EFFECT ON STAND ESTABLISHMENT OF IN-FURROW FUNGICIDES APPLIED WITH AND WITHOUT STARTER FERTILIZER

Jason R. Brantner and Carol E. Windels

Research Fellow and Emeritus Professor, respectively
University of Minnesota, Northwest Research and Outreach Center, Crookston, MN 56716

Damping-off and Rhizoctonia crown and root rot (RCRR) of sugarbeet, caused by the soilborne fungus *Rhizoctonia solani* AG 2-2, is increasing in prevalence and severity in Minnesota and North Dakota. This increase is due to a buildup of pathogen populations over many years of growing sugarbeet and susceptible rotation crops, as well as occurrence of warm and wet weather favorable for disease development. There is a need for effective and economical control methods. Current control methods include planting partially resistant varieties, cultural practices (i.e., non-host crops in the rotation), and application of fungicides in-furrow or postemergence.

The registered fungicides Quadris (azoxystrobin, Syngenta Crop Protection, Inc.), Headline (pyraclostrobin, BASF), and Vertisan (penthiopyrad, DuPont) control RCRR when applied in-furrow. Although these fungicides provide excellent early-season control of *Rhizoctonia*, questions have arisen concerning their safety on seedling emergence especially when applied with starter fertilizer.

OBJECTIVES

A field trial was established to evaluate in-furrow fungicides applied down the drip tube or in a t-band with and without starter (10-34-0) fertilizer for effect on sugarbeet emergence, yield, and quality.

MATERIALS AND METHODS

The trial was established at the University of Minnesota, Northwest Research and Outreach Center, Crookston on a site naturally infested with low population densities of *R. solani*. The trial was sown on two planting dates (April 19 and May 8) with a *Rhizoctonia*-susceptible variety (rating = 4.4) in six-row plots (22-inch row spacing) at a 4.5-inch seed spacing. Counter 20 G (6.8 lb A^{-1}) was applied at planting for control of root maggot. Glyphosate (4.5 lb product ae/gallon, 22 oz A^{-1}) was applied on May 22 (planting date 1 only), June 15, and July 5 (planting date 2 only) for control of weeds. Treatments are shown in Table 1 and included the in-furrow fungicides Quadris, Headline, and Vertisan at 0.6, 0.5, and 1.2 fl oz product per 1,000 ft of row (= 14.5, 12, and 28.5 fl oz product A^{-1}), respectively. A no-fungicide control also was included. Each in-furrow fungicide was applied by two different methods (down the in-furrow drip tube or in a t-band directly behind the disc openers) by itself or with starter fertilizer (10-34-0, 3 GPA). The starter fertilizer was always applied down the in-furrow drip tube. Liquids applied down the drip tube go into the furrow as a constant stream directly over the seed while liquids applied in the t-band go into the furrow as a narrow (~4-inch) band directly over the seed. Treatments were arranged in a randomized block design with four replicates. Cercospora leaf spot was controlled by Super Tin 80WP + Topsin M 4.5F (6 oz + 7.6 fl oz product) and Headline (9 oz product) in 20 gallons of water A^{-1} with a tractor-mounted sprayer with TeeJet 8002 flat fan nozzles at 100 psi on July 27 and August 17, respectively.

Stand counts were taken 14, 21, 28, and 35 days after planting in both trials. The center two rows of plots were harvested September 26 and data were collected for number of harvested roots, yield and quality. Twenty roots per plot also were arbitrarily selected and rated for severity of RCRR using a 0 to 7 scale (0 = healthy root, 7 = root completely rotted and foliage dead).

Statistical analysis. Data were subjected to analysis of variance (ANOVA) for comparison of main effects of fungicide, application method, and starter fertilizer and interactions of fungicide x application method, fungicide x starter fertilizer, and fungicide x application method x starter fertilizer using SAS (SAS Institute, Cary, NC).

Table 1. In-furrow fungicide, application method, and starter fertilizer (10-34-0, 3 GPA) treatment combinations used in a field trial testing effect of in-furrow fungicides on sugarbeet emergence, yield, and quality.

In-furrow fungicide	Application method	Starter (10-34-0)
No fungicide	-	-
	-	+
Quadris @ 14.3 fl oz A^{-1}	Down drip tube	-
	Down drip tube (mixed with starter)	+
	t-band	-
	t-band	+
Headline @ 12 fl oz A^{-1}	Down drip tube	-
	Down drip tube (mixed with starter)	+
	t-band	-
	t-band	+
Vertisan @ 28.5 oz A^{-1}	Down drip tube	-
	Down drip tube (mixed with starter)	+
	t-band	-
	t-band	+

RESULTS

Overall, emergence was much higher in planting date one (PD1) (Fig. 1) than planting date two (PD2) (Fig. 2) because of much drier soil conditions during emergence of PD2. For PD1 stand data, there was a significant (P = 0.05) three-way interaction for starter fertilizer x in-furrow fungicide x application method (Fig. 1, A-D). In general, stands were lower in plots treated with starter fertilizer than in plots without starter fertilizer. Specifically, stands were much lower when starter fertilizer was applied in combination with Headline (Fig. 1B) or Quadris applied by t-band (Fig 1C), but not with Vertisan applied by t-band (Fig. 1D). For PD2, there were no significant interactions for stand data. There were no significant effects on stand of in-furrow fungicide or application method, but stands were significantly (P = 0.05) lower in plots treated with starter fertilizer than in plots without starter fertilizer. No obvious symptoms of foliar phytotoxicity (stunting, discoloration of foliage) on sugarbeet seedlings were observed for any fungicide or method of application at either planting date.

For PD1, there were no significant two- or three-way interactions for any harvest variables except number of harvested roots (Table 2). Specifically, without starter fertilizer, the number of harvested roots was higher when fungicides were applied in a t-band than down the drip tube, but with starter fertilizer, the number of harvested roots with in-furrow Quadris and Headline was higher when applied by drip tube than in a t-band. This parallels the early season stand results shown in Fig. 1. In addition, main effects of in-furrow fungicide, application method, and starter fertilizer were not significant for any harvest variable except number of harvested roots (Table 2). The number of harvested roots was significantly higher for Vertisan compared to other in-furrow fungicides, and was higher in plots without starter fertilizer compared to plots with starter fertilizer (Table 2). There was a statistically significant (P = 0.05) effect of in-furrow fungicide and starter fertilizer on RCRR ratings (Table 2), but ratings were so low for all treatments, that this effect was not biologically meaningful.

For PD2, there were no significant two- or three-way interactions except for a fungicide x application method x starter fertilizer interaction for number of harvested roots (Table 3). Results for number of harvested roots did not follow any consistent pattern, other than being lower in plots with starter fertilizer compared to plots without starter. There were no significant main effects for in-furrow fungicide, application method, or starter fertilizer on any harvest parameters (Table 3).

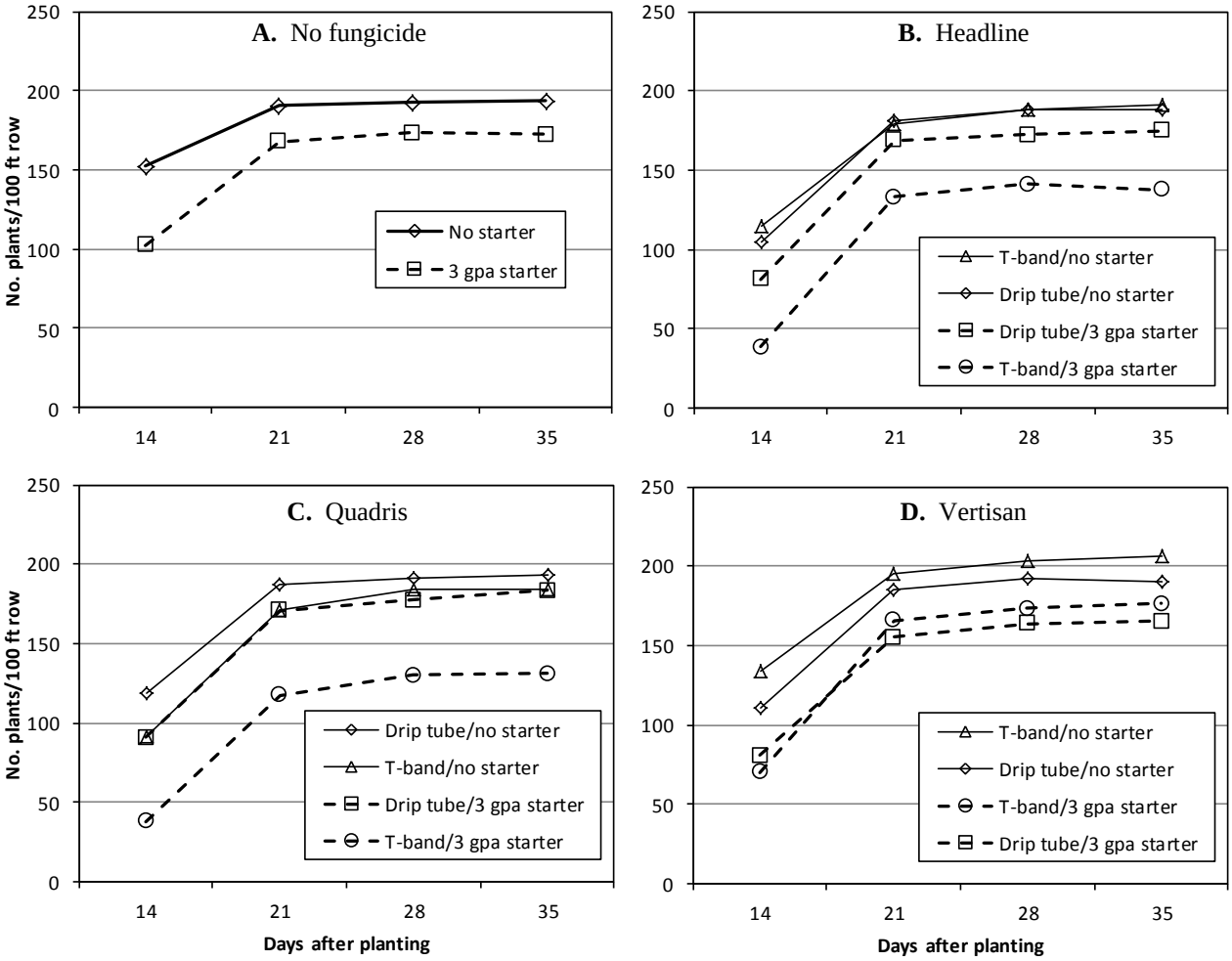

Fig. 1. Emergence and stand establishment of sugarbeet plots treated with **A)** no fungicide, **B)** Headline, **C)** Quadris, or **D)** Vertisan in-furrow in a t-band or down the drip tube with and without starter fertilizer (10-34-0) in trials sown on April 19, 2012; there were significant (P = 0.05) starter fertilizer x fungicide x application method interactions.

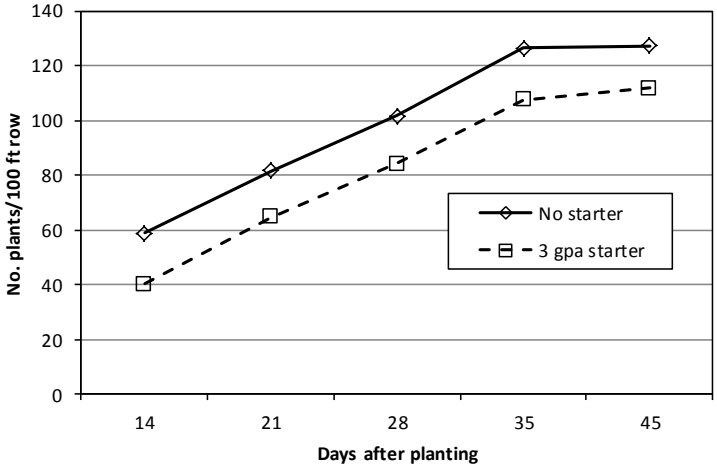

Fig. 2. Emergence and stand establishment of sugarbeet plots treated with and without starter fertilizer (10-34-0) in trials sown on May 8, 2012; there were no significant interactions, so data represent mean of 28 plots averaged across in-furrow fungicide treatments; stands were significantly (P = 0.05) higher for plots without starter fertilizer compared to those treated with starter fertilizer.

Table 2. Main effects of in-furrow fungicide, application method, and starter fertilizer (10-34-0) on Rhizoctonia crown and root rot (RCRR) and yield, quality, and revenue of sugar beet planted April 19, 2012.

Main effect	No. harv. root/100 ft	RCRR (0-7)	Yield T A^{-1}	Sucrose %	Sucrose lb ton^{-1}	Sucrose lb recov. A^{-1}	Revenue ($ A^{-1})
In-furrow fungicide[W]							
No fungicide	153	1.3	22.7	20.8	386	8763	1694
Headline	148	1.1	24.2	20.8	388	9367	1816
Quadris	149	1.1	23.2	21.1	393	9124	1785
Vertisan	159	1.3	23.5	20.6	383	8993	1728
ANOVA p-value[X]	0.045	0.013	0.1540	0.281	0.307	0.272	0.343
Application method[Y]							
Drip tube	152	1.2	23.7	20.8	388	9199	1784
T-band	152	1.2	23.5	20.9	388	9123	1769
ANOVA p-value[X]	0.865	0.865	0.626	0.946	0.975	0.688	0.755
Starter fertilizer (10-34-0)[Z]							
None	164	1.1	23.1	20.9	390	9005	1753
3 GPA	140	1.3	23.9	20.7	385	9204	1776
ANOVA p-value[X]	<0.0001	0.023	0.139	0.541	0.466	0.470	0.793
Fungicide x application method	0.004	0.687	0.311	0.467	0.456	0.871	0.956
Fungicide x starter fertilizer	0.615	0.630	0.687	0.853	0.817	0.806	0.846
Fungicide x application x starter	0.018	0.233	0.272	0.565	0.562	0.668	0.820

[W] Main effect of in-furrow fungicide; the no-fungicide treatment was not included in the statistical analysis to keep treatments balanced but values are shown for comparison; data represent mean of 16 plots averaged across application method and starter fertilizer treatment.

[X] ANOVA = Analysis of Variance, *P*-values less than 0.05 indicate significant differences among treatment main effects or significant interactions

[Y] Main effect of in-furrow fungicide application method; data represent mean of 24 plots averaged across fungicide and starter fertilizer.

[Z] Main effect of starter fertilizer; data represent mean of 24 plots averaged across fungicide and application method.

DISCUSSION

Results in PD1 were similar to those in 2011. There was a significant ($P = 0.05$) in-furrow fungicide by application method effect on stand. Current hypothesis based on conventional wisdom is that in-furrow fungicides will have less detrimental effect on sugarbeet emergence when applied in a t-band versus down the drip tube. This is because with a t-band, the fungicide is spread out in a narrow band in the furrow so theoretically, less of the fungicide comes in contact with the seed. In 2011, results for Headline and Vertisan fit this hypothesis, but results for Quadris were the opposite. Stands were higher in plots receiving Quadris down the drip tube than in plots receiving Quadris in a t-band. In 2012, only results for Vertisan fit the conventional hypothesis. When starter fertilizer was applied, stands were better for both Headline and Quadris applied down the drip tube than applied in a t-band. The same equipment was used for application of all three fungicides and was rinsed well between each fungicide. These results are not consistent with anecdotal evidence from Michigan where growers use t-band applications of Quadris in-furrow to reduce detrimental effects on stand. In PD2, soil conditions were dry, so emergence was low and there were no interactions or main effects involving in-furrow fungicides.

One consistent result in both planting dates in 2011 and 2012 was lower stands in plots treated with starter fertilizer (10-34-0) compared to plots not treated with starter fertilizer.

This trial was set up in a low disease pressure site since it was intended to assess possible phytotoxic effects of in-furrow fungicide and starter combinations. Although there were effects on stand, there were no other visible effects of phytotoxicity (stunting, discoloration) on seedling foliage. Plants compensated for early stand differences and by harvest, the same fungicide by application method interactions did not occur.

Table 3. Main effects of in-furrow fungicide, application method, and starter fertilizer (10-34-0) on Rhizoctonia crown and root rot (RCRR) and yield, quality, and revenue of sugar beet planted May 8, 2012.

Main effect	No. harv. root/100 ft	RCRR (0-7)	Yield T A^{-1}	Sucrose %	Sucrose lb ton^{-1}	Sucrose lb recov. A^{-1}	Revenue ($ A^{-1})
In-furrow fungicide[W]							
No fungicide	99	1.4	25.1	18.6	338	8475	1475
Headline	104	1.2	22.3	19.5	354	7870	1423
Quadris	98	1.3	23.0	20.0	365	8352	1543
Vertisan	103	1.2	22.5	20.0	367	8253	1539
ANOVA p-value[X]	0.272	0.257	0.820	0.145	0.154	0.530	0.332
Application method[Y]							
Drip tube	100	1.3	22.1	19.8	362	7967	1465
T-band	103	1.2	23.1	19.9	362	8350	1539
ANOVA p-value[X]	0.422	0.140	0.324	0.960	0.914	0.300	0.319
Starter fertilizer (10-34-0)[Z]							
None	105	1.2	22.8	19.7	360	8196	1501
3 GPA	97	1.3	23.0	19.6	357	8212	1495
ANOVA p-value[X]	0.013	0.617	0.809	0.960	0.948	0.817	0.823
Fungicide x application method	0.692	0.027	0.514	0.674	0.470	0.783	0.936
Fungicide x starter fertilizer	0.089	0.825	0.733	0.230	0.328	0.870	0.891
Fungicide x application x starter	0.038	0.239	0.921	0.333	0.324	0.932	0.839

[W] Main effect of in-furrow fungicide; the no-fungicide treatment was not included in the statistical analysis to keep treatments balanced but values are shown for comparison; data represent mean of 16 plots averaged across application method and starter fertilizer treatment.

[X] ANOVA = Analysis of Variance, *P*-values less than 0.05 indicate significant differences among treatment main effects or significant interactions

[Y] Main effect of in-furrow fungicide application method; data represent mean of 24 plots averaged across fungicide and starter fertilizer.

[Z] Main effect of starter fertilizer; data represent mean of 24 plots averaged across fungicide and application method.

Phytotoxic effects on sugarbeet seedling stands by in-furrow fungicides and application method are likely to vary with environmental conditions such as soil moisture, temperature, and soil type. Caution should be exercised in making conclusions based on this trial in one location. Future trials that include starter fertilizer with in-furrow fungicides applied down the drip tube and by t-band will be planted in multiple locations to assess effects on emergence and disease control.

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