

# EVALUATION OF SEED TREATMENTS, IN-FURROW FUNGICIDES, AND IN-FURROW BIOCONTROL AGENTS FOR CONTROL OF *RHIZOCTONIA SOLANI* IN SUGARBEET, 2024

<sup>1</sup>Austin K. Lien and <sup>2</sup>Ashok K. Chanda

<sup>1</sup>Research Professional 3; <sup>2</sup>Associate Professor and Extension Sugarbeet Pathologist  
University of Minnesota, Department of Plant Pathology, St. Paul, MN & Northwest Research and Outreach Center,  
Crookston, MN

Corresponding Author: Ashok Chanda, achanda@umn.edu

## INTRODUCTION

For over the past decade, the most common root disease of sugarbeet in Minnesota and North Dakota diagnosed by the Sugarbeet Plant Pathology lab has been *Rhizoctonia* crown and root rot (RCRR) and damping-off caused by *Rhizoctonia solani* AG 2-2 (Brantner and Windels 2009, 2011; Crane et al. 2013; Brantner 2015; Brantner and Chanda 2017, 2019; Lien et al. 2022; Lien et al. 2024). Environmental factors such as abundant soil moisture and warm temperatures are favorable for pathogen growth. Preemergence damping-off can lead to reduced plant emergence early in the season, while disease occurring throughout the growing season can result in reduced plant stands, root yield, and sucrose quality. Moderate to severely infected roots can also have greater sugar loss during storage and increased respiration may increase losses in nearby healthy roots as well (Campbell et al. 2013). The pathogen is presumed to be present in most agricultural soils in Minnesota and Eastern North Dakota, with more than half of survey respondents reporting that their fields were affected by RCRR in 2023 (Hakk et al. 2024). The widespread prevalence of this pathogen is likely due to its wide host range, affecting the primary crops grown in the area (e.g., soybeans, edible beans, and corn) (Windels and Brantner 2006, 2010a, 2010b). The pathogen can also survive multiple years in soil as sclerotia and infected crop residues and can be dispersed by water and soil movement (e.g., surface runoff and bare soils containing root chips and tailings). An integrated management strategy for diseases caused by *R. solani* should incorporate multiple control options, which can include rotating with non-host crops (e.g., small grains), planting partially resistant varieties, planting early when soil temperatures are cool, improving soil drainage, and applying fungicides as seed treatments, in-furrow (IF), and/or postemergence (Windels et al. 2009; Chanda et al. 2016, 2017 and 2019; Brantner and Chanda 2018 and 2020; Lien et al. 2022, 2023 and 2024). It is an industry standard for commercially available sugar beet seed to come treated with a fungicide labelled for control of *R. solani*; however, each brand offers a unique fungicide. Additionally, growers have the flexibility to choose and apply an in-furrow fungicide at the time of planting. In-furrow fungicides can provide added protection and typically have greater persistence in the soil compared to seed treatments, increasing the length of protection through the growing season. In addition, there is increased interest in the use of biocontrol agents in place of chemical control methods for their reduced environmental impact.

## OBJECTIVES

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

## MATERIALS AND METHODS

The trial was established at the University of Minnesota, Northwest Research and Outreach Center (NWROC), Crookston on a Hegne-Fargo silty clay soil with an organic matter content of 4.6%. Field plots were fertilized for optimal yield and quality. A moderately susceptible variety (Crystal 793RR) with a 2-year average *Rhizoctonia* rating of 4.5 (Brantner and Moomjian 2023) was used. Treatments were arranged in a randomized complete block design with four replicates. Seed treatments and rates are summarized in Table 1 and were applied by Germaines Seed Technology, Fargo, ND. In-furrow fungicides (Table 1) (mixed in 3 gal water) were applied down the drip tube in 6 gallons total volume/A. The nontreated control did not include any seed or in-furrow fungicide treatment that would suppress or control *Rhizoctonia*. Prior to planting, soil was infested with *R. solani* AG 2-2-infested (a mixture of four isolates) whole barley (50 kg/ha) by hand-broadcasting in plots and incorporating with an 11-ft Rau seedbed finisher. The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 10 at 4.5-inch seed spacing.

Counter 20G (7.5 lb/A) was applied at planting followed by postemergence application of Asana XL + Exponent (9.6 + 8 fl/A) on Jun 10 (10 gal/A, 30 psi, Teejet 8002 nozzles) for control of sugarbeet root maggot. For the control of weeds, ethofumesate (6 pt/A) was applied before planting using a spray boom mounted to the front of the Rau seedbed finisher to incorporate the product parallel with the direction of rows, followed by Sequence (glyphosate + S-metolachlor, 8 fl oz + 2.5 pt/A) on June 12. Cercospora leaf spot was controlled by applying Inspire XT + Manzate Pro-Stick (7 fl oz + 2 lbs/A) on July 09, SuperTin 4L + Topsin 4.5FL (8 + 10 fl oz/A) on July 23, Proline 480 SC + Manzate Pro-Stick (5.7 fl oz + 2 lbs/A) on Aug 06, and SuperTin 4L + Priaxor Xemium (8 + 6.7 fl oz/A) on Aug 19.

Plant stands were evaluated beginning May 17 (7 days after planting [DAP]) through June 13 (34 DAP) by counting the number of plants in the center two rows of each plot. On Sept 17, plots were defoliated and the center two rows of each plot were harvested mechanically and weighed for root yield. Data was also collected for root rot severity and number of harvested roots immediately following harvest. Twenty roots per plot were arbitrarily selected, and root surfaces were rated for the severity of *Rhizoctonia* crown and root rot (RCRR) using a 0 to 10 scale with a 10% incremental increase per each unit of rating (i.e., 0=0%, 5 = 41-50%, 10=91-100%). Each rating was mid-point transformed to percent severity for statistical analysis. Ten representative roots from each plot were analyzed for sugar quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. Statistical analysis was conducted in SAS (version 9.4; SAS Institute, Cary, NC). A mixed-model analysis of variance was performed using the GLIMMIX procedure, with treatments defined as the fixed factor and replication as the random factor. Treatment means were separated based on the least square means test at the 0.10 significance level using the *emmeans* (v 1.8.7) with no adjustments. The CONTRAST statement was used to compare the means of seed treatments vs. in-furrow treatments.

**Table 1.** Application type, product names, active ingredients, and rates of fungicides used at planting in a field trial for control of *Rhizoctonia solani* AG 2-2 on sugarbeet.

Application <sup>z</sup>	Product <sup>y</sup>	Active ingredient (FRAC Group)	Rate <sup>x</sup>
Nontreated	-	-	-
Seed	Kabina ST	Penthiopyrad (7)	14 g a.i./unit seed
Seed	Systiva	Fluxapyroxad (7)	5 g a.i./unit seed
Seed	Vibrance	Sedaxane (7)	1.5 g a.i./unit seed
Seed	Zeltera	Inpyrfluxam (7)	0.1 g a.i./unit seed
In-furrow	AZteroid FC <sup>3,3</sup>	Azoxystrobin (11)	5.7 fl oz product/A
In-furrow	Quadris	Azoxystrobin (11)	9.5 fl oz product/A
In-furrow	Headline SC	Pyraclostrobin (11)	9.0 fl oz product/A
In-furrow	Elatus WG	Azoxystrobin (11) + Benzovindiflupyr (7)	7.1 oz product/A
In-furrow	Proline 480 SC	Prothioconazole (3)	5.7 fl oz product/A
In-furrow	Propulse	Fluopyram (7) + Prothioconazole (3)	13.6 fl oz product/A
In-furrow	Priaxor	Fluxapyroxad (7) + Pyraclostrobin (11)	6.7 fl oz product/A
In-furrow	Zironar	<i>Bacillus licheniformis</i> FMCH001 + <i>B. subtilis</i> FMCH002 (BM02)	12 fl oz product/A
In-furrow	Bexfond	<i>B. amyloliquefaciens</i> subsp. <i>plantarum</i> FZB42 (BM02)	14 fl oz product/A
In-furrow	Serenade ASO	<i>Bacillus subtilis</i> . (BM 02)	128 fl oz product/A

<sup>z</sup> In-furrow fungicides were mixed in 3 gal water prior to mixing with 3 gal water.

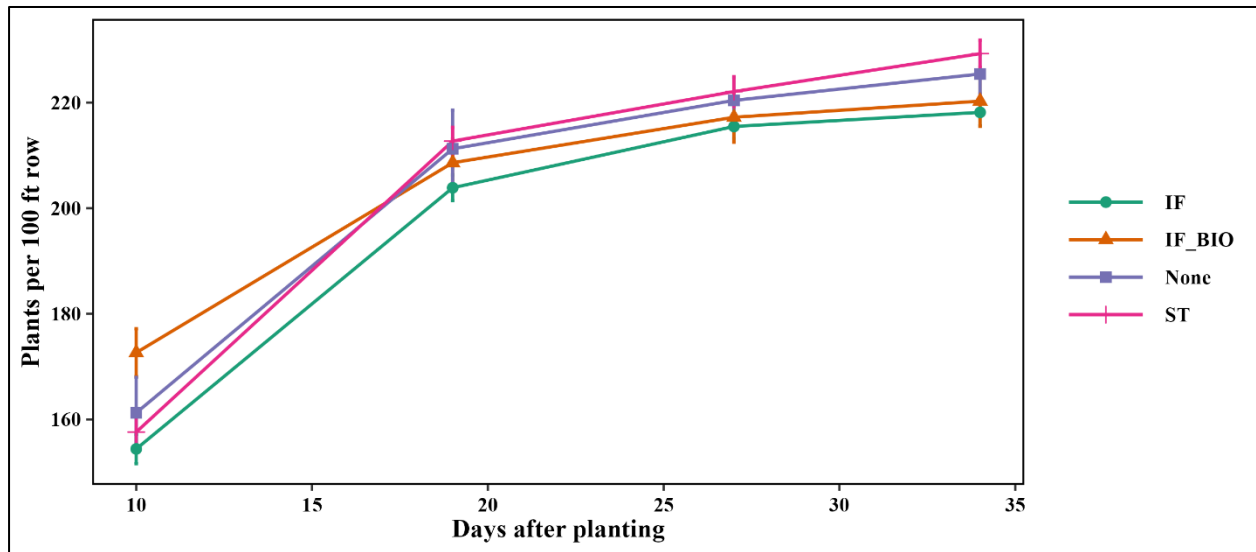
<sup>y</sup> Standard rates of Allegiance + Thiram and 45 g/unit Tachigaren were on all seeds.

<sup>x</sup> 5.7 fl oz AZteroid FC<sup>3,3</sup> and 9.5 fl oz Quadris contain 67 and 70 g azoxystrobin, respectively; 9.0 fl oz Headline EC contain 67 g pyraclostrobin; 7.1 oz Elatus WG contains 60 g azoxystrobin and 30 g benzovindiflupyr; 5.7 fl oz Proline 480 SC contains 81 g prothioconazole; 13.6 fl oz Propulse contains 80 g each of fluopyram and prothioconazole; 6.7 fl oz Priaxor contains 33 g fluxapyroxad and 66 g pyraclostrobin

## RESULTS AND DISCUSSION

The average plant populations across all treatments was 222 plants per 100 ft of row on 13 June (34 DAP). There were significant ( $P = 0.0276$ ) differences among treatments for plant stands only on 20 May (10 DAP) in which Zironar and Bexfond had a greater number of plants than only Priaxor (Table 2). Analysis of application type showed a significant ( $P = 0.0005$ ) difference on 20 May (10 DAP) in which the in-furrow biocontrol agents had a greater number of plants compared to the other in-furrow fungicide treatments and fungicide seed treatments, but not the nontreated control (Fig 1). By 13 June (34 DAP), seed treatments had the greatest number of plants and was significantly ( $P = 0.0349$ ) greater than the in-furrow fungicide treatments, but not the in-furrow biocontrol agents or the nontreated control (Table 2). There were no significant differences ( $P > 0.10$ ) among treatments for RCRR severity, percent sugar, percent sugar loss to molasses (SLM), root yield, or recoverable sucrose (Table 3). Significant differences were present for RCRR incidence in which Elatus was the lowest, but different from only Zironar and Quadris (Table 3). Analysis of application type showed significant differences for only RCRR severity

and percent sugar (Table 3). Generally, in-furrow fungicide treatments resulted in the lowest RCRR severity and the in-furrow biocontrol agents resulted in the greatest sugar percentage. Overall, in-furrow biocontrol agents were safer on plant emergence compared to in-furrow fungicide treatments and seed treatments and also led to higher concentration of sugar in the roots; however, the efficacy in managing RCRR was lower than traditional in-furrow fungicide treatments.



**Fig. 1.** Emergence and stand establishment of seed treatments (ST), in-furrow fungicides (IF), and in-furrow biocontrol agents (IF\_BIO) compared to the nontreated control (None) in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2 in Crookston, MN planted on May 10, 2024.

**Table 2.** Effects of at-planting fungicide treatments on emergence and stand establishment in a *Rhizoctonia*-infested field trial planted on May 10, 2024 at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Treatment and (rate) <sup>z</sup>	Plants per 100-ft row <sup>y</sup>				
	May 17 (7 DAP) <sup>x</sup>	May 20 (10 DAP) <sup>w</sup>	May 29 (19 DAP)	June 6 (27 DAP)	June 13 (34 DAP)
Nontreated Control	18	161 ab	211	220	225
Kabina ST (14 g) <sup>v</sup>	15	156 ab	217	232	238
Systiva XS (5 g) <sup>v</sup>	21	164 ab	211	215	230
Vibrance (1.5 g) <sup>v</sup>	14	152 ab	208	217	222
Zeltera (0.1 g) <sup>v</sup>	15	158 ab	214	224	227
Quadris (9.5 fl oz) <sup>u</sup>	19	160 ab	210	223	227
Elatus WG (7.1 oz) <sup>u</sup>	22	160 ab	205	219	224
AZteroid FC3.3 (5.7 fl oz) <sup>u</sup>	18	158 ab	206	212	216
Headline SC (9 fl oz) <sup>u</sup>	12	155 ab	204	216	221
Priaxor (6.7 fl oz) <sup>u</sup>	14	145 a	199	210	211
Proline 480 SC (5.7 fl oz) <sup>u</sup>	11	152 ab	202	216	218
Propulse (13.6 fl oz) <sup>u</sup>	16	152 ab	201	212	210
Zironar (12 fl oz) <sup>t</sup>	20	178 b	203	212	215
Bexfond (14 fl oz) <sup>t</sup>	22	175 b	213	220	224
Serenade ASO (128 fl oz) <sup>t</sup>	21	165 ab	210	220	222
<i>P</i> -value	0.0604	<b>0.0276</b>	0.8307	0.5325	0.1617

<b>Contrast analysis of Treatment Types</b>					
Nontreated Control	18	161 ab	211	220	225 ab
Fungicide Seed Treatments	16	158 a	213	222	229 b
In-furrow Fungicide Treatments	16	154 a	204	215	218 a
In-furrow Biocontrol Agents	21	173 b	209	217	220 ab
<i>P</i> -value	0.0600	<b>0.0005</b>	0.1580	0.3509	<b>0.0349</b>

<sup>z</sup> Treatments were applied as a seed treatment [ST] or in-furrow application [IF]; the active ingredient and FRAC group of each product is as follows: Kabina ST is penthiopyrad (7), Systiva XS is fluxapyroxad (7), Vibrance is sedaxane (7), Zeltera is inpyrfluxam (7), Elatus WG is azoxystrobin (11) + benzovindiflupyr (7), Quadris and AZteroid FC3.3 are azoxystrobin (11), Headline SC is pyraclostrobin (11), Priaxor is fluxapyroxad (7) + pyraclostrobin (11), Proline 480 SC is prothioconazole (3), Propulse is fluopyram (7) + prothioconazole (3), Zironar is *Bacillus licheniformis* FMCH001 + *B. subtilis* FMCH002 (BM02), Bexfond is *B. amyloliquefaciens* subsp. *plantarum* FZB42 (BM02), and Serenade ASO is *B. subtilis* QST713 (BM02).

<sup>y</sup> Plant stands based on the number of plants in the center two rows of each plot.

<sup>x</sup> Days after planting; DAP.

<sup>w</sup> Means within a column followed by a common letter are not significantly different by Estimated Marginal Means (EMMs) at the 0.10 significance level.

<sup>v</sup> Fungicide seed treatments; rates are per unit of seed (100,000 seeds); applied by Germain's Seed Technology, Fargo, ND

<sup>u</sup> In-furrow fungicide treatments; rates are per acre and applied down a drip tube in 6 gallons total volume/acre.

<sup>t</sup> In-furrow biocontrol agents; rates are per acre and applied down a drip tube in 6 gallons total volume/acre.

**Table 3.** Effects of at-planting treatments on *Rhizoctonia* crown and root rot (RCRR) and sugarbeet yield and quality in a *Rhizoctonia*-infested field trial at the University of Minnesota, Northwest Research and Outreach Center, Crookston planted on May 10, 2024.

Treatment and (rate) <sup>z</sup>	Harvested Roots <sup>y</sup>	Plant Loss (%) <sup>x</sup>	RCRR Severity (%) <sup>w,v</sup>	RCRR Incidence (%) <sup>u</sup>	Sugar (%)	SLM (%) <sup>t</sup>	Root Yield (tons/A)	Sucrose (lb/A) <sup>s</sup>
Nontreated Control	200	11.6	3.7	15.0 ab	16.88	1.85	33.1	9955
Kabina ST (14 g) <sup>r</sup>	212	10.9	2.5	16.3 ab	16.45	2.02	34.0	9824
Systiva XS (5 g) <sup>r</sup>	191	16.9	2.0	8.8 ab	16.68	1.90	32.7	9662
Vibrance (1.5 g) <sup>r</sup>	203	9.0	2.2	6.3 ab	16.87	1.92	33.2	9907
Zeltera (0.1 g) <sup>r</sup>	195	14.7	3.0	15.0 ab	16.52	1.92	31.0	9051
Quadris (9.5 fl oz) <sup>q</sup>	199	12.9	2.9	18.8 b	16.87	1.90	32.5	9742
Elatus WG (7.1 oz) <sup>q</sup>	206	9.3	0.2	1.3 a	16.95	1.85	33.6	10132
AZteroid FC3.3 (5.7 fl oz) <sup>q</sup>	190	12.2	2.7	11.3 ab	16.65	1.91	31.0	9145
Headline SC (9 fl oz) <sup>q</sup>	180	19.5	2.8	10.0 ab	16.66	1.93	32.1	9494
Priaxor (6.7 fl oz) <sup>q</sup>	186	12.1	1.2	10.0 ab	16.88	1.85	32.5	9751
Proline 480 SC (5.7 fl oz) <sup>q</sup>	189	14.5	0.5	3.8 ab	17.09	1.85	30.4	9251
Propulse (13.6 fl oz) <sup>q</sup>	172	19.0	1.3	3.8 ab	16.93	1.93	29.3	8793
Zironar (12 fl oz) <sup>p</sup>	179	17.3	5.5	18.8 b	16.89	1.90	31.4	9424
Bexfond (14 fl oz) <sup>p</sup>	188	16.5	3.6	10.0 ab	17.30	1.80	31.3	9712
Serenade ASO (128 fl oz) <sup>p</sup>	188	16.2	3.5	11.3 ab	16.97	1.87	30.7	9265
<i>P</i> -value	0.2228	0.1924	0.3120	<b>0.0162</b>	0.5084	0.3479	0.2172	0.4678

### Contrast analysis of Treatment Types

Nontreated Control	200	11.6	3.7 ab	15.0	16.88 ab	1.85	33.1	9955
Fungicide Seed Treatments	200	12.9	2.4 ab	11.6	16.63 a	1.94	32.7	9611
In-furrow Fungicide Treatments	189	14.2	1.7 a	8.4	16.86 ab	1.89	31.6	9473
In-furrow Biocontrol Agents	185	16.7	4.2 b	13.3	17.05 b	1.85	31.1	9467
<i>P</i> -value	0.1194	0.3066	<b>0.0227</b>	0.1882	<b>0.0886</b>	0.1044	0.2030	0.6510

<sup>z</sup> Treatments were applied as a seed treatment [ST] or in-furrow application [IF]; the active ingredient and FRAC group of each product is as follows: Kabina ST is penthiopyrad (7), Systiva XS is fluxapyroxad (7), Vibrance is sedaxane (7), Zeltera is inpyrfluxam (7), Elatus WG is azoxystrobin (11) + benzovindiflupyr (7), Quadris and AZteroid FC3.3 are azoxystrobin (11), Headline SC is pyraclostrobin (11), Priaxor is fluxapyroxad (7) + pyraclostrobin (11), Proline 480 SC is prothioconazole (3), Propulse is fluopyram (7) + prothioconazole (3), Zironar is *Bacillus licheniformis* FMCH001 + *B. subtilis* FMCH002 (BM02), Bexfond is *B. amyloliquefaciens* subsp. *plantarum* FZB42 (BM02), and Serenade ASO is *B. subtilis* QST713 (BM02).

<sup>y</sup> Harvested roots are equal to number of roots per 100 ft of row.

<sup>x</sup> Plant loss percent equals  $100 * (\text{Maximum number of live plants} - \text{number of harvested roots}) / (\text{Maximum number of live plants})$ .

<sup>w</sup> Percent severity of *Rhizoctonia* crown and root rot based on a 0 to 10 scale with a 10% incremental increase per each unit of rating (i.e., 0=0%, 5 = 41-50%, 10=91-100%). Each rating was mid-point transformed to percent severity for statistical analysis.

<sup>v</sup> Means within a column followed by a common letter are not significantly different by Estimated Marginal Means (EMMs) at the 0.10 significance level.

<sup>u</sup> Percent incidence of rated roots with > 0% of rot on the root surface.

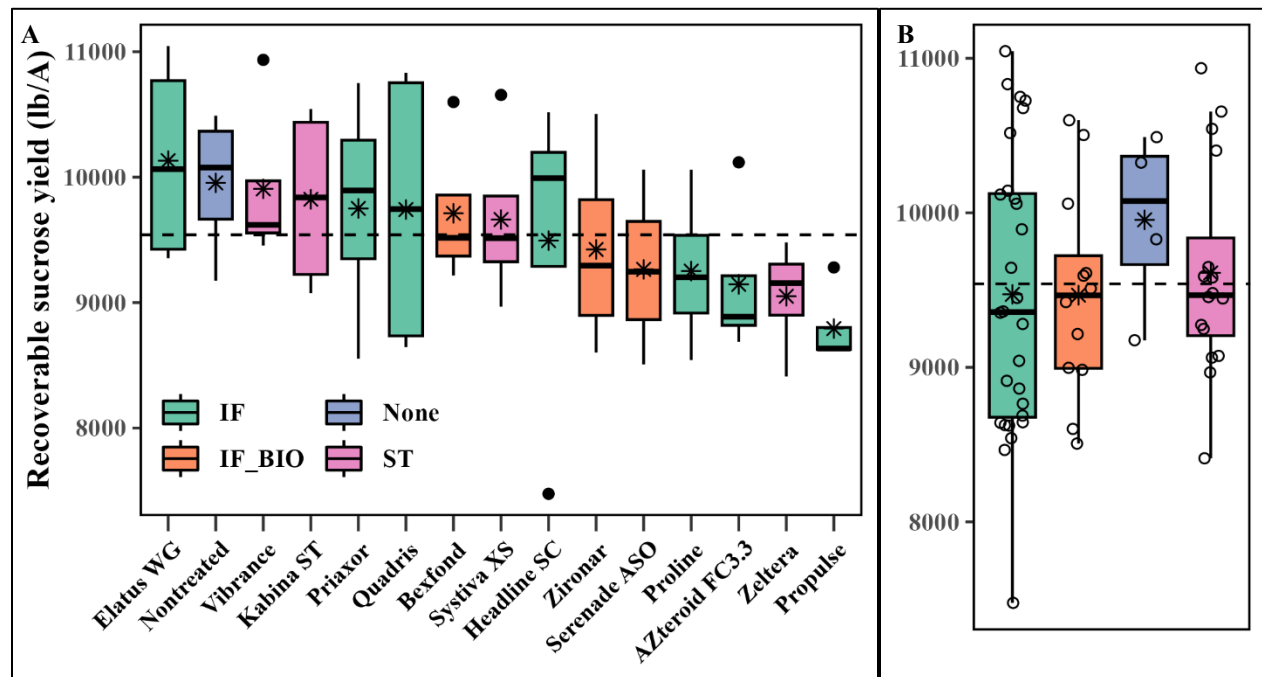
<sup>t</sup> Percent sugar loss to molasses (SLM).

<sup>s</sup> Recoverable sucrose per acre; equal to  $\text{yield} * (\text{percent sugar} - \text{percent SLM}) * 20$ .

<sup>r</sup> Fungicide seed treatments; rates are per unit of seed (100,000 seeds); applied by Germain's Seed Technology, Fargo, ND

<sup>q</sup> In-furrow fungicide treatments; rates are per acre and applied down a drip tube in 6 gallons total volume/acre.

<sup>p</sup> In-furrow biocontrol agents; rates are per acre and applied down a drip tube in 6 gallons total volume/acre.



**Fig. 2.** Effect of at-planting treatments on recoverable sucrose (lbs/A) in sugarbeets (A) and averages by seed treatments (ST), and in-furrow fungicides (IF), in-furrow biocontrol agents (IF\_BIO) compared to the nontreated control (None) (B) in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2 in Crookston, MN. Boxplots display the distribution of data for each treatment based (minimum, first quartile, median, third quartile, and maximum); filled dots represent outliers; hollow dots represent each data point; asterisks represent treatment means. The dashed horizontal line represents the mean of all treatments in this trial.

## ACKNOWLEDGEMENTS

We thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for funding this research; Crystal Beet Seed for providing seed; Germains Seed Technology for treating seed; BASF, Bayer Crop Science, Mitsui Chemicals Agro, Inc., Syngenta, UPL, Valent, Vive Crop Protection for providing additional chemical products for plot maintenance and execution; the University of Minnesota Northwest Research and Outreach Center, Crookston for providing land, equipment and other facilities; Michael Leiseth, Amber Cymbaluk, and Darla Knuth for plot maintenance; Jacob Fjeld and Darren Neiswaag for technical assistance; American Crystal Sugar Company, East Grand Forks, MN for sugarbeet quality analysis.

## LITERATURE CITED

- Brantner JR and Windels CE. 2009. Plant pathology laboratory: summary of 2007-2008 field samples. *2008 Sugarbeet Res. Ext. Rept.* **39**: 250-251.
- Brantner JR and Windels CE. 2011. Plant pathology laboratory: summary of 2009-2010 field samples. *2010 Sugarbeet Res. Ext. Rept.* **41**: 260-261.
- Brantner JR. 2015. Plant pathology laboratory: summary of 2013-2014 field samples. *2014 Sugarbeet Res. Ext. Rept.* **45**: 138-139.
- Brantner JR and Chanda AK. 2017. Plant pathology laboratory: summary of 2015-2016 field samples. *2016 Sugarbeet Res. Ext. Rept.* **47**: 203-204.
- Brantner JR and Chanda AK. 2019. Plant Pathology Laboratory: Summary of 2017-2018 Field Samples. *2018 Sugarbeet Res. Ext. Rept.* **49**: 202-203.
- Brantner J and Moomjian DL. 2023. Results of American Crystal Company's 2022 coded official variety trials. *2022 Sugarbeet Res. Ext. Rept.* **53**: 204-237.
- Brantner J and Deschene A. 2024. Results of American Crystal Sugar Company's 2023 Coded Official Variety Trials. *2023 Sugarbeet Research Ext. Rep.* **54**: 208-239.
- Brantner JR and Chanda AK. 2018. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on sugarbeet. *2017 Sugarbeet Res. Ext. Rept.* **48**: 150-153.
- Chanda, AK, Brantner JR, Metzger M, Radermacher J. 2016. Integrated Management of *Rhizoctonia* on Sugarbeet with Varietal Resistance, At-Planting Treatments and Postemergence Fungicides. *2015 Sugarbeet Res. Ext. Rept.* **46**: 154-159.
- Chanda AK and Brantner JR. 2016. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani*. *2015 Sugarbeet Res. Ext. Rept.* **46**: 151-153.
- Chanda AK and Brantner JR. 2017. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on sugarbeet. *2016 Sugarbeet Res. Ext. Rept.* **47**: 166-168.
- Chanda AK and Brantner JR. 2019. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on sugarbeet. *2018 Sugarbeet Res. Ext. Rept.* **49**: 176-179.
- Crane E, Brantner JR, Windels CE. 2013. Plant pathology laboratory: summary of 2011-2012 field samples. *2012 Sugarbeet Res. Ext. Rept.* **43**: 169-170.
- Hakk PC, Branch EA, Chanda AK, Peters TJ, Boetel MA. 2024. Turning Point Survey of Fungicide Use in Sugarbeet in Minnesota and Eastern North Dakota in 2023. *2023 Sugarbeet Res. Ext. Rept.* **54**: 160-166.
- Lien AK, Brantner JR, Chanda AK. 2022. Plant Pathology Laboratory: Summary of 2019-2021 Field Samples. *2021 Sugarbeet Res. Ext. Rept.* **52**: 170-172.
- Lien AK, Brantner JR, Chanda AK. 2024. Plant Pathology Laboratory: Summary of 2022-2023 Field Samples. *2023 Sugarbeet Res. Ext. Rept.* **54**: 203-205.
- Lien A, Brantner JR, Chanda AK. 2021. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on sugarbeet, 2020. *2020 Sugarbeet Res. Ext. Rept.* **51**: 137-140.
- Lien AK, Nielsen J, Chanda AK. 2022. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on sugarbeet, 2021. *2021 Sugarbeet Res. Ext. Rept.* **52**: 173-177.
- Lien AK, Nielsen J, Chanda AK. 2023. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on sugarbeet, 2022. *2022 Sugarbeet Res. Ext. Rept.* **53**: 169-174.
- Lien AK and Chanda AK. 2024. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on Sugarbeet, 2023. *2023 Sugarbeet Res. Ext. Rept.* **54**: 190-195.
- Windels C, Brantner J. 2006. Crop Rotation Effects on *Rhizoctonia solani* AG 2-2. *2005 Sugarbeet Res. Ext. Rept.* **36**: 286-290.

Windels CE, Jacobsen BJ, Harveson RM. 2009. *Rhizoctonia Root and Crown Rot*. In: Harveson RM, Hanson LE, Hein GL, editors. Compendium of Beet Diseases and Pests. 2nd Ed. APS Press, St. Paul, MN, USA. p. 33-36.

Windels C, Brantner J. 2010a. Rotation Crop Effects on Rhizoctonia Diseases of Sugarbeet in Infested Fields. 2009 *Sugarbeet Res. Ext. Rept.* **40**: 225-229.

Windels C, Brantner J. 2010b. Aggressiveness of *Rhizoctonia solani* AG 2-2 on Sugarbeet and Other Crops. 2009 *Sugarbeet Res. Ext. Rept.* **40**: 230-236.

Campbell L, Windels C, Fugate K, Brantner J. 2013. Postharvest Respiration Rate and Sucrose Concentration of Rhizoctonia-infected Sugarbeet Roots. 2012 *Sugarbeet Res. Ext. Rept.* **43**: 112-120.

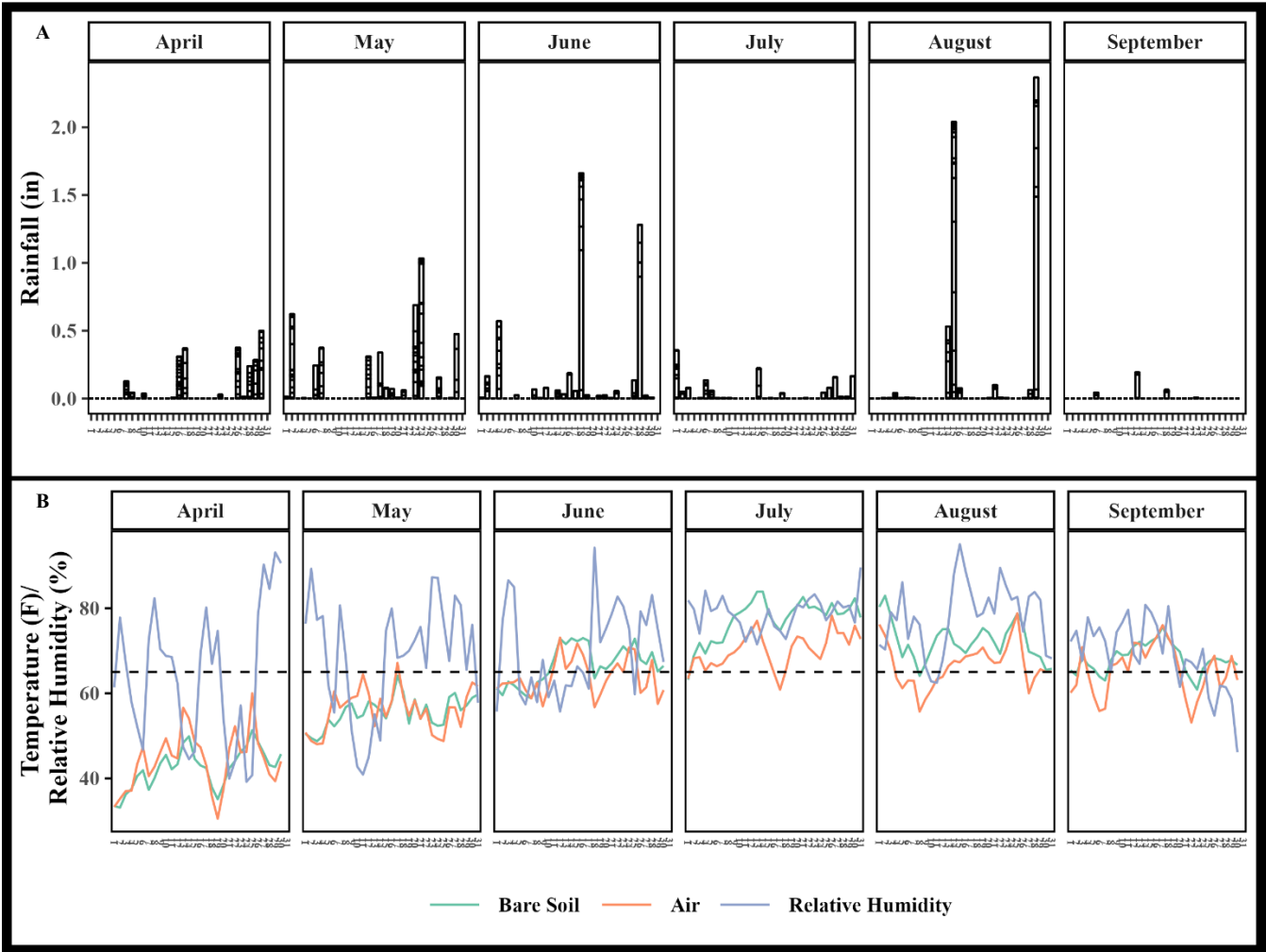
Brantner JR and Chanda AK. 2020. Evaluation of at-planting fungicide treatments for control of *Rhizoctonia solani* on sugarbeet. 2019 *Sugarbeet Res. Ext. Rept.* **50**: 165-169.

Supplementary Weather Table and Figure

**Supplementary Table S1.** Weather data for the 2024 growing season compared to the normal (30-year average). Data was retrieved from the Eldred North Dakota Agricultural Weather Network station (47.68769, -96.82221), located approximately 12.8 miles southwest of the Northwest Research and Outreach Center (NWROC), Crookston, MN.

Month	Total Rainfall (inch)		Average Air Temperature (°F)	
	2024	Normal <sup>z</sup>	2024	Normal
April	2.33	1.42	44.3	41.7
May	4.49	2.86	55.5	55.3
June	4.48	4.01	63.4	65.8
July	1.42	3.45	70.0	69.8
August	5.26	2.86	66.6	68.0
September <sup>y</sup>	0.31	2.03	66.0	60.2

<sup>z</sup> Normals are interpolated from National Weather Service (NWS) Cooperative stations (1991-2020) and are defined as the average of a variable for a continuous 3-decade (30-year) period.



**Supplementary Fig. S1.** Daily rainfall totals in which stacked bars represent 1-hour intervals (A) and daily mean air temperature, 4-in. bare soil