APPLICATION METHOD AND RATE OF QUADRIS FOR CONTROL OF RHIZOCTONIA CROWN AND ROOT ROT

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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 band application of fungicides in-furrow or post-emergence.

The fungicide Quadris (azoxystrobin, Syngenta Crop Protection, Inc.) controls RCRR when applied before infections occur. The product is expensive and growers often are confused about when to apply the fungicide for maximum disease control. Labeled rates of Quadris for control of *Rhizoctonia* (in 22-inch rows) are from 0.4 to 0.7 fl oz product per 1,000 ft of row in a 7-inch band (= 9.5 to 16.6 fl oz product A^{-1}). At a current price tag of around \$320 per gallon, cost for Quadris is from \$23.75 to \$41.50 A^{-1}. Product rebates sometimes decrease the cost per gallon. Questions have arisen about the possibility of reducing rates of Quadris in band applications (amount of product and/or band width) and for growers without band sprayers, about the effectiveness of broadcast applications.

OBJECTIVES

Two field trials were established to evaluate Quadris in 5- and 7-inch band widths and broadcast applications at four rates for 1) control of RCRR and 2) effects on sugarbeet yield and quality.

MATERIALS AND METHODS

The trial was established in two locations at the University of Minnesota, Northwest Research and Outreach Center, Crookston. One site was naturally infested with low population densities of *R. solani* (non-inoculated) and the other site was inoculated with *R. solani* AG 2-2 IIIB. Trials were sown with a susceptible variety (2-year RCRR rating = 5.8) in six-row plots (22-inch row spacing) on May 11 and May 17, 2010 at a 2.4-inch seed spacing. Counter 15 G (1.4 lb a.i. A^{-1}) was applied at planting for control of root maggot and glyphosate (4.5 lb product ae/gallon) was applied on June 3 and 24 or 29 (24 and 28 oz A^{-1}, respectively) for control of weeds. Quadris treatments included 5- and 7-inch bands and broadcast applications at 0.2, 0.3, 0.4, and 0.6 fl oz product per 1,000 ft of row (= 5, 7.5, 10, and 14.5 fl oz product A^{-1}). Non-inoculated and inoculated, no fungicide controls also were included. Treatments were arranged in a randomized block design with four replicates. Cercospora leaf spot was controlled by Super Tin 80WP + Topsin M (5 oz + 0.5 lb 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 August 17 and September 4, respectively.

Non-inoculated trial. Plots were thinned to the equivalent of 175 plants per 100 ft of row on June 2. Quadris applications were made on June 7 when plants were in the 4-leaf stage and the 4-inch soil temperature maximum was 60.4 °F. Stand counts were taken after thinning and at 11 and 21 days after Quadris application. The center two rows of plots were harvested September 28 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).

Inoculated trial. Plots were thinned to the equivalent of 175 plants per 100 ft of row on June 9. Quadris applications were made on June 16 when plants were in the 6-leaf stage and the 4-inch soil temperature maximum was 71.9 °F. Later on the same day, *R. solani* AG 2-2 IIIB-infested ground barley inoculum (28 g/30 ft row) was deposited in sugarbeet crowns in the four middle rows of plots with a Gandy granule applicator. Then the trial was cultivated to throw soil into crowns and cover inoculum. Stand counts were taken after thinning and at 14, 20, 34, 42, and 64 days after inoculation. Plots were harvested October 4 and data was collected as previously described.

Statistical analysis. Data were subjected to orthogonal contrasts (P = 0.05) for comparison of application methods and linear and quadratic responses to rate of Quadris using SAS Proc Mixed (SAS Institute, Cary, NC).

RESULTS

Non-inoculated trial. Data for the no fungicide control are shown for comparison (Table 1), but are not included in the statistical analysis to have balance for orthogonal contrasts. There were no significant application method by rate interactions (Table 1) so main effects will be discussed separately. Broadcast applications were significantly higher (Table 1) for number of harvested roots and root yields and were significantly lower for RCRR than band applications. There were no statistical differences between broadcast and band applications for sucrose (percent, pounds per ton, pounds recoverable A^{-1}) and revenue. There were no significant differences between 5- and 7-inch bands for any parameter (Table 1).

There were no significant (P = 0.05) effects (linear or quadratic) of Quadris rate on any of the harvest parameters (Table 1). There was, however, a trend for increased yield, recoverable sucrose A^{-1}, and revenue as Quadris rates increased (Table 1). The increase in revenue over the no fungicide control at the 10.0 and 14.5 fl oz product A^{-1} rates was greater than the cost of the product but the 5.0 and 7.5 fl oz rates did not increase revenue enough to pay for the product cost (Table 2).

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Table 1. Effect of various rates and application methods of Quadris (azoxystrobin) applied at the 4-leaf stage on Rhizoctonia crown and root rot (RCRR) at harvest and on sugarbeet yield and quality compared to a no fungicide control in a field that was naturally infested with a low population density of *Rhizoctonia solani*.

	No. harvested	RCRR	Yield	Sucrose			Revenue
Treatment	roots/100 ft	(0-7)	(T/A)	%	lb/ton	lb recov./A	($/A)
Control (no fungicide)	137	2.4	24.0	18.4	343	8270	1401
Application method							
5-inch band	146	2.1	25.3	17.7	331	8379	1370
7-inch band	147	1.8	26.6	17.9	334	8903	1469
Broadcast	163	1.5	27.7	17.8	332	9181	1501
Broadcast vs. band[z]	***	**	*	NS	NS	NS	NS
5-inch vs. 7-inch band[z]	NS	NS	NS	NS	NS	NS	NS
Application rate							
5.0 fl oz product/A	151	1.8	25.5	17.7	330	8413	1368
7.5 fl oz product/A	150	1.8	25.9	17.7	331	8587	1403
10.0 fl oz product/A	156	1.8	27.0	17.9	334	9062	1496
14.5 fl oz product/A	151	1.7	27.6	17.9	334	9223	1520
Rate linear[z]	NS	NS	NS	NS	NS	NS	NS
Rate quadratic[z]	NS	NS	NS	NS	NS	NS	NS
Method x rate linear[z]	NS	NS	NS	NS	NS	NS	NS
Method x rate quadratic[z]	NS	NS	NS	NS	NS	NS	NS

[z] * signifies significant contrast at P = 0.05, ** = significant at P = 0.01, *** = significant at P = 0.001 ; NS = not significant.

Table 2. Revenue summary for Quadris treatment rates minus product cost in a field that was naturally infested with a low population density of *Rhizoctonia solani*.

Quadris rate (fl oz product/A)	Revenue ($/A)	Product cost ($/A)	Benefit over no fungicide[z] ($/A)
Control (no fungicide)	1401	-	-
5.0	1368	12.50	-46
7.5	1403	18.75	-17
10.0	1496	25.00	70
14.5	1520	36.25	83

z Product cost subtracted, but does not account for other costs associated with application.

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Inoculated trial. By 2 weeks after inoculation, stands were declining in the *Rhizoctonia*-inoculated, no fungicide control and 6 weeks later, averaged only 20 plants per 100-ft row (Fig. 1). Plots treated with all rates and application methods of Quadris (banded and broadcast) and in the non-inoculated control maintained nearly uniform stands throughout this period (Fig. 1).

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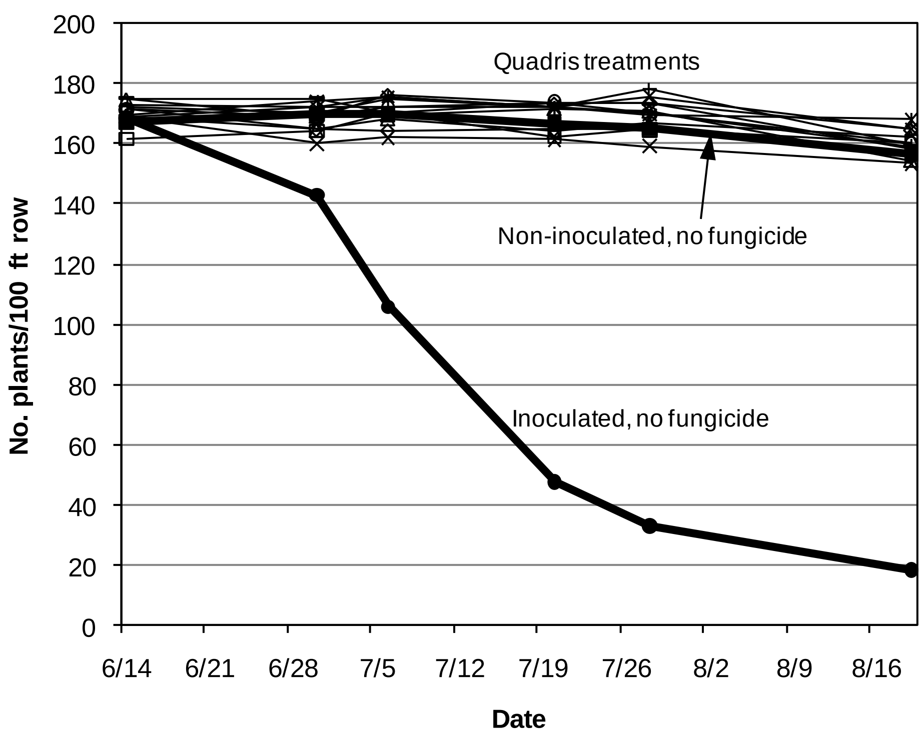

Fig. 1. Sugarbeet stand during 2 months after plants in the 6-leaf stage were treated with various rates of Quadris (= azoxystrobin at 5, 7.5, 10, 14.5 fl oz product per 1000-ft row) and application methods (5- and 7-inch bands, broadcast) on June 16; later in the day, inoculum of *Rhizoctonia solani* AG 2-2 IIIB (28g of infested ground barley grain per 30-ft row) was deposited in sugarbeet crowns with a Gandy applicator and plots were cultivated to throw soil into crowns to favor infections and disease development. Controls (bold lines) included non-inoculated and inoculated plots, each with no fungicides. Each data point is averaged over four replicates.

Data for the no fungicide controls (non-inoculated and inoculated) are shown for comparison (Table 3), but are not included in the statistical analysis to have balance for orthogonal contrasts. Ratings for RCRR in the inoculated, no fungicide control averaged 6.8 (nearly all roots were completely rotted and foliage was dead) and harvest parameters were extremely poor (Table 3). All application methods and rates controlled RCRR but there were some differences in level of control and harvest data (Table 3). There were no significant application method by rate interactions (Table 3) so main effects will be discussed separately. Band applications resulted in significantly higher yield, recoverable sucrose A^{-1}, and revenue compared to broadcast applications. There were no differences between broadcast and band applications for number of harvested roots, RCRR, percent sugar, and pounds of sugar per ton. All harvest parameters were equal for 5- and 7-inch bands except number of harvested roots, which was higher for the 7-inch band.

There was a significant linear effect of Quadris rate on RCRR (Table 3) but not on any other harvest parameter. There was a trend for higher root yield, recoverable sucrose A^{-1}, and revenue as Quadris rate increased (Table 3). When compared with the inoculated, no fungicide control (where disease was very severe and revenue very low), all rates of Quadris increased revenue tremendously (Table 4). Even when compared with the non-inoculated, no fungicide control (where disease was very low), the 7.5, 10.0, and 14.5 fl oz product A^{-1} rates resulted in revenue increases greater than the cost of the product, but the 5.0 fl oz rate did not increase revenue (Table 4).

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Table 3. Effect of various rates and applications of Quadris (azoxystrobin) applied at the 6-leaf stage on Rhizoctonia crown and root rot (RCRR) at harvest and on sugarbeet yield and quality compared to two controls (non-inoculated, no fungicide and inoculated with *Rhizoctonia solani* AG 2-2, no fungicide). Fungicides were applied on June 16 and crowns were inoculated with *R. solani* later the same day.

Treatment	No. harvested roots/100 ft	RCRR (0-7)	Yield (T/A)	Sucrose %	Sucrose lb/ton	Sucrose lb recov./A	Revenue ($/A)
Controls							
Non-inoculated	150	2.3	25.9	19.0	358	9253	1614
Inoculated, no fungicide	13	6.8	2.7	16.5	301	825	124
Application method							
5-inch band	153	2.2	27.0	18.9	355	9613	1670
7-inch band	162	2.2	27.7	19.1	360	9953	1745
Broadcast	158	2.4	25.8	18.9	357	9218	1609
Broadcast vs. band[z]	NS	NS	*	NS	NS	*	*
5-inch vs. 7-inch band[z]	*	NS	NS	NS	NS	NS	NS
Application rate							
5.0 fl oz product/A	153	2.5	26.4	18.7	352	9304	1605
7.5 fl oz product/A	160	2.3	26.5	19.1	360	9543	1677
10.0 fl oz product/A	157	2.1	27.2	19.0	358	9754	1706
14.5 fl oz product/A	160	2.0	27.2	19.0	359	9777	1712
Rate linear[z]	NS	*	NS	NS	NS	NS	NS
Rate quadratic[z]	NS	NS	NS	NS	NS	NS	NS
Method x rate linear[z]	NS	NS	NS	NS	NS	NS	NS
Method x rate quadratic[z]	NS	NS	NS	NS	NS	NS	NS

[z] * signifies significant contrast at $P = 0.05$; NS = not significant.

Table 4. Revenue summary for Quadris treatment rates minus product cost in a field inoculated with high levels of *Rhizoctonia solani*.

Quadris rate (fl oz product/A)	Revenue ($/A)	Product cost ($/A)	Benefit over no fungicide[z] Inoculated ($/A)	Non-inoculated ($/A)
No fungicide, non-inoculated	1614	-	-	-
No fungicide, inoculated	124	-	-	-
5.0	1605	12.50	1469	-22
7.5	1677	18.75	1534	44
10.0	1706	25.00	1557	67
14.5	1712	36.25	1552	62

[z] Product cost subtracted, but does not account for other costs associated with application.

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DISCUSSION

Results for application method differed for the natural, low disease pressure site and the inoculated, high disease pressure site. Under low disease pressure, broadcast applications performed better than band applications, while the opposite was true in the high disease pressure site. Equipment used to apply Quadris was the same for both sites but applications in the low disease pressure site were made earlier (June 7) and on smaller plants (4-leaf) than in the high disease pressure site (June 16 on 6-leaf plants). Currently, Quadris is NOT labeled as a broadcast product for control of RCRR – use of the product in this manner wastes product on exposed soil between rows and is environmentally unsound. Results with 5- and 7-inch bands were similar at both sites.

Although Quadris rate did not significantly (P = 0.05) affect harvest parameters in either site, there were trends at both sites for increased yield, recoverable sucrose, and revenue with increasing rates of Quadris. This increase in revenue with higher rates of Quadris was more than enough to pay for the product at both sites regardless of whether or not plots were inoculated. All rates of Quadris increased revenue tremendously under high disease pressure compared with the inoculated, no fungicide control. Compared with non-inoculated plots, revenue was lost at both sites with the 5 oz product A^{-1} rate and lost at one site with the 7.5 oz product A^{-1} rate. Based on this preliminary (one year) data, labeled rates (10-14.5 fl oz product A^{-1}) give more consistent benefit over a wide range of disease conditions, so reduced rates are not recommended.

The most significant factor in controlling RCRR is to apply Quadris **before** plants become infected by *R. solani*. It is difficult to time application of fungicides before *Rhizoctonia* infects plants, however, applying Quadris when soil temperatures reach 65 °F at the 4-inch depth is a helpful tool. While Quadris protects roots from infections originating in the crown, which is most common, its effect on infections that occur lower in the soil is questionable. Further research under natural inoculum conditions where infections occur at the crown and/or lower in the soil, as well as at different timings, is warranted to clarify efficacy of different application methods and rates of Quadris.

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