86
Candidates for Approval (2 Yr)					**<=3.82**						
BTS 8018	Not Approved	--	4.16	3.83	4.00	--	--	2.41	2.31	2.36	--
BTS 8034	Not Approved	--	4.56	3.88	4.22	--	--	2.70	2.56	2.63	--
BTS 8073	Not Approved	--	4.11	3.67	3.89	--	--	4.68	4.56	4.62	--
BTS 8092	Approved	--	3.81	3.81	3.81	--	--	4.26	4.62	4.44	--
BTS 8629	Not Approved	3.89	4.30	4.22	4.26	4.14	4.66	4.55	4.78	4.67	4.66
BTS 8882	Not Approved	4.27	4.26	4.26	4.26	4.26	4.18	4.71	4.92	4.82	4.60
BTS 8927	Not Approved	3.93	4.37	3.68	4.03	3.99	4.35	4.42	4.48	4.45	4.42
BTS 8961	Not Approved	3.79	4.11	3.75	3.93	3.88	4.27	4.69	4.53	4.61	4.50
Crystal 021	Approved	--	3.88	3.38	3.63	--	--	2.20	2.28	2.24	--
Crystal 022	Approved	--	3.49	3.53	3.51	--	--	4.71	4.97	4.84	--
Crystal 025	Approved	--	3.72	3.76	3.74	--	--	4.56	4.84	4.70	--
Crystal 026	Approved	--	3.57	3.34	3.46	--	--	4.76	4.43	4.60	--
Crystal 029	Not Approved	--	4.31	3.87	4.09	--	--	4.67	4.59	4.63	--
Crystal 572	Not Approved	4.14	4.21	3.88	4.05	4.08	4.68	4.46	4.75	4.61	4.63
Crystal 684	Not Approved	4.01	4.15	3.82	3.99	3.99	4.12	4.44	4.54	4.49	4.37
Crystal 793	Not Approved	4.18	4.84	4.36	4.60	4.46	4.04	4.31	4.13	4.22	4.16
Crystal 796	Not Approved	3.85	4.45	4.12	4.29	4.14	4.74	4.95	4.98	4.97	4.89
Crystal 803	Not Approved	4.54	5.00	4.39	4.70	4.64	3.88	3.93	3.86	3.90	3.89
Crystal 913	Not Approved	4.31	4.58	3.94	4.26	4.28	4.11	4.13	4.10	4.12	4.11
Hilleshög HIL2317	Not Approved	4.19	4.95	4.76	4.86	4.63	4.90	5.05	4.57	4.81	4.84
Hilleshög HIL2320	Not Approved	4.04	4.64	3.80	4.22	4.16	4.92	5.11	4.78	4.95	4.94
Hilleshög HIL2366	Not Approved	--	4.24	3.98	4.11	--	--	4.94	5.01	4.98	--
Hilleshög HIL2367	Not Approved	--	4.26	4.10	4.18	--	--	5.08	4.75	4.92	--
Hilleshög HIL2368	Approved	--	3.52	2.92	3.22	--	--	4.69	4.66	4.68	--
Hilleshög HIL9920	Not Approved	4.68	5.12	4.70	4.91	4.83	4.95	4.82	4.75	4.79	4.84
Hilleshög HIL9528	Not Approved	4.10	4.57	4.47	4.52	4.38	4.93	4.84	4.52	4.68	4.76
Maribo MA504	Not Approved	4.69	4.83	4.91	4.87	4.81	5.34	5.35	5.07	5.21	5.25
Maribo MA717	Not Approved	4.15	4.61	4.31	4.46	4.36	5.11	5.11	4.68	4.90	4.97
Maribo MA902	Not Approved	3.97	3.93	3.80	3.87	3.90	4.91	4.96	4.63	4.80	4.83
SX 1804	Not Approved	--	4.38	4.19	4.29	--	--	4.76	4.80	4.78	--
SX 1888	Not Approved	4.19	4.17	4.25	4.21	4.20	4.89	4.67	5.03	4.85	4.86
SX 1898	Not Approved	4.21	4.16	4.34	4.25	4.24	4.68	4.73	4.76	4.75	4.72
SV 203	Not Approved	--	4.29	4.34	4.32	--	--	5.03	4.75	4.89	--
SV 265	Not Approved	4.25	4.21	4.17	4.19	4.21	4.28	4.55	4.30	4.43	4.38
SV 268	Not Approved	4.21	5.24	4.38	4.81	4.61	4.82	4.78	5.18	4.98	4.93
SV 285	Not Approved	4.38	4.03	4.26	4.15	4.22	4.84	4.50	4.78	4.64	4.71
SV 375	Not Approved	4.05	4.54	4.22	4.38	4.27	4.11	4.78	4.71	4.75	4.53
Susceptible Checks											
RH CK#55 CRYS803		--	--	4.96							
RH CK#21 CRYS768		4.66	4.50	4.32							
RH CK#25 HILL4043RR		4.66	4.89	4.47							
RH CK#35 SES36812RR		4.29	--	--							
RH CK#36 BTS85RR02		4.56	5.10	5.53							
RH CK#57 BTS8606		--	--	--							
RH CK#40 CRYS101		4.73	4.52	5.04							
RH CK#56 MARI504		--	--	--							
RH CK#47 SES36272RR		4.26	--	--							
RH CK#49 CRYS247		4.16	4.41	4.70							
RH CK#51 SXWinchester		--	4.25	4.37							
RH CK#52 CRYS573		--	5.31	4.29							
RH CK#53 BTS8500		--	--	4.18							
Susceptible Hybrid Mean		4.49	4.67	4.65	4.69	4.63				**5.00**	
Approval Criteria ++		3.82	3.82	3.82	**3.82**	3.82					
Disapproval Criteria						**4.16**					**5.30**

Rhc and CR ratings were adjusted based upon check performance. Created 10/30/2021

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

++ Candidates must have 2yr Rhizoctonia rating less than or equal to 3.82 or the mean of the susceptable check * 80% (if greater than 3.82) . To maintain approval, 3 yr Rhizoctonia rating must be less than or equal to 4.12 or the susceptable check mean * 90%. (if greater than 4.12) Previously approved varieties not meeting current approval standards may be sold in 2022.

Table 24.

2021 Aphanomyces Ratings for Official Trial Entries

		Unadjusted ^^				Adjusted ++									
Chk++	Code Description	Geor NA	Hill NA	Shak 8/25	Glyn NA	Geor NA	Hill NA	Shak 8/25	Glyn NA	2021	2 Yr	3 Yr	2020 ++	2019 ++	Trial Yrs $$
	522 BTS 8018			4.36				4.52		4.52	4.20	--	3.87	--	2
	514 BTS 8034			3.12				3.24		3.24	3.80	--	4.36	--	2
	508 BTS 8073			4.14				4.30		4.30	3.87	--	3.45	--	2
	561 BTS 8092			3.96				4.11		4.11	3.98	--	3.85	--	2
	541 BTS 8100			3.75				3.89		3.89	--	--	--	--	1
	538 BTS 8122			4.54				4.71		4.71	--	--	--	--	1
	529 BTS 8133			3.33				3.46		3.46	--	--	--	--	1
	505 BTS 8140			4.50				4.67		4.67	--	--	--	--	1
	564 BTS 8156			3.51				3.64		3.64	--	--	--	--	1
	517 BTS 8164			3.71				3.85		3.85	--	--	--	--	1
	566 BTS 8187			4.13				4.29		4.29	--	--	--	--	1
	532 BTS 8629			4.09				4.24		4.24	4.08	4.50	3.92	5.32	6
	518 BTS 8882			3.13				3.25		3.25	3.79	4.25	4.33	5.17	4
	504 BTS 8927			4.35				4.51		4.51	4.19	4.15	3.87	4.06	3
	530 BTS 8938			3.92				4.07		4.07	3.96	3.89	3.86	3.75	3
	553 BTS 8961			4.63				4.80		4.80	4.42	4.25	4.04	3.89	3
	555 Crystal 021			4.04				4.19		4.19	3.83	--	3.46	--	2
	534 Crystal 022			4.62				4.79		4.79	4.30	--	3.81	--	2
	501 Crystal 025			3.39				3.52		3.52	3.46	--	3.40	--	2
	535 Crystal 026			3.60				3.74		3.74	3.74	--	3.75	--	2
	565 Crystal 029			4.14				4.30		4.30	3.95	--	3.60	--	2
	544 Crystal 130			4.08				4.23		4.23	--	--	--	--	1
	537 Crystal 132			3.86				4.01		4.01	--	--	--	--	1
	552 Crystal 134			4.23				4.39		4.39	--	--	--	--	1
	567 Crystal 137			3.02				3.13		3.13	--	--	--	--	1
	507 Crystal 138			4.04				4.19		4.19	--	--	--	--	1
	551 Crystal 572			4.31				4.47		4.47	4.38	4.58	4.28	4.98	7
	549 Crystal 684			3.47				3.60		3.60	3.78	3.96	3.97	4.33	6
	542 Crystal 793			3.60				3.74		3.74	3.80	3.77	3.87	3.72	5
	502 Crystal 796			4.55				4.72		4.72	4.29	4.18	3.85	3.97	5
	536 Crystal 803			3.75				3.89		3.89	3.92	4.10	3.96	4.45	4
	527 Crystal 804			3.31				3.43		3.43	3.52	3.78	3.61	4.30	4
	558 Crystal 912			3.81				3.95		3.95	3.81	3.84	3.67	3.91	3
	513 Crystal 913			4.23				4.39		4.39	4.07	3.91	3.75	3.58	3
	531 Hilleshög HIL2317			4.83				5.01		5.01	4.44	4.28	3.86	3.96	3
	511 Hilleshög HIL2320			4.49				4.66		4.66	4.11	4.26	3.55	4.58	3
	545 Hilleshög HIL2366			5.60				5.81		5.81	4.81	--	3.81	--	2
	556 Hilleshög HIL2367			4.94				5.13		5.13	4.32	--	3.51	--	2
	509 Hilleshög HIL2368			5.06				5.25		5.25	4.47	--	3.70	--	2
	554 Hilleshög HIL2385			5.10				5.29		5.29	--	--	--	--	1
	510 Hilleshög HIL2386			5.76				5.98		5.98	--	--	--	--	1
	526 Hilleshög HIL2387			4.12				4.28		4.28	--	--	--	--	1
	539 Hilleshög HIL2388			4.50				4.67		4.67	--	--	--	--	1
	562 Hilleshög HIL2389			3.72				3.86		3.86	--	--	--	--	1
	557 Hilleshög HIL9528			5.31				5.51		5.51	4.62	4.60	3.72	4.56	8
	521 Hilleshög HIL9708			6.11				6.34		6.34	5.15	4.97	3.96	4.61	7
	569 Hilleshög HIL9920			4.48				4.65		4.65	4.15	4.45	3.65	5.05	5
	525 Maribo MA504			6.72				6.97		6.97	6.01	6.06	5.06	6.17	7
	512 Maribo MA717			6.50				6.75		6.75	5.26	4.98	3.77	4.42	5
	519 Maribo MA902			6.71				6.96		6.96	5.48	5.43	4.01	5.31	3
	547 Maribo MA930			5.29				5.49		5.49	--	--	--	--	1
	516 Maribo MA931			4.59				4.76		4.76	--	--	--	--	1
	540 Maribo MA932			4.43				4.60		4.60	--	--	--	--	1
	559 SV 203			4.19				4.35		4.35	4.34	--	4.34	--	2
	548 SV 211			5.05				5.24		5.24	--	--	--	--	1
	523 SV 213			3.97				4.12		4.12	--	--	--	--	1
	546 SV 214			4.30				4.46		4.46	--	--	--	--	1
	503 SV 215			4.85				5.03		5.03	--	--	--	--	1
	506 SV 265			4.77				4.95		4.95	4.47	4.80	3.98	5.47	6
	528 SV 268			4.75				4.93		4.93	4.71	4.83	4.49	5.08	6
	563 SV 285			4.32				4.48		4.48	4.38	4.41	4.28	4.47	4
	543 SV 375			4.60				4.77		4.77	4.41	4.62	4.04	5.03	5
	520 SX 1804			3.92				4.07		4.07	4.04	--	4.02	--	2

Table 24.

2021 Aphanomyces Ratings for Official Trial Entries

			Unadjusted ^^				Adjusted ++									
			Geor	Hill	Shak	Glyn	Geor	Hill	Shak	Glyn						Trial
Chk++	Code	Description	NA	NA	8/25	NA	NA	NA	8/25	NA	2021	2 Yr	3 Yr	2020 ++	2019 ++	Yrs $$
	570	SX 1815			4.04				4.19		4.19	--	--	--	--	1
	524	SX 1816			5.02				5.21		5.21	--	--	--	--	1
	550	SX 1817			4.08				4.23		4.23	--	--	--	--	1
	515	SX 1818			5.36				5.56		5.56	--	--	--	--	1
	560	SX 1819			4.71				4.89		4.89	--	--	--	--	1
	568	SX 1888			3.97				4.12		4.12	4.06	4.25	3.99	4.65	4
	533	SX 1898			4.79				4.97		4.97	4.37	4.49	3.76	4.74	3
1	1001	AP CK-32 CRYS981			3.94				4.09		4.09	4.04	3.65	3.99	2.87	13
1	1002	AP CK-33 CRYS768			3.68				3.82		3.82	4.35	4.51	4.87	4.85	15
1	1003	AP CK-35 BETA87RR58			4.62				4.79		4.79	4.74	4.95	4.68	5.39	15
1	1004	AP CK-41 CRYS765			4.71				4.89		4.89	5.33	5.54	5.78	5.96	11
1	1005	AP CK-43 BTS80RR32			4.76				4.94		4.94	4.93	4.79	4.92	4.50	12
1	1006	AP CK-44 SEEDVISION RR			3.99				4.14		4.14	4.65	4.79	5.15	5.06	13
1	1007	AP CK-45 CRYS986			5.37				5.57		5.57	5.14	4.96	4.71	4.60	13
1	1008	AP CK-47 CRYS101			4.29				4.45		4.45	4.15	3.74	3.86	2.92	11
1	1009	AP CK-59 BTS8606			4.88				5.06		5.06	4.81	4.91	4.56	5.11	6
1	1010	AP CK-51 CRYS246			4.34				4.50		4.50	4.66	4.75	4.82	4.94	10
1	1011	AP CK-52 HILL4094RR			4.76				4.94		4.94	4.59	4.97	4.23	5.74	14
1	1012	AP CK-55 CRYS247			4.56				4.73		4.73	4.98	4.95	5.22	4.90	10
1	1013	AP CK-56 BTS8363			5.29				5.49		5.49	5.24	5.24	4.99	5.25	9
1	1014	AP CK-57 CRYS578			4.77				4.95		4.95	4.80	4.73	4.66	4.58	7
1	1015	AP CK-58 CRYS572			4.62				4.79		4.79	4.68	4.83	4.56	5.13	7
	1016	AP CHK MOD RES RR			3.52				3.65		3.65	4.13	4.55	4.61	5.39	15
	1017	AP CHK RES RR#6			3.61				3.75		3.75	3.75	3.74	3.75	3.72	5
	1018	AP CHK SUS HYB#3			4.17				4.33		4.33	5.13	5.38	5.94	5.88	15
	1019	AP CHK SUS HYB#4			4.16				4.32		4.32	4.90	5.29	5.48	6.06	15
	1020	AP CHK MOD SUS RR#5			5.04				5.23		5.23	4.90	4.97	4.56	5.11	6
	Check Mean				4.57				4.74		4.74					
15	Trial Mean				4.41				4.58		4.58					
	Coeff. of Var. (%)				18.8				18.8							
	Mean LSD (0.05)				0.99				1.03							
	Mean LSD (0.01)				1.30				1.35							
	Sig Lvl				**				**							
	Adjustment Factor				1.038											

^^ 2021 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. Georgetown(Geor) - Abandoned due to lack of Aph pressure
Hillsboro(Hill)-Abandoned due to lack of Aph pressure
Glyndon(Glyn)-Abandoned due to lack of Aph pressure

Created 11/10/2021

Green highlighted ratings indicate specialty resistance
Red highlighted ratings indicate a level of concern

Table 25.

2021 Cercospora Ratings for Official Trial Entries

Chk	Code	Description	Unadjusted Randolph Avg	Unadjusted BSDF Avg	Unadjusted Foxhome Avg	Adjusted to 1982 Basis ++ Randolph Avg	Adjusted BSDF Avg	Adjusted Foxhome Avg	2021	2 Yr	3 Yr	2020	2019	Trial Yrs $$
			9 Dates+	NA	6 Dates+	9 Dates+	NA	6 Dates+	2 loc					
	522	BTS 8018	2.14		1.96	2.29		2.33	2.31	2.36	--	2.41	--	2
	514	BTS 8034	2.63		1.94	2.82		2.30	2.56	2.63	--	2.70	--	2
	508	BTS 8073	3.75		4.29	4.02		5.09	4.56	4.62	--	4.68	--	2
	561	BTS 8092	4.13		4.05	4.43		4.81	4.62	4.44	--	4.26	--	2
	541	BTS 8100	3.59		3.52	3.85		4.18	4.01	--	--	--	--	1
	538	BTS 8122	2.81		3.44	3.01		4.08	3.55	--	--	--	--	1
	529	BTS 8133	2.47		1.64	2.65		1.95	2.30	--	--	--	--	1
	505	BTS 8140	3.07		3.80	3.29		4.51	3.90	--	--	--	--	1
	564	BTS 8156	2.73		1.72	2.93		2.04	2.48	--	--	--	--	1
	517	BTS 8164	4.40		3.79	4.72		4.50	4.61	--	--	--	--	1
	566	BTS 8187	3.59		4.15	3.85		4.93	4.39	--	--	--	--	1
	532	BTS 8629	4.44		4.05	4.76		4.81	4.78	4.66	4.66	4.55	4.66	6
	518	BTS 8882	4.82		3.94	5.17		4.68	4.92	4.81	4.60	4.71	4.18	4
	504	BTS 8927	3.93		4.00	4.21		4.75	4.48	4.45	4.42	4.42	4.35	3
	530	BTS 8938	4.45		3.92	4.77		4.65	4.71	4.68	4.57	4.66	4.35	3
	553	BTS 8961	4.08		3.94	4.37		4.68	4.53	4.61	4.49	4.69	4.27	3
	555	Crystal 021	2.38		1.69	2.55		2.01	2.28	2.24	--	2.20	--	2
	534	Crystal 022	4.18		4.59	4.48		5.45	4.97	4.84	--	4.71	--	2
	501	Crystal 025	4.01		4.53	4.30		5.38	4.84	4.70	--	4.56	--	2
	535	Crystal 026	3.73		4.10	4.00		4.87	4.43	4.60	--	4.76	--	2
	565	Crystal 029	3.82		4.29	4.10		5.09	4.59	4.63	--	4.67	--	2
	544	Crystal 130	2.23		1.99	2.39		2.36	2.38	--	--	--	--	1
	537	Crystal 132	3.98		4.39	4.27		5.21	4.74	--	--	--	--	1
	552	Crystal 134	4.19		3.95	4.49		4.69	4.59	--	--	--	--	1
	567	Crystal 137	2.54		1.97	2.72		2.34	2.53	--	--	--	--	1
	507	Crystal 138	3.93		4.43	4.21		5.26	4.74	--	--	--	--	1
	551	Crystal 572	4.23		4.19	4.53		4.98	4.75	4.61	4.63	4.46	4.68	7
	549	Crystal 684	4.32		3.75	4.63		4.45	4.54	4.49	4.37	4.44	4.12	6
	542	Crystal 793	3.60		3.71	3.86		4.41	4.13	4.22	4.16	4.31	4.04	5
	502	Crystal 796	4.71		4.13	5.05		4.90	4.98	4.96	4.89	4.95	4.74	5
	536	Crystal 803	3.31		3.51	3.55		4.17	3.86	3.89	3.89	3.93	3.88	4
	527	Crystal 804	4.44		3.87	4.76		4.60	4.68	4.72	4.63	4.77	4.46	4
	558	Crystal 912	4.67		4.43	5.01		5.26	5.13	4.94	4.83	4.75	4.62	3
	513	Crystal 913	3.57		3.68	3.83		4.37	4.10	4.12	4.11	4.13	4.11	3
	531	Hilleshög HIL2317	4.08		4.01	4.37		4.76	4.57	4.81	4.84	5.05	4.90	3
	511	Hilleshög HIL2320	4.50		3.99	4.82		4.74	4.78	4.94	4.94	5.11	4.92	3
	545	Hilleshög HIL2366	4.98		3.94	5.34		4.68	5.01	4.98	--	4.94	--	2
	556	Hilleshög HIL2367	4.57		3.88	4.90		4.61	4.75	4.92	--	5.08	--	2
	509	Hilleshög HIL2368	4.62		3.67	4.95		4.36	4.66	4.67	--	4.69	--	2
	554	Hilleshög HIL2385	4.62		3.78	4.95		4.49	4.72	--	--	--	--	1
	510	Hilleshög HIL2386	4.27		3.38	4.58		4.01	4.30	--	--	--	--	1
	526	Hilleshög HIL2387	4.53		4.06	4.86		4.82	4.84	--	--	--	--	1
	539	Hilleshög HIL2388	4.78		3.84	5.12		4.56	4.84	--	--	--	--	1
	562	Hilleshög HIL2389	4.62		3.99	4.95		4.74	4.85	--	--	--	--	1
	557	Hilleshög HIL9528	4.55		3.51	4.88		4.17	4.52	4.68	4.76	4.84	4.93	8
	521	Hilleshög HIL9708	4.42		3.85	4.74		4.57	4.65	4.81	4.86	4.97	4.96	7
	569	Hilleshög HIL9920	4.11		4.29	4.41		5.09	4.75	4.78	4.84	4.82	4.95	5
	525	Maribo MA504	4.94		4.08	5.30		4.84	5.07	5.21	5.25	5.35	5.34	7
	512	Maribo MA717	4.48		3.83	4.80		4.55	4.68	4.89	4.97	5.11	5.11	5
	519	Maribo MA902	4.40		3.83	4.72		4.55	4.63	4.80	4.83	4.96	4.91	3
	547	Maribo MA930	5.19		4.01	5.56		4.76	5.16	--	--	--	--	1
	516	Maribo MA931	4.88		4.02	5.23		4.77	5.00	--	--	--	--	1
	540	Maribo MA932	4.66		3.97	5.00		4.71	4.85	--	--	--	--	1
	559	SV 203	4.36		4.06	4.67		4.82	4.75	4.89	--	5.03	--	2
	548	SV 211	4.64		3.95	4.97		4.69	4.83	--	--	--	--	1
	523	SV 213	4.80		4.14	5.15		4.92	5.03	--	--	--	--	1
	546	SV 214	4.12		3.72	4.42		4.42	4.42	--	--	--	--	1
	503	SV 215	4.80		4.28	5.15		5.08	5.11	--	--	--	--	1
	506	SV 265	4.02		3.61	4.31		4.29	4.30	4.42	4.38	4.55	4.28	6
	528	SV 268	4.92		4.29	5.27		5.09	5.18	4.98	4.93	4.78	4.82	6
	563	SV 285	4.49		3.99	4.81		4.74	4.78	4.64	4.70	4.50	4.84	4
	543	SV 375	4.38		3.98	4.70		4.73	4.71	4.74	4.53	4.78	4.11	5
	520	SX 1804	4.38		4.13	4.70		4.90	4.80	4.78	--	4.76	--	2

Table 25.

2021 Cercospora Ratings for Official Trial Entries

			Unadjusted			Adjusted to 1982 Basis ++								
			Randolph	BSDF	Foxhome	Randolph	BSDF	Foxhome						Trial
Chk	Code	Description	Avg	Avg	Avg	Avg	Avg	Avg	2021	2 Yr	3 Yr	2020	2019	Yrs $$
	570	SX 1815	4.45	4.03		4.77	4.79		4.78	--	--	--	--	1
	524	SX 1816	4.17	4.03		4.47	4.79		4.63	--	--	--	--	1
	550	SX 1817	4.87	4.28		5.22	5.08		5.15	--	--	--	--	1
	515	SX 1818	4.63	4.01		4.96	4.76		4.86	--	--	--	--	1
	560	SX 1819	4.30	4.05		4.61	4.81		4.71	--	--	--	--	1
	568	SX 1888	4.74	4.20		5.08	4.99		5.03	4.85	4.87	4.67	4.89	4
	533	SX 1898	4.46	3.99		4.78	4.74		4.76	4.74	4.72	4.73	4.68	3
1	1101	CR CK#19 CRYS808	4.71	4.40		5.05	5.22		5.14	5.15	5.18	5.17	5.25	4
1	1102	CR CK#24 HILL4012RR	4.13	4.89		4.43	5.81		5.12	5.21	5.25	5.30	5.33	16
1	1103	CR CK#52 MARI717	4.50	4.00		4.82	4.75		4.79	4.95	5.00	5.11	5.11	5
1	1104	CR CK#41 CRYS981RR	4.73	4.06		5.07	4.82		4.95	4.99	5.02	5.04	5.08	13
1	1105	CR CK#43 CRYS246RR	4.78	4.08		5.12	4.84		4.98	4.86	4.80	4.74	4.69	10
1	1106	CR CK#44 BETA80RR32	4.88	4.11		5.23	4.88		5.06	4.93	4.95	4.80	4.99	12
1	1107	CR CK#45 HILL4448RR	5.13	4.21		5.50	5.00		5.25	5.42	5.49	5.59	5.62	10
1	1108	CR CK#47 HILL4094RR	3.85	3.79		4.13	4.50		4.31	4.27	4.27	4.22	4.28	14
1	1109	CR CK#48 MARI504	4.95	4.13		5.31	4.90		5.11	5.27	5.31	5.43	5.38	7
1	1110	CR CK#49 CRYS578RR	4.77	4.23		5.11	5.02		5.07	4.93	4.86	4.78	4.73	7
1	1111	CR CK#50 CRYS101RR	4.25	3.54		4.56	4.20		4.38	4.53	4.56	4.68	4.61	11
1	1112	CR CK#51 CRYS355RR	4.36	4.25		4.67	5.05		4.86	4.78	4.69	4.71	4.51	9
	1113	CR CK MOD SUS HYB#6	4.87	4.49		5.22	5.33		5.28	5.17	5.04	5.07	4.78	4
	1114	CR CK MOD RES HYB#4	4.10	4.01		4.40	4.76		4.58	4.63	4.51	4.69	4.26	14

12	Check Mean	4.59	4.14	4.92	4.92	4.92
	Trial Mean	4.20	3.84	4.50	4.56	4.53
	Coeff. of Var. (%)	6.4	4.8	6.4	4.8	
	Mean LSD (0.05)	0.33	0.25	0.35	0.30	
	Mean LSD (0.01)	0.43	0.32	0.46	0.38	
	Sig Mrk	**	**	**	**	
	Adj Factor			1.07202	1.18744	

* 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.
BSDF- Ratings not used due to lack of correlation with Randolph and Foxhome.
Green highlighted ratings indicate good resistance
Red highlighted ratings indicate a level of concern

Created 11/10/2021

Table 26.

2021 Rhizoctonia Ratings for OVT Entries Rhizoctonia

Sus				Unadjusted				Adjusted @									
Chk	Chk			BSDF	TSC-E	TSC-W	NWROC	BSDF	TSC-E	TSC-W	NWROC						
^	@	Code	Description	NA	8/10	9/8	NA	NA	8/10	9/8	NA	2021	2 Yr	3 Yr	2020	2019	Years
		522	BTS 8018		2.94	2.94			3.93	3.74		3.83	3.99	--	4.16	--	2
		514	BTS 8034		2.73	3.23			3.65	4.10		3.88	4.22	--	4.56	--	2
		508	BTS 8073		2.81	2.82			3.75	3.58		3.67	3.89	--	4.11	--	2
		561	BTS 8092		2.71	3.15			3.62	4.00		3.81	3.81	--	3.81	--	2
		541	BTS 8100		2.27	2.48			3.03	3.15		3.09	--	--	--	--	1
		538	BTS 8122		2.53	2.60			3.38	3.30		3.34	--	--	--	--	1
		529	BTS 8133		2.65	3.30			3.54	4.19		3.87	--	--	--	--	1
		505	BTS 8140		2.58	2.78			3.45	3.53		3.49	--	--	--	--	1
		564	BTS 8156		2.59	3.28			3.46	4.17		3.81	--	--	--	--	1
		517	BTS 8164		2.67	2.99			3.57	3.80		3.68	--	--	--	--	1
		566	BTS 8187		2.63	3.08			3.51	3.91		3.71	--	--	--	--	1
		532	BTS 8629		3.04	3.44			4.06	4.37		4.22	4.26	4.14	4.30	3.89	6
		518	BTS 8882		3.13	3.42			4.18	4.35		4.26	4.26	4.26	4.26	4.27	4
		504	BTS 8927		2.87	2.78			3.83	3.53		3.68	4.03	3.99	4.37	3.93	3
		530	BTS 8938		2.92	2.96			3.90	3.76		3.83	3.87	3.74	3.90	3.47	3
		553	BTS 8961		2.71	3.05			3.62	3.88		3.75	3.93	3.88	4.11	3.79	3
		555	Crystal 021		2.42	2.78			3.23	3.53		3.38	3.63	--	3.88	--	2
		534	Crystal 022		2.61	2.81			3.49	3.57		3.53	3.51	--	3.49	--	2
		501	Crystal 025		2.61	3.17			3.49	4.03		3.76	3.74	--	3.72	--	2
		535	Crystal 026		2.42	2.71			3.23	3.44		3.34	3.45	--	3.57	--	2
		565	Crystal 029		3.10	2.83			4.14	3.60		3.87	4.09	--	4.31	--	2
		544	Crystal 130		2.79	2.68			3.73	3.41		3.57	--	--	--	--	1
		537	Crystal 132		2.92	3.26			3.90	4.14		4.02	--	--	--	--	1
		552	Crystal 134		2.52	2.76			3.37	3.51		3.44	--	--	--	--	1
		567	Crystal 137		2.43	3.00			3.25	3.81		3.53	--	--	--	--	1
		507	Crystal 138		2.64	2.76			3.53	3.51		3.52	--	--	--	--	1
		551	Crystal 572		3.12	2.83			4.17	3.60		3.88	4.05	4.08	4.21	4.14	7
		549	Crystal 684		2.72	3.16			3.63	4.02		3.82	3.99	3.99	4.15	4.01	6
		542	Crystal 793		3.31	3.39			4.42	4.31		4.36	4.60	4.46	4.84	4.18	5
		502	Crystal 796		3.18	3.14			4.25	3.99		4.12	4.28	4.14	4.45	3.85	5
		536	Crystal 803		3.44	3.30			4.59	4.19		4.39	4.69	4.64	5.00	4.54	4
		527	Crystal 804		2.66	3.13			3.55	3.98		3.76	3.83	3.80	3.90	3.72	4
		558	Crystal 912		2.65	3.15			3.54	4.00		3.77	3.66	3.63	3.54	3.58	3
		513	Crystal 913		3.05	2.99			4.07	3.80		3.94	4.26	4.28	4.58	4.31	3
		531	Hilleshög HIL2317		3.73	3.57			4.98	4.54		4.76	4.85	4.63	4.95	4.19	3
		511	Hilleshög HIL2320		2.71	3.13			3.62	3.98		3.80	4.22	4.16	4.64	4.04	3
		545	Hilleshög HIL2366		2.91	3.21			3.89	4.08		3.98	4.11	--	4.24	--	2
		556	Hilleshög HIL2367		3.04	3.26			4.06	4.14		4.10	4.18	--	4.26	--	2
		509	Hilleshög HIL2368		2.18	2.30			2.91	2.92		2.92	3.22	--	3.52	--	2
		554	Hilleshög HIL2385		2.95	3.13			3.94	3.98		3.96	--	--	--	--	1
		510	Hilleshög HIL2386		2.80	3.66			3.74	4.65		4.20	--	--	--	--	1
		526	Hilleshög HIL2387		2.92	3.38			3.90	4.29		4.10	--	--	--	--	1
		539	Hilleshög HIL2388		2.66	2.91			3.55	3.70		3.63	--	--	--	--	1
		562	Hilleshög HIL2389		2.98	3.15			3.98	4.00		3.99	--	--	--	--	1
		557	Hilleshög HIL9528		3.18	3.69			4.25	4.69		4.47	4.52	4.38	4.57	4.10	8
		521	Hilleshög HIL9708		2.84	2.97			3.79	3.77		3.78	3.81	3.83	3.83	3.87	7
		569	Hilleshög HIL9920		3.40	3.82			4.54	4.85		4.70	4.91	4.83	5.12	4.68	5
		525	Maribo MA504		3.74	3.80			4.99	4.83		4.91	4.87	4.81	4.83	4.69	7
		512	Maribo MA717		3.26	3.35			4.35	4.26		4.31	4.46	4.36	4.61	4.15	5
		519	Maribo MA902		2.74	3.10			3.66	3.94		3.80	3.86	3.90	3.93	3.97	3
		547	Maribo MA930		3.85	4.34			5.14	5.51		5.33	--	--	--	--	1
		516	Maribo MA931		2.76	3.36			3.69	4.27		3.98	--	--	--	--	1
		540	Maribo MA932		3.17	3.01			4.23	3.82		4.03	--	--	--	--	1
		559	SV 203		3.25	3.41			4.34	4.33		4.34	4.31	--	4.29	--	2
		548	SV 211		3.17	3.29			4.23	4.18		4.21	--	--	--	--	1
		523	SV 213		3.53	3.78			4.71	4.80		4.76	--	--	--	--	1
		546	SV 214		2.90	3.22			3.87	4.09		3.98	--	--	--	--	1
		503	SV 215		2.85	2.97			3.81	3.77		3.79	--	--	--	--	1
		506	SV 265		3.16	3.24			4.22	4.12		4.17	4.19	4.21	4.21	4.25	6
		528	SV 268		3.31	3.42			4.42	4.35		4.38	4.81	4.61	5.24	4.21	6
		563	SV 285		2.92	3.63			3.90	4.61		4.26	4.15	4.22	4.03	4.38	4
		543	SV 375		3.11	3.37			4.15	4.28		4.22	4.38	4.27	4.54	4.05	5
		520	SX 1804		3.09	3.35			4.13	4.26		4.19	4.28	--	4.38	--	2

Table 26.

2021 Rhizoctonia Ratings for OVT Entries Rhizoctonia

Sus Chk ^	Chk @	Code	Description	Unadjusted BSDF NA	Unadjusted TSC-E 8/10	Unadjusted TSC-W 9/8	Unadjusted NWROC NA	Adjusted @ BSDF NA	Adjusted @ TSC-E 8/10	Adjusted @ TSC-W 9/8	Adjusted @ NWROC NA	2021	2 Yr	3 Yr	2020	2019	Years
		570	SX 1815		2.96	3.81			3.95	4.84		4.40	--	--	--	--	1
		524	SX 1816		2.89	3.40			3.86	4.32		4.09	--	--	--	--	1
		550	SX 1817		3.10	3.35			4.14	4.26		4.20	--	--	--	--	1
		515	SX 1818		3.23	3.54			4.31	4.50		4.41	--	--	--	--	1
		560	SX 1819		3.06	2.95			4.09	3.75		3.92	--	--	--	--	1
		568	SX 1888		3.17	3.36			4.23	4.27		4.25	4.21	4.20	4.17	4.19	4
		533	SX 1898		3.37	3.29			4.50	4.18		4.34	4.25	4.24	4.16	4.21	3
1	1	1301	RH CK#55 CRYS803		3.94	3.67			5.26	4.66		4.96	4.98	4.83	5.00	4.54	4
1	1	1302	RH CK#21 CRYS768		3.05	3.60			4.07	4.57		4.32	4.41	4.50	4.50	4.66	13
1	1	1303	RH CK#25 HILL4043RR		3.29	3.58			4.39	4.55		4.47	4.68	4.67	4.89	4.66	13
	1	1304	RH CK#35 SES36812RR		3.07	3.24			4.10	4.12		4.11	4.29	4.29	4.46	4.29	14
1	1	1305	RH CK#36 BTS85RR02		3.99	4.51			5.33	5.73		5.53	5.32	5.06	5.10	4.56	17
	1	1306	RH CK#57 BTS8606		3.24	3.65			4.33	4.64		4.48	4.62	4.61	4.75	4.60	6
1	1	1307	RH CK#40 CRYS101		3.75	3.99			5.01	5.07		5.04	4.78	4.77	4.52	4.73	11
	1	1308	RH CK#56 MARI504		3.44	3.59			4.59	4.56		4.58	4.70	4.70	4.83	4.69	7
	1	1309	RH CK#47 SES36272RR		3.15	3.13			4.21	3.98		4.09	4.23	4.24	4.36	4.26	10
	1	1310	RH CK#48 HILL4094RR		2.25	2.71			3.00	3.44		3.22	3.42	3.60	3.61	3.98	14
1	1	1311	RH CK#49 CRYS247		3.73	3.48			4.98	4.42		4.70	4.55	4.42	4.41	4.16	10
1	1	1312	RH CK#51 SXWinchester		3.19	3.52			4.26	4.47		4.37	4.31	4.31	4.25	4.30	9
1	1	1313	RH CK#52 CRYS573		3.50	3.07			4.67	3.90		4.29	4.80	4.60	5.31	4.20	7
1	1	1314	RH CK#53 BTS8500		3.22	3.20			4.30	4.07		4.18	4.29	4.40	4.39	4.63	7
	1	1315	RH CK#54 CRYS574		2.93	3.34			3.91	4.24		4.08	4.00	4.15	3.92	4.45	7
		1316	MOD RHC #10		3.65	3.88			4.87	4.93		4.90	4.95	4.81	5.00	4.54	4
		1317	MOD RHC #9		3.11	3.10			4.15	3.94		4.05	4.33	4.37	4.61	4.45	7
		1318	RES RHC #3		2.58	2.58			3.45	3.28		3.36	3.46	3.61	3.57	3.90	8
15			Mean of Check Varieties		3.32	3.49			4.43	4.43		4.43	4.49	4.48	4.55	4.45	
9			Mean of Susc Checks		3.52	3.62			4.70	4.61		4.65	4.68	4.62	4.71	4.49	
Trial Mean					3.00	3.23			4.01	4.10							
Coeff. of Var. (%)					12.6	11.3			12.6	11.3							
Mean LSD (0.05)					0.47	0.46			0.63	0.58							
Mean LSD (0.01)					0.61	0.61			0.81	0.78							
Sig Lvl Adjustment Factor					**	**			**	**							
					1.3355	1.2707											
Specialty Approval Limit (80% of					2.81	2.90			3.76	3.68		3.72	3.74	3.69	3.77	3.60	

++ Adjustment is based upon check varieties.

@ Ratings adjusted to 2009 basis (2007-2009) RH nurseries. Ratings adjusted on the basis of checks Lower numbers indicate better tolerance (0=Ex, 7=Poor).

^ Approval criteria is based upon the mean of susc varieties (approval option 2) or 3.82 (approval option 1). BSDF - Ratings not used due to high severity and lack of separation

NWROC - Ratings not used due to erratic stand and Root Maggot damage

Green highlighted ratings indicate good resistance.

Red highlighted ratings indicated a level of concern.

Created 11/10/2021

			Unadjusted		Adjusted @							
Chk @	Code	Description	N Mhd 3Dates+	Sab NA	N Mhd 3Dates+	Sab NA	2021	2 Yr	3 Yr	2020	2019	Years
522		BTS 8018	3.39		3.22	3.22		2.85	--	2.47	--	2
514		BTS 8034	2.85		2.71	2.71		2.48	--	2.26	--	2
508		BTS 8073	3.82		3.63	3.63		3.11	--	2.58	--	2
561		BTS 8092	4.28		4.07	4.07		3.88	--	3.70	--	2
541		BTS 8100	2.95		2.80	2.80		--	--	--	--	1
538		BTS 8122	4.14		3.93	3.93		--	--	--	--	1
529		BTS 8133	3.81		3.62	3.62		--	--	--	--	1
505		BTS 8140	4.38		4.16	4.16		--	--	--	--	1
564		BTS 8156	2.86		2.72	2.72		--	--	--	--	1
517		BTS 8164	3.28		3.12	3.12		--	--	--	--	1
566		BTS 8187	4.19		3.98	3.98		--	--	--	--	1
532		BTS 8629	4.43		4.21	4.21		4.00	3.90	3.78	3.71	6
518		BTS 8882	3.42		3.25	3.25		2.68	2.76	2.11	2.91	4
504		BTS 8927	4.21		4.00	4.00		3.29	3.12	2.59	2.77	3
530		BTS 8938	4.75		4.51	4.51		4.09	3.75	3.66	3.06	3
553		BTS 8961	3.50		3.33	3.33		2.76	2.69	2.19	2.55	3
555		Crystal 021	4.40		4.18	4.18		3.52	--	2.85	--	2
534		Crystal 022	3.68		3.50	3.50		3.05	--	2.60	--	2
501		Crystal 025	2.55		2.42	2.42		2.47	--	2.51	--	2
535		Crystal 026	2.94		2.79	2.79		2.55	--	2.31	--	2
565		Crystal 029	3.03		2.88	2.88		2.65	--	2.42	--	2
544		Crystal 130	3.39		3.22	3.22		--	--	--	--	1
537		Crystal 132	3.72		3.53	3.53		--	--	--	--	1
552		Crystal 134	4.33		4.11	4.11		--	--	--	--	1
567		Crystal 137	2.37		2.25	2.25		--	--	--	--	1
507		Crystal 138	3.95		3.75	3.75		--	--	--	--	1
551		Crystal 572	3.52		3.34	3.34		2.85	2.70	2.36	2.39	7
549		Crystal 684	2.90		2.76	2.76		2.54	2.39	2.32	2.10	6
542		Crystal 793	2.95		2.80	2.80		2.71	2.71	2.61	2.71	5
502		Crystal 796	3.12		2.96	2.96		2.58	2.54	2.20	2.45	5
536		Crystal 803	3.70		3.52	3.52		3.02	2.91	2.52	2.70	4
527		Crystal 804	2.99		2.84	2.84		2.56	2.47	2.29	2.28	4
558		Crystal 912	4.32		4.11	4.11		3.86	3.69	3.61	3.37	3
513		Crystal 913	3.87		3.68	3.68		3.13	2.94	2.59	2.56	3
531		Hilleshög HIL2317	6.38		6.06	6.06		6.02	5.78	5.97	5.30	3
511		Hilleshög HIL2320	4.74		4.50	4.50		4.53	4.48	4.56	4.37	3
545		Hilleshög HIL2366	4.89		4.65	4.65		4.60	--	4.55	--	2
556		Hilleshög HIL2367	4.49		4.27	4.27		4.35	--	4.44	--	2
509		Hilleshög HIL2368	4.67		4.44	4.44		4.15	--	3.86	--	2
554		Hilleshög HIL2385	6.17		5.86	5.86		--	--	--	--	1
510		Hilleshög HIL2386	4.48		4.26	4.26		--	--	--	--	1
526		Hilleshög HIL2387	4.75		4.51	4.51		--	--	--	--	1
539		Hilleshög HIL2388	4.74		4.50	4.50		--	--	--	--	1
562		Hilleshög HIL2389	5.00		4.75	4.75		--	--	--	--	1
557		Hilleshög HIL9528	5.17		4.91	4.91		4.80	4.59	4.68	4.16	8
521		Hilleshög HIL9708	5.01		4.76	4.76		4.20	4.10	3.64	3.89	7
569		Hilleshög HIL9920	5.74		5.45	5.45		5.87	5.72	6.28	5.42	5
525		Maribo MA504	5.01		4.76	4.76		4.51	4.54	4.25	4.61	7
512		Maribo MA717	5.38		5.11	5.11		4.87	4.85	4.62	4.81	5
519		Maribo MA902	4.74		4.50	4.50		4.26	4.08	4.01	3.71	3
547		Maribo MA930	4.85		4.61	4.61		--	--	--	--	1
516		Maribo MA931	4.62		4.39	4.39		--	--	--	--	1
540		Maribo MA932	4.26		4.05	4.05		--	--	--	--	1
559		SV 203	6.30		5.99	5.99		5.62	--	5.26	--	2
548		SV 211	6.08		5.78	5.78		--	--	--	--	1
523		SV 213	5.84		5.55	5.55		--	--	--	--	1
546		SV 214	4.43		4.21	4.21		--	--	--	--	1
503		SV 215	5.04		4.79	4.79		--	--	--	--	1
506		SV 265	5.95		5.65	5.65		5.68	5.66	5.70	5.64	6
528		SV 268	6.53		6.21	6.21		5.12	5.06	4.04	4.92	6
563		SV 285	6.59		6.26	6.26		5.83	5.47	5.40	4.76	4
543		SV 375	6.17		5.86	5.86		5.56	5.36	5.25	4.97	5
520		SX 1804	5.65		5.37	5.37		5.46	--	5.56	--	2

Chk			Unadjusted		Adjusted @							
Chk @	Code	Description	N Mhd 3Dates+	Sab NA	N Mhd 3Dates+	Sab NA	2021	2 Yr	3 Yr	2020	2019	Years
	570	SX 1815	5.07		4.82		4.82	--	--	--	--	1
	524	SX 1816	4.60		4.37		4.37	--	--	--	--	1
	550	SX 1817	5.23		4.97		4.97	--	--	--	--	1
	515	SX 1818	5.54		5.26		5.26	--	--	--	--	1
	560	SX 1819	6.15		5.84		5.84	--	--	--	--	1
	568	SX 1888	6.04		5.74		5.74	5.64	5.60	5.54	5.51	4
	533	SX 1898	5.97		5.67		5.67	5.54	5.41	5.41	5.14	3
1	1201	FS CK #08 HILL4000RR	6.21		5.90	5.90		6.19	6.11	6.48	5.96	14
1	1202	FS CK #34 SES265	6.33		6.02	6.02		5.86	5.79	5.70	5.64	6
1	1203	FS CK #12 HILL4012RR	6.56		6.23	6.23		6.34	6.10	6.45	5.63	16
1	1204	FS CK #13 HILL4043RR	5.87		5.58	5.58		5.37	5.54	5.16	5.87	15
1	1205	FS CK #18 CRYS768RR	4.07		3.87	3.87		4.04	4.17	4.21	4.45	13
1	1206	FS CK #33 SES375	6.37		6.05	6.05		5.65	5.42	5.25	4.97	5
1	1207	FS CK #29 CRYS875RR	4.71		4.48	4.48		4.66	4.78	4.84	5.01	14
1	1208	FS CK #30 BTS8337	3.72		3.53	3.53		3.57	3.56	3.60	3.56	9
1	1209	FS CK #31 SXMarathon	6.02		5.72	5.72		5.51	5.49	5.30	5.46	7
1	1210	FS CK #32 CRYS574	2.81		2.67	2.67		2.58	2.39	2.48	2.03	7
	1211	FS CHK SUS RR #11	5.74		5.45	5.45		5.45	5.45	5.45	5.45	9
	1212	FS CHK MOD RR SUS #2	6.14		5.83	5.83		5.30	5.22	4.77	5.04	9
	1213	FS CHK RES RR #4	3.01		2.86	2.86		2.56	2.38	2.26	2.03	7
	1214	FS CHK SUS RR #11	5.36		5.09	5.09		5.27	5.33	5.45	5.45	9
10	Check Mean		5.27		5.01	5.01						
	Trial Mean		4.61		4.38	4.38						
	Coeff. of Var. (%)		11.8		11.8							
	Mean LSD (0.05)		0.78		0.74							
	Mean LSD (0.01)		1.03	0.98								
	Sig Mrk Adj Factor		**	** 0.9503								

@ 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). Sabin(Sab) - Ratings not used due to erratic stands

Green highlighted ratings indicate good resistance.

Red highlighted ratings indicate a level of concern.

Created 11/10/2021

Table 28. Pesticides Applied to ACSC Official Trials

	Herbicide			Fungicide		
Location	Herbicide & Rate	Spray Dates	Method	Fungicide Used	Spray Dates	Method
Casselton	RU1, RU1	6/1, 6/25	Ground	CR1,CR2,CR3,CR4,CR5	7/1,7/15,7/30,8/13,9/1	Ground
Glyndon	RU1, RU1	6/1, 6/25	Ground	CR1,CR2,CR3,CR4,CR5	7/1,7/15,7/30,8/13,9/1	Ground
Georgetown	RU1, RU1	5/27, 6/17	Ground	CR1,CR2,CR3,CR4,CR5	7/1,7/15,7/30,8/13,9/1	Ground
Hendrum	RU1, RU1	5/28, 6/18	Ground	CR1,CR2,CR3,CR4,CR5	7/1,7/15,7/30,8/13,9/1	Ground
Hillsboro	RU1, RU1	6/1, 6/25	Ground	CR1,CR2,CR3,CR4,CR5	7/1,7/15,7/30,8/13,9/1	Ground
Grand Forks	RU1, RU1	6/2, 6/24	Ground	CR1,CR2,CR3,CR4,CR5	7/1,7/16,7/31,8/18,9/1	Ground
Scandia	RU1, RU1	5/27, 6/24	Ground	CR1,CR2,CR3,CR4,CR5	7/2,7/15,7/31,8/19,9/1	Ground
Climax	RU1, RU1	6/2, 6/24	Ground	CR1,CR2,CR3,CR4,CR5	7/1,7/15,7/31,8/19,9/1	Ground
Forest River	RU1, RU1	6/2, 6/24	Ground	CR2,CR3,CR4,CR5	7/16,7/28,8/18,9/1	Ground
Hallock	RU1, RU1	6/2, 6/24	Ground	CR3,CR4,CR5	7/28,8/18,9/1	Ground
Bathgate	RU1, RU1	5/27, 6/24	Ground	CR3,CR4,CR5	7/28,8/18,9/1	Ground

Ground applications made by beet seed personnel from Crystal Technical Services Center.

Created 11/29/2021

RU1 = Roundup Powermax (28 oz./A), Event (1 gal./100 gal water).

CR1
=Insire XT + Manzate Max Counter 20G applied at 8.9 lbs./A at all locations.

CR2
=Agritin + Incognito AZteroid in-furrow (5.7 fl oz/A) was used at all locations.

CR3
=Proline+Manzate Max Quadris (14 fl oz/A) was applied to 4-8 leaf beets at all locations

CR4
=Manzate Max

CR5=Priaxor + Agritin