EVALUATION OF AT-PLANTING FUNGICIDE TREATMENTS FOR CONTROL OF *RHIZOCTONIA SOLANI* ON SUGARBEET, 2023

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Rhizoctonia damping-off and crown and root rot (RCRR) caused by *Rhizoctonia solani* AG 2-2 have been the most common root diseases of sugarbeet in Minnesota and North Dakota for over the past decade (Brantner and Windels 2009, 2011; Crane et al. 2013; Brantner 2015; Brantner and Chanda 2017, 2019; Lien et al. 2022). Disease can occur throughout the growing season and reduce plant stand, root yield, and quality especially when warm and wet soil conditions favor infection. Disease management options include rotating with non-host crops (small grains), planting partially resistant varieties, planting early when soil temperatures are cool, improving soil drainage, and applying fungicides as seed treatments, in-furrow (IF), and/or postemergence. An integrated management strategy should use multiple control options to reduce Rhizoctonia crown and root rot (Windels et al. 2009, Chanda et al. 2016).

OBJECTIVES

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

MATERIALS AND METHODS

The trial was established at the University of Minnesota, Northwest Research and Outreach Center (NWROC), Crookston on a Hegne-Fargo silty clay soil with an organic matter content of 5.2%. Field plots were fertilized for optimal yield and quality. A moderately susceptible variety (Crystal 793RR) with a 2-year average Rhizoctonia rating of 4.5 (Brantner and Moomjian 2023) was used. Treatments were arranged in a randomized complete block design with four replicates. Seed treatments and rates are summarized in Table 1 and were applied by Germains Seed Technology, Fargo, ND. In-furrow fungicides (Table 1) (mixed in 3 gal water) mixed with starter fertilizer (3 gallons 10-34-0) were applied down the drip tube in 6 gallons total volume/A. The nontreated control did not include any seed or in-furrow fungicide treatment that would suppress or control *Rhizoctonia*. Prior to planting, soil was infested with *R. solani* AG 2-2-infested (a mixture of four isolates) whole barley (50 kg/ha) by hand-broadcasting in plots and incorporating with an 11-ft Rau seedbed finisher. The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 12 at 4.5-inch seed spacing.

Counter 20G (7.5 lb/A) was applied at planting for control of sugarbeet root maggot. For the control of weeds, ethofumesate (6 pt/A) was applied before planting using a spray boom mounted to the front of the Rau seedbed finisher to incorporate the product parallel with the direction of rows, glyphosate (3 lb ae/gal; 32 fl oz/A) plus clopyralid (1.8 fl/A) was applied on May 23, and Sequence (glyphosate + S-metolachlor, 2.5 pt/A) with additional glyphosate (4.5 lb ae/gal; 8 fl oz/A) was applied on June 07. For postemergence control of sugarbeet root maggot, Asana XL + Exponent (9.6 fl + 8 fl oz/A) was applied on June 08. Cercospora leaf spot was controlled by applying Inspire XT + Manzate Pro-Stick (7 fl oz + 2 lbs/A) on July 13, SuperTin 4L + Topsin 4.5FL (8 + 10 fl oz/A) on July 26, Proline 480 SC + Manzate Pro-Stick (5.7 fl oz + 2 lbs/A) on Aug 17, and SuperTin 4L + Priaxor Xemium (8 + 6.7 fl oz/A) on Aug 30.

Plant stands were evaluated beginning May 23 (11 days after planting [DAP]) through June 30 (49 DAP) by counting the number of plants in the center two rows of each plot. On Sept 12, plots were defoliated and the center two rows of each plot were harvested mechanically and weighed for root yield. Data was also collected for root rot severity and number of harvested roots immediately following harvest. Twenty roots per plot were arbitrarily selected, and root surfaces were rated for the severity of Rhizoctonia crown and root rot (RCRR) using a 0 to 10 scale with a 10% incremental increase per each unit of rating (i.e., 0=0%, 5 = 41-50%, 10=91-100%). Each rating was mid-point transformed to percent severity for statistical analysis. Ten representative roots from each plot were analyzed for sugar quality at the American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, MN. Statistical analysis was conducted in SAS (version 9.4; SAS Institute, Cary, NC). A mixed-model analysis of variance was performed using the GLIMMIX procedure, with treatments defined as the fixed factor and replication as the random factor. Treatment means were separated based on the least square means test at the 0.05 significance level using the LSMEANS statement. The CONTRAST statement was used to compare the means of seed treatments vs. in-furrow treatments.

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

Application[Z]	Product[Y]	Active ingredient (FRAC Group)	Rate[X]
Nontreated	-	-	-
Seed	Kabina ST	Penthiopyrad (7)	14 g a.i./unit seed
Seed	Systiva	Fluxapyroxad (7)	5 g a.i./unit seed
Seed	Vibrance	Sedaxane (7)	1.5 g a.i./unit seed
Seed	Zeltera	Inpyrfluxam (7)	0.1 g a.i./unit seed
Seed	Metlock Suite + Zeltera	Metconazole (3) + Tolclofos-methyl (14) Inpyrfluxam (7)	0.21 g a.i + 0.5 g a.i./unit seed 0.05 g a.i/unit seed
In-furrow	AZteroid FC3.3	Azoxystrobin (11)	5.7 fl oz product/A
In-furrow	Quadris	Azoxystrobin (11)	9.5 fl oz product/A
In-furrow	Headline SC	Pyraclostrobin (11)	9.0 fl oz product/A
In-furrow	Elatus WG	Azoxystrobin (11) + Benzovindiflupyr (7)	7.1 oz product/A
In-furrow	Proline 480 SC	Prothioconazole (3)	5.7 fl oz product/A
In-furrow	Propulse	Fluopyram (7) + Prothioconazole (3)	13.6 fl oz product/A
In-furrow	Priaxor	Fluxapyroxad (7) + Pyraclostrobin (11)	6.7 fl oz product/A

Z All treatments received 3 gal 10-34-0 applied down the drip tube in a total volume of 6 gal/A; In-furrow fungicides were mixed in 3 gal water prior to mixing with 3 gal 10-34-0.

Y Standard rates of Allegiance + Thiram and 45 g/unit Tachigaren were on all seeds.

X 5.7 fl oz AZteroid FC3.3 and 9.5 fl oz Quadris contain 67 and 70 g azoxystrobin, respectively; 9.0 fl oz Headline EC contain 67 g pryaclostrobin; 7.1 oz Elatus WG contains 60 g azoxystrobin and 30 g benzovindiflupyr; 5.7 fl oz Proline 480 SC contains 81 g prothioconazole; 13.6 fl oz Propulse contains 80 g each of fluopyram and prothioconazole; 6.7 fl oz Priaxor contains 33 g fluxapyroxad and 66 g pyraclostrobin

RESULTS AND DISCUSSION

The Northwest Research and Outreach Center, Crookston, MN, recorded a total rainfall of 1.71 and 0.87 in. for April and May, which was less than the 30-year average of 1.32 and 2.81 in., respectively. Warm conditions and adequate soil moisture at planting allowed for the rapid emergence of sugarbeet seedlings and generally high plant populations of 215 plants per 100 ft. of row averaged across all treatments in this trial on May 23 (11 DAP).

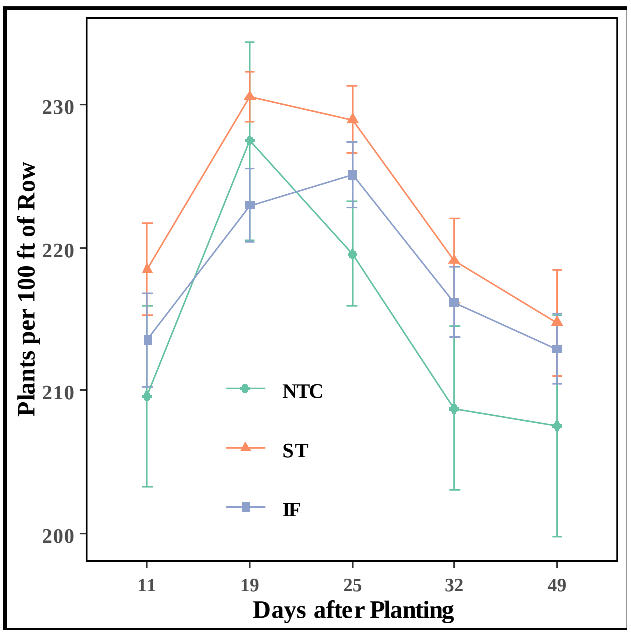

Figure 1. Emergence and stand establishment in 2023 comparing the averages of seed treatments and in-furrow fungicide treatments compared to the nontreated control in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2 in Crookston, MN.

There were no significant differences among at-planting treatments for plant stands at any evaluation date or by the time of harvest (Table 2). However, based on the contrast analysis, in-furrow treatments had a statistically lower number of plants compared to the seed treatments on May 31 (19 DAP) (Table 2). Generally, seed treatments had a slightly higher number of plants throughout the first 7 weeks after planting (Fig. 1). Optimum soil moisture at planting typically does not result in seedling injury associated with in-furrow products as seen in previous years (Chanda and Brantner 2016, 2017; Lien et al. 2020, Lien et al. 2023). However, it is not unusual for stands to be lower for in-furrow fungicides compared to seed treatments under drier soil conditions (Brantner and Chanda 2018, 2020; Chanda and Brantner 2019; Lien et al. 2022).

Warmer temperatures in May and June likely contributed to a favorable environment for Rhizoctonia establishment early on; however, lower-than-average rainfall later in the season was unfavorable for disease development and resulted in moderately low disease pressure throughout the season in 2023. There were no significant differences (*P* > 0.05) among treatments for severity and incidence of Rhizoctonia crown and root rot (RCRR), sucrose percentage, root yield, or recoverable sucrose. However, based on the contrast analysis, in-furrow treatments had statistically lower plant loss, lower incidence and severity of RCRR, and higher yield and recoverable sucrose per acre compared to seed treatments (Table 3 and Fig. 2B).

Table 2. Effects of at-planting (seed treatment or in-furrow) fungicide treatments on emergence and stand establishment in a *Rhizoctonia*-infested field trial planted on May 12, 2023 at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

	Plants per 100 ft row [y,x]				
Treatment and rate (Application type)[z]	May 23 11 DAP	May 31 19 DAP	June 6 25 DAP	June 13 32 DAP	June 30 49 DAP
Nontreated Control	210	228	220	209	208
§Headline SC (9 fl oz)	212	225	225	215	213
§Priaxor (6.7 fl oz)	209	218	223	214	217
§Proline (5.7 fl oz)	218	219	228	220	215
§Propulse (13.6 fl oz)	220	222	223	212	203
¥Kabina ST (14 g)	216	232	223	209	204
¥Systiva XS (5 g)	205	227	226	215	210
¥Vibrance (1.5 g)	230	233	235	231	229
¥Zeltera (0.1 g)	220	232	227	219	218
¥Metlock Suite (0.21 + 0.5) + Zeltera (0.05 g)	222	230	234	221	213
§Quadris (9.5 fl oz)	207	224	219	211	206
§Elatus WG (7.1 oz)	221	235	235	229	226
§AZteroid FC[3.3] (5.7 fl oz)	208	218	224	212	210
LSD	-	-	-	-	-
P-value	0.5511	0.4246	0.5847	0.2568	0.3137
Contrast analysis of Seed Treatments vs. In-furrow Treatments [w]					
Mean of In-furrow treatments	214	223	225	216	213
Mean of Seed treatments	218	231	229	219	215
P-value	0.2063	**0.0366**	0.2946	0.5679	0.9709

z Treatments were applied as seed treatment (grams per unit of seed) or in-furrow application (rate per acre)
y Plant stands based on the number of plants in the center two rows of each plot
x Means followed by the same letter are not significantly based on LSMEANS test (*P*=0.05)
w Contrast analysis of seed versus in-furrow treatments does not include nontreated control
¥ Seed treatments applied by Germains Seed Technology, Fargo, ND
§ In-furrow fungicide application applied down a drip tube in 6 gallons total volume/A

Table 3. Effects of at-planting (seed treatment or in-furrow) fungicide treatments on Rhizoctonia crown and root rot and sugarbeet yield and quality in a *Rhizoctonia*-infested field trial at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Treatment and (Application rate)[z]	Plant Stand at Harvest[y]	Plant Loss (%)[x]	RCRR Severity (%)[w]	RCRR Incidence (%)[w]	Sugar (%)[t]	SLM (%)[t]	Sucrose (%)	Yield (tons/A)	Sucrose (lb/A)
§Elatus WG (7.1 oz)	185	22.4	8.2	36.2	20.1	1.0	19.1	27.9	10608
§Propulse (13.6 fl oz)	170	24.9	6.9	32.5	19.6	0.9	18.7	27.5	10256
§Proline (5.7 fl oz)	175	23.3	5.8	26.2	19.6	1.0	18.6	27.1	9991
§Priaxor (6.7 fl oz)	184	18.2	4.6	31.2	19.5	1.0	18.5	27.0	9962
§AZteroid FC[3.3] (5.7 fl oz)	175	23.2	4.5	21.2	19.1	1.1	18.0	27.5	9891
§Quadris (9.5 fl oz)	172	24.2	7.4	32.5	19.8	1.1	18.7	26.3	9723
¥Kabina ST (14 g)	158	32.0	11.3	41.2	19.7	1.0	18.7	25.8	9608
¥Vibrance (1.5 g)	174	27.0	9.2	43.8	19.4	1.0	18.4	25.5	9388
¥Zeltera (0.1 g)	172	25.8	9.2	40.0	19.7	1.0	18.7	25.2	9364
Nontreated Control	157	31.0	8.6	33.8	19.0	1.0	18.0	26.0	9324
¥Metlock Suite (0.2 + 0.5 g) + Zeltera (0.05 g)	169	29.0	11.1	38.8	19.7	1.1	18.6	25.0	9180
¥Systiva XS (5 g)	167	27.6	8.6	31.2	20.0	1.0	19.0	23.7	9022
§Headline SC (9 fl oz)	161	29.3	6.5	32.5	19.4	1.1	18.3	24.8	8983
P-value	0.2831	0.1634	0.4536	0.7218	0.8514	0.6178	0.8521	0.5084	0.2508
[v] Contrast analysis of Seed Treatments vs. In-furrow Treatments									
Mean of In-furrow treatments	175	23.7	6.3	30.4	19.6	1.0	18.6	26.9	9916
Mean of Seed treatments	168	28.3	9.9	39.0	19.7	1.0	18.7	25.0	9312
P-value	0.1274	**0.0148**	**0.0073**	**0.0480**	0.6257	0.3268	0.6043	**0.0338**	**0.0411**

z Treatments were applied as seed treatment (grams per unit of seed) or in-furrow application (rate per acre)
y Plant stands are equivalent to number of plants per 100 ft of row
x Plant loss percent equals 100 * (Maximum number of live plants – number of harvested roots) / (Maximum number of live plants)
w Ratings and incidence Rhizoctonia crown and root rot are described in text
v Contrast analysis of seed versus in-furrow treatments does not include nontreated control
¥ Seed treatments applied by Germains Seed Technology, Fargo, ND
§ In-furrow fungicide application applied down a drip tube in 6 gallons total volume/A

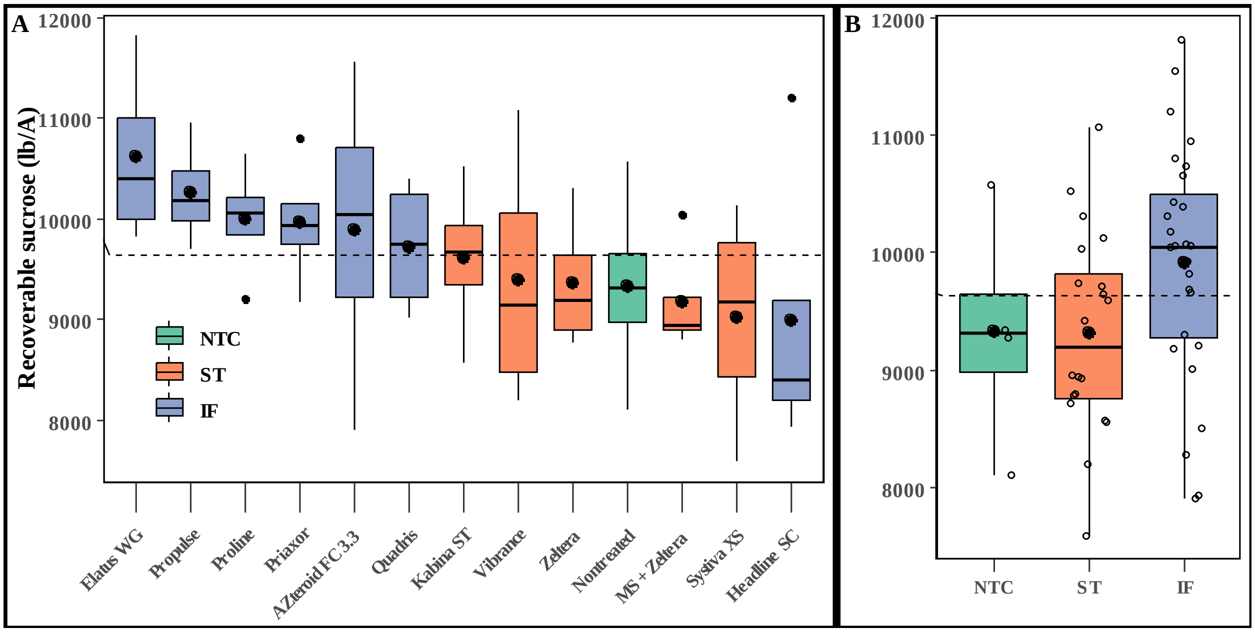

Figure 2. Effect of at-planting treatments on recoverable sucrose (lbs/A) in sugarbeets (A) and averages of seed treatments (ST) and in-furrow fungicide treatments (IF) compared to the nontreated control (NTC) (B) in a sugarbeet field trial infested with *Rhizoctonia solani* AG 2-2 in Crookston, MN. Boxplots display the distribution of data for each treatment based (minimum, first quartile, median, third quartile, and maximum); hollow dots represent each data point; filled dots represent treatment means. The dashed horizontal line represents the mean of all treatments in this trial.

ACKNOWLEDGEMENTS

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

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