EVALUATION OF POSTEMERGENCE FUNGICIDES AND APPLICATION METHOD ON SUGAR BEET FOR CONTROL OF RHIZOCTONIA CROWN AND ROOT ROT, 2025

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Rhizoctonia crown and root rot (RCRR), caused by *Rhizoctonia solani* AG 2-2, is a persistent and economically important root disease of sugarbeet in Minnesota and North Dakota. Protection from early-season damping-off caused by *R. solani* is typically achieved through seed treatments and in-furrow fungicides; however, the efficacy of these at-planting approaches generally diminishes within the first few weeks after emergence. Because RCRR can continue to develop throughout the season, especially when warm, moist soils favor pathogen activity, plants remain vulnerable to stand loss, root rot, and declines in sucrose quality well beyond the period covered by seed or in-furrow treatments. Although planting varieties with tolerance to RCRR is an important component of disease management, varietal resistance in sugarbeet is age-dependent, and all varieties remain susceptible during the early growth stages (Liu et al. 2019). Increase in inter-row cultivation to manage herbicide resistant weeds is resulting in throwing soil into crown areas which are highly susceptible to Rhizoctonia infection.

Postemergence fungicides have therefore become an important tool for extending protection into mid-season, particularly when applications are made at the 4- to 8-leaf stage, where they have been shown to reduce RCRR severity and minimize yield loss (Windels et al. 2009; Chanda et al. 2016, 2017, 2018, 2019, 2020, 2021). Despite the number of fungicides currently labeled for postemergence management of RCRR, relatively few field studies have directly compared their efficacy under uniform disease pressure. Furthermore, it remains unclear whether fungicide performance differs between broadcast applications and narrower 7-in. banded applications, the latter of which may improve treatment precision and reduce cost but could also limit fungicide coverage. Improved understanding of these application strategies is critical for optimizing RCRR management, particularly in seasons where environmental conditions support moderate to high disease pressure.

OBJECTIVES

A field trial was established to evaluate various postemergence fungicide treatments as a 7-in. band or broadcast application for 1) control of early-season damping-off and RCRR and 2) effect on plant stand, yield, and quality of sugarbeet.

MATERIALS AND METHODS

The study was conducted at the University of Minnesota Northwest Research and Outreach Center (NWROC) in Crookston, MN, on a Hegne–Fargo silty clay soil with 5.6% organic matter. The field received fertilizer according to University of Minnesota fertilizer guidelines in the fall of 2024 to support optimal root yield and sucrose quality. A moderately susceptible sugarbeet variety 'Crystal 793RR', with a two-year average Rhizoctonia rating of 4.1 (Brantner et al. 2025), was used. Seed was commercially treated with Allegiance, Thiram, Tachigaren (45 g a.i./unit), and Kabina (14 g a.i./unit). Plots were arranged in a randomized complete block design with four replications. Sugarbeet was planted on 07 May in six-row plots (22-in. row spacing, 30-ft length) using a Monosem NG Plus planter at a 4.5-in. seed spacing. At planting, an XLR-rate starter fertilizer (7-23-5) was applied in-furrow at 3 gal/A with a total application volume of 6 gal/A, and Counter 20G was applied at 7.5 lb/A. Mustang Maxx (4 fl oz/A) was applied on 04 June (10 gal/A, 30 psi, TeeJet 8002 nozzles) for sugarbeet root maggot management; approximate fly counts were 33 and 110 flies per sticky-stake trap on 03 June and 05 June, respectively. Preplant ethofumesate (6 pt/A) was incorporated using a front-mounted spray boom on a Rau seedbed finisher, followed by a combination of RoundUp PowerMax 3 (28 fl oz/A) and Stinger HL (3 fl oz/A) on 04 June, and an application of Sequence (2.5 pt/A) on 27 June for weed control. Cercospora leaf spot was managed using fungicide program consisting of Inspire XT + Manzate Pro-Stick (7 fl oz + 2 lb/A) on 25 July, SuperTin 4L + Topsin 4.5 FL (8 + 10 fl oz/A) on 13 August, and Proline 480 SC + Manzate Pro-Stick (5.7 fl oz + 2 lb/A) on 26 August.

Postemergence fungicide treatments for Rhizoctonia management (Table 1) were applied on 17 June at the 8-leaf stage to the center four rows of each plot. Treatments were applied either as a 7-in. band or as a full broadcast using a tractor-mounted sprayer equipped with TeeJet 8002 (band) or 11002 (broadcast) flat-fan nozzles calibrated to deliver 10 gal/A at 30 psi. Following the appropriate re-entry interval, plots were inoculated the same day (17 June) by applying 0.71 oz/row of *R. solani*-infested barley directly over the crowns using a tractor-driven Gandy applicator. The inoculum consisted of autoclaved barley colonized with two isolates each of *R. solani* AG 2-2 IIIB and AG 2-2 IV. After colonization, barley was air-dried, ground using a Wiley mill, and passed through a 3-mm sieve prior to field application. Inter-row cultivation occurred on 23 June.

Plant stands were assessed on 18 June (42 days after planting) by counting living plants in the center two rows of each plot. On 12 September, plots were defoliated and the center two rows were harvested and weighed to obtain root yield. Ten representative roots per plot were submitted to the American Crystal Sugar Company Quality Tare Laboratory (East Grand Forks, MN) for sucrose quality analysis. Following harvest, twenty additional roots were arbitrarily selected from each plot and rated for RCRR severity. Remaining roots were counted to determine the number of harvested roots. Disease severity was evaluated using a 0-10 scale corresponding to 10% increments of root area affected (0 = no visible rot, 1 = 1–10%, 5 = 41–50%, 10 = 91–100%). Ratings were transformed to midpoint percentage values for statistical analysis. Statistical analyses were conducted in R (v. 4.3.3; R Core Team 2025). A mixed-model ANOVA was performed using the lmerTest package (v. 3.1-3), with treatment considered a fixed effect and replication a random effect. Estimated marginal means (EMMs) were separated at the 0.10 significance level using emmeans (v. 1.11.1), and treatment contrasts were performed to compare banded versus broadcast applications. Weather data was retrieved from the Minnesota Agricultural Weather Network, Crookston, MN Station (47.823333°, -96.620556°).

RESULTS AND DISCUSSION

A weather station located 1.72 miles north-northwest of the research plots maintained by the Northwest Research and Outreach Center, Crookston, MN (47.801785, -96.600455) recorded a total rainfall of 1.79 and 2.01 in. for April and May, which was near the 30-year average of 1.27 and 2.75 in., respectively (Supplementary Table S1). Extreme fluctuating temperatures around the time of planting and heavy rainfall events contributed to soil crusting and variable emergence of sugar beet seedlings in the area. In this trial, there was a moderately high plant population of 181 plants per 100 ft of row, equivalent to 67.8% emergence, averaged across the reported treatments in this trial on 18 June. There were no significant ($P = 0.3776$) differences among treatments for plant populations on 18 June (42 DAP).

Mean daily soil temperatures rose above 65°F after June 14, the temperature which is known to be conducive for *R. solani* infection, and rainfall totaling 0.84 in. shortly after fungicide application and inoculation (Supplementary Fig. S1) created conditions favorable for *R. solani* development at the trial site, resulting in moderate disease pressure. Under these conditions, significant differences in plant loss were observed among treatments, with the nontreated control showing the greatest reduction in stand (Table 1). All fungicide treatments improved plant survival relative to the nontreated control, reflecting the importance of postemergence protection once early-season seed-applied fungicides no longer provide activity. Clear treatment effects were also detected for both RCRR severity and incidence (Table 1). Every fungicide program, regardless of product or application method, significantly reduced disease compared with the nontreated control. This indicates that all evaluated fungicides provided meaningful suppression of RCRR when applied at the 6-8 leaf stage, even under moderate disease pressure.

Differences in sucrose quality traits were minimal; although percent sugar and recoverable sucrose yield did not vary significantly among treatments, there was a detectable effect on sugar loss to molasses (SLM; Table 1). AZterknot applied as a 7-in. band had the lowest SLM values, but this treatment differed statistically only from the 7-in. band applications of AZteroid FC[3.3] and Quadris. There were no significant differences ($P > 0.10$) in the number of harvested roots, percent sugar, root yield, or recoverable sucrose yield. However, there were numerical differences in which the nontreated control resulted in the lowest number of harvested roots, root yield and sucrose yield.

Contrast analysis comparing all 7-in. banded applications with all broadcast applications showed greater plant loss in the broadcast treatments (Table 1). However, banded and broadcast treatments both reduced RCRR severity and incidence relative to the nontreated control. Overall, the findings from this study demonstrate that postemergence fungicides applied at the 6- to 8-leaf stage can significantly reduce RCRR-related stand loss and disease severity in a moderately susceptible sugarbeet variety. While both application methods provided substantial disease suppression, 7-in. band applications performed slightly better under the conditions of this trial, suggesting a potential advantage in seasons or fields with elevated disease risk.

Table 1. Effects of postemergence fungicide treatments applied as either a 7-in band or broadcast application on Rhizoctonia crown and root rot and sugarbeet yield and quality in a field trial inoculated with *Rhizoctonia solani* at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Treatment and (rate/acre) [q]	**Harvested Roots** [r]	**Plant Loss (%)** [s,t]	**RCRR Severity (%)** [t,u]	**RCRR Incidence (%)** [v]	**Sugar (%)**	**SLM (%)** [w]	**Yield (tons/A)**	**Sucrose (lb/A)** [x]
Nontreated	138	24.5 b	22.1 b	51.3 b	16.09	1.49 ab	25.9	7583
Elatus WG (7.1 oz) [y]	163	9.4 a	1.2 a	11.3 a	16.56	1.47 ab	30.2	9100
Elatus WG (7.1 oz) [z]	159	15.8 ab	1.1 a	3.8 a	16.36	1.48 ab	27.7	8243
Excalia (0.64 fl oz) [y]	157	13.4 ab	1.3 a	6.3 a	16.59	1.51 ab	26.4	7962
Excalia (2 fl oz) [z]	152	13.3 ab	0.8 a	5.0 a	16.22	1.60 ab	26.3	7694
Quadris (10 fl oz) [y]	150	12.2 a	0.9 a	8.8 a	16.95	1.47 ab	26.3	8163
Quadris (10 fl oz) [z]	149	18.7 ab	3.5 a	20.0 a	16.55	1.52 ab	26.1	7848
Quadris (14.3 fl oz) [y]	158	14.8 ab	2.0 a	11.3 a	16.92	1.61 b	26.7	8160
Quadris (14.3 fl oz) [z]	160	12.9 a	2.7 a	12.5 a	16.60	1.56 ab	27.7	8328
AZteroid FC[3.3] (9.2 fl oz) [y]	163	10.5 a	2.8 a	7.5 a	16.40	1.61 b	29.9	8809
AZteroid FC[3.3] (9.2 fl oz) [z]	154	16.3 ab	1.5 a	3.8 a	16.53	1.54 ab	28.3	8472
AZterknot (16.6 fl oz) [y]	160	13.5 ab	2.7 a	12.5 a	16.85	1.44 a	28.7	8834
AZterknot (16.6 fl oz) [z]	154	13.0 a	2.0 a	5.0 a	16.81	1.50 ab	26.8	8194
Proline 480 SC (5.7 fl oz) [y]	149	12.8 a	3.3 a	21.3 a	16.46	1.46 ab	27.5	8274
Proline 480 SC (5.7 fl oz) [z]	153	16.1 ab	4.2 a	10.0 a	16.27	1.50 ab	27.0	7994
P- value	0.2952	**0.0216**	**<0.0001**	**<0.0001**	0.3858	**0.0391**	0.4500	0.4222
Contrast analysis of 7-in. Band Treatments vs. Broadcast Treatments								
7-in. Band	157	12.4	2.0	11.3	16.68	1.51	28.0	8472
Broadcast	154	15.1	2.2	8.6	16.48	1.53	27.1	8110
P- value	0.3585	**0.0380**	0.8650	0.3911	0.1393	0.3531	0.2522	0.1090

[q] The active ingredient and FRAC group of each treatment follows: Excalia SC is inpyrfluxam (7), Quadris and AZteroid FC[3.3] is azoxystrobin (11), Proline 480 SC is prothioconazole (3), AZterknot is azoxystrobin (11) + extract of *Reynoutria sachalinensis* (P 05), and Elatus WG is azoxystrobin (11) + benzovindiflupyr (7)

[r] Harvest roots are equal to number of roots per 100 ft of row.

[s] Plant loss percent equals 100 * (live plants per 100 ft row on 18 Jun [42 DAP] – number of harvested roots) / live plants per 100 ft row on 18 Jun [42 DAP]

[t] Means within a column followed by a common letter are not significantly different by Estimated Marginal Means (EMMs) at the 0.10 significance level.

[u] 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.

[v] Percent incidence of rated roots with > 0% of rot on the root surface.

[w] Percent sugar loss to molasses (SLM).

[x] Recoverable sucrose per acre; equal to yield*(percent sugar – percent SLM)*20.

[y] 7-inch band application.

[z] Broadcast application.

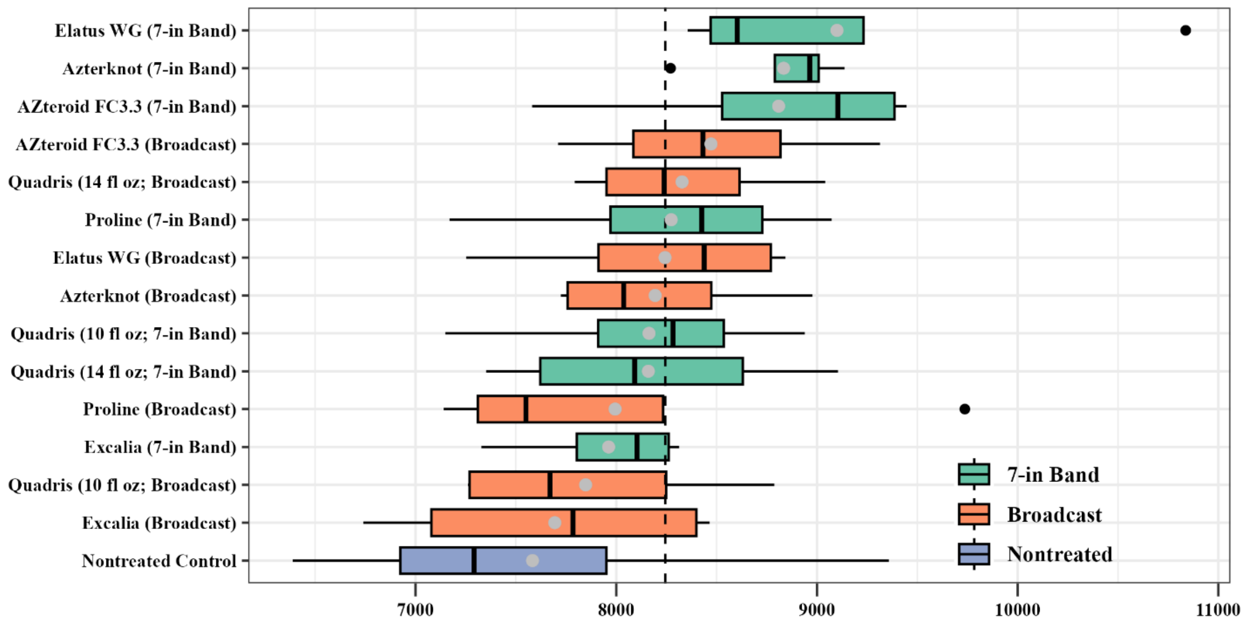

Fig. 1. Effect of postemergence fungicide treatments applied as a 7-in. band application or a broadcast application on recoverable sucrose (lbs/A) in sugarbeet compared to the nontreated control in a field trial inoculated with *Rhizoctonia solani* AG 2-2 in Crookston, MN. Boxplots display the distribution of data for each treatment (minimum, first quartile, median, third quartile, and maximum); filled black dots represent outliers, filled gray dots represent treatment means. The dashed horizontal line represents the mean of all treatments in this trial.

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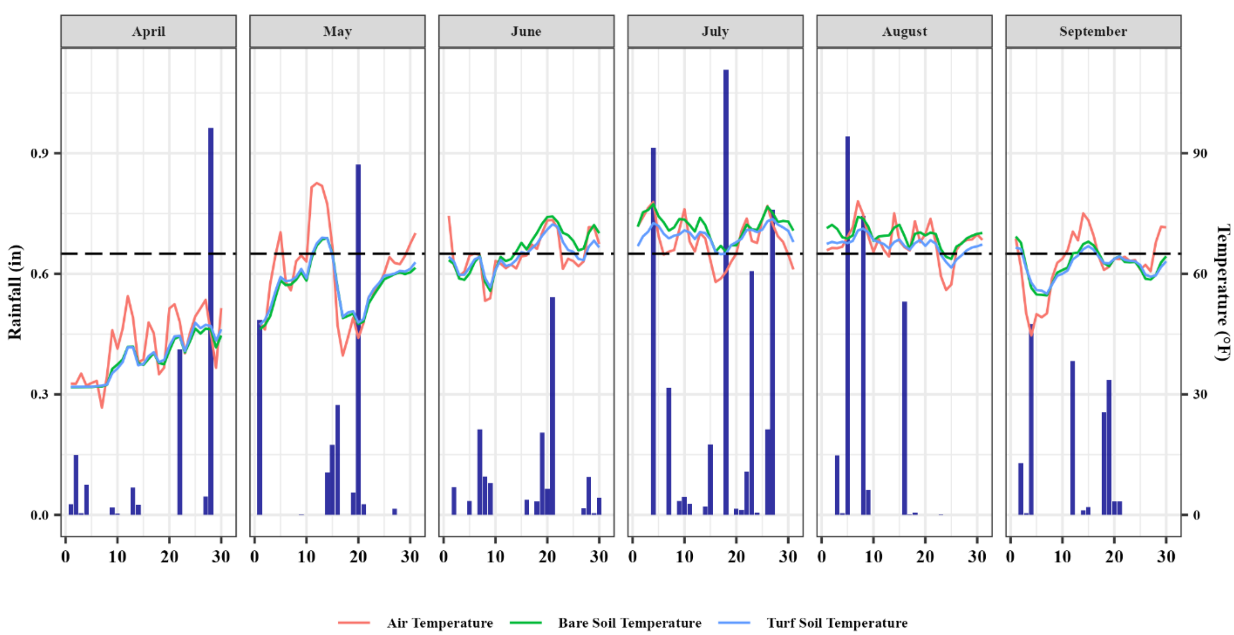
Supplementary Weather Table and Figure

Supplementary Table S1. Weather data for the 2025 growing season compared to the normal (30-year average). Data was retrieved from the Crookston Minnesota Agricultural Weather Network station (47.823333, -96.620556), located approximately 1.72 miles north-northwest of the research plots maintained by the Northwest Research and Outreach Center, Crookston, MN (47.801785, -96.600455).

Month	**Total Rainfall (inch)**		**Average Air Temperature (°F)**	
	2025	**Normal** [z]	**2025**	**Normal** [z]
April	1.79	1.27	41.8	40.8
May	2.01	2.75	59.8	54.7
June	1.52	4.15	63.6	65.2
July	4.36	3.27	67.6	69.1
August	2.44	2.97	68.2	67.4
September	1.68	2.6	62.8	58.2
Growing Season	**13.80**	**17.01**	**60.6**	**59.2**

[z] 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 (bars) and daily mean air temperature (red line), and daily mean relative humidity (blue line) for the 2025 growing season recorded 0.63 miles north-northwest of research plots in Crookston, MN. The dotted horizontal line represents 65°F.