BAND AND BROADCAST APPLICATIONS OF QUADRIS FOR CONTROL OF RHIZOCTONIA ROOT AND CROWN ROT ON SUGARBEET

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Rhizoctonia solani AG-2-2 (= *R. solani*) is a soilborne fungus that can cause disease on sugarbeet throughout the growing season. Warm, wet conditions favor disease development and depending on when these conditions occur, the fungus can cause seed rot, damping-off of seedlings, and root and crown rot of older plants. In recent years, mid-to late-season root and crown rot has been a frequent problem in the Red River Valley of Minnesota and North Dakota. Fungicides have not previously been available to control Rhizoctonia root and crown rot, but late in 2000, Quadris was registered for control of this disease as well as Cercospora leaf spot.

In previous studies, Quadris has been shown to reduce Rhizoctonia diseases on sugarbeet (see: 1998 Sugarbeet Research and Extension Reports 29:275-277, 1999 Sugarbeet Research and Extension Reports 30:266-270). Trials where *R. solani* AG-2-2 was inoculated on sugarbeet early in the season (when plants were at the five- to eight-leaf stage) and environmental conditions were favorable for disease, indicated that even three applications of Quadris were insufficient to adequately control root and crown rot. Trials inoculated with *R. solani* at row closure, however, showed excellent protection through harvest with two applications of Quadris when the product first was applied at row closure (before disease developed) and again, 3 weeks later. Both trials need to be repeated to confirm reliability of results. Another question also arose as to whether Quadris controlled Rhizoctonia root and crown rot if applied after early, aboveground symptoms (slight darkening of petioles on crown) were observed.

OBJECTIVES

Our objectives were to evaluate control of Rhizoctonia root and crown rot by 1) two and three band applications of Quadris on sugarbeet plants inoculated with *R. solani* at the 7- to 8-leaf stage and 2) two broadcast applications of Quadris where the first is applied when beets are inoculated with *R. solani* at row closure or after aboveground symptoms are observed and the second is applied 2 weeks later.

MATERIALS AND METHODS

Separate trials were established at the University of Minnesota, Northwest Research and Outreach Center, Crookston in 2001 to evaluate band and broadcast applications of Quadris. Cultivar VDH 66283 was sown for the band application trial on May 18 and for the broadcast application trial on May 30. Plots in both trials consisted of six rows spaced 22-inch apart and 30 feet long. Treatments were applied to, and data collected from, the center two rows of each plot. Trials were arranged in a randomized complete block design with four replicates. The insecticide Counter was applied at 1.8 lb/A at planting. Microrate applications of Betanex, Upbeet, Stinger, and Poast and methylated seed oil adjuvant (0.5 pint, 0.125 oz, 1.3 oz, 5.3 oz and 1.5 pint/A, respectively, were made on June 18 and 26 for weed control. Cercospora leaf spot control consisted of Eminent (13 oz/A) applied on August 6 and Tin/Topsin (5.3 oz and 0.5 lb/A, respectively) on August 20. Plots were thinned to the equivalent of 150 plants/100 ft of row on June 22.

Data were collected on plant stands during the season and for number of harvested beets, root rot, yield and quality on October 3. Twenty roots were randomly selected from each plot and rated for Rhizoctonia root and crown rot using a 0 to 7 scale (0 = root clean and healthy, 7 = root completely rotted and foliage dead). Ten roots were selected at random from each plot and analyzed by the American Crystal Sugar Quality Laboratory, East Grand Forks, Minnesota to determine sugar yield and quality.

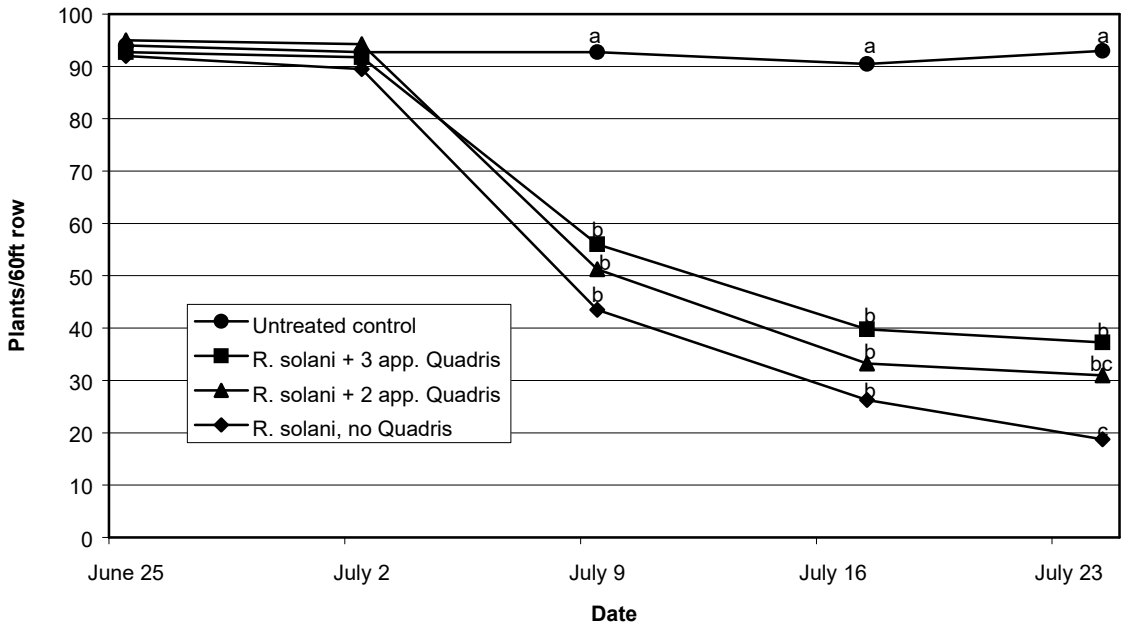

Figure 1. Sugarbeet stand in plots inoculated with *Rhizoctonia solani* AG-2-2 on June 25 and treated with two or three applications of Quadris compared to control plots inoculated with *R. solani* and not treated with Quadris and an untreated control (no *R. solani*, no application of Quadris). Quadris applications were made on June 25 and July 9 for plots treated two times, and on June 25 and July 9 and 23 for plots treated three times. For each date, data points followed by the same letter are not significantly different (*P*=0.05).

Band applications. Stand was counted on June 25 to determine baseline plant populations. Beets were in the seven- to eight-leaf stage. Plots were inoculated the same day by spreading 16 grams of barley grains infested with *R. solani* AG-2-2 along each of the center two rows. Plots then were cultivated to cover the inoculum with soil and favor disease development. About 2 hours later, Quadris was applied in a 7-inch band at 0.15 oz active ingredient/1000 feet of row. Plots were irrigated on June 26 using drip tape to deliver 72 gallons of water to the center two rows of each plot. One set of *R. solani*-inoculated plots received one additional application of Quadris (on July 9) and another set received two additional applications (on July 9 and 23). Controls consisted of untreated plots (no *R. solani* inoculum or Quadris) and plots inoculated with *R. solani* but not treated with Quadris.

Broadcast applications. Plots were inoculated on August 8 by spreading 16 grams of barley grains infested with *R. solani* AG-2-2 along each of the center two rows. Hand rakes were used to cover the inoculum with soil. Quadris was broadcast-applied the same day for one treatment at a rate of 0.15 lb active ingredient/A. Plots were not irrigated because 1.2 inches of rainfall occurred that evening. A second application of Quadris was applied on August 22. For another treatment, the first application of Quadris was made on August 22, when aboveground symptoms of Rhizoctonia root rot and crown rot (limited dark discoloration of petioles at crown) first appeared, and a second application was made on September 10. Controls consisted of untreated plots (no *R. solani* inoculum or Quadris) and plots inoculated with *R. solani* but not treated with Quadris.

RESULTS

Band applications. Baseline stands averaged about 95 plants per 60 feet of row on June 25. Between 7 and 14 days after inoculation with *R. solani*, there was a rapid and significant decline in plant populations for all treatments except the untreated control (Figure 1). Stands in *R. solani*-inoculated plots treated with Quadris tended to be higher than in plots without Quadris, but were not significantly different. Additional applications of Quadris slightly reduced the rate of stand loss in *R. solani*-inoculated plots (Figure 1).

Table 1. Effect of band applications of Quadris on root rot, yield and quality of sugarbeet. At 5½ weeks after planting, plants in the seven- to eight-leaf stage were inoculated with *Rhizoctonia solani* AG-2-2 and Quadris was applied 2 hours later followed by one or two biweekly applications of Quadris. Controls included *R. solani* AG-2-2 inoculated plots not treated with Quadris and an untreated control (no *R. solani* or Quadris).

Treatment[y]	No. harvested beets/60 ft	Root rot rating[z]	Yield				
			Tons/A	% Sugar	% Loss to molasses	Recoverable sugar	
						lb/Ton	lb/A
Untreated control	76	2.3	22.9	16.1	1.5	292	6652
Rhizoctonia + Quadris (3 applications after inoc.)	29	3.8	13.6	17.1	1.4	313	4244
Rhizoctonia + Quadris (2 applications after inoc.)	26	4.1	9.9	16.1	1.6	291	2884
Rhizoctonia-inoculated control	14	5.1	4.9	15.3	1.7	272	1314
LSD (*P* = 0.05)	20	0.6	7.2	NS	0.2	NS	2139

[y] On June 25, inoculum of *R. solani* AG-2-2 (16 grams per 30 ft row) and Quadris (0.15 oz active ingredient/1,000 ft row) were applied. Quadris was re-applied 2 weeks later and in another set of plots, at 2 and 4 weeks later (4 replicates/treatment). LSD = Least Significant Difference; if significant, LSD value provided for mean separation; NS = not significant.

[z] Root rot rating at harvest (October 3, 2001) based on a 0-7 scale; 0 = root clean and healthy, 7 = root completely rotted and foliage dead.

Table 2. Effect of broadcast applications of Quadris on root rot, yield and quality of sugarbeet. One treatment consisted of plants inoculated with *Rhizoctonia solani* AG-2-2 + Quadris at canopy closure with a second application 2 weeks later; another treatment consisted of plants inoculated with *R. solani* at canopy closure and Quadris was applied at the onset of aboveground symptoms of root and crown rot with a second application 2 weeks later; controls consisted of plants inoculated with *R. solani* at canopy closure (no Quadris applied) and an untreated control (no *R. solani* or Quadris applied).

Treatment[y]	No. harvested beets/60 ft	Root rot rating[z]	Yield				
			Tons/A	% Sugar	% Loss to molasses	Recoverable Sugar	
						lb/Ton	lb/A
Untreated control	76	1.0	17.3	17.2	1.4	318	5487
Rhizoctonia + Quadris (appl. @ canopy closure + 2 wk later)	72	0.7	16.5	17.1	1.4	315	5178
Rhizoctonia + Quadris (appl. @ onset of symptoms + 2 wk later)	61	4.1	10.4	13.5	1.5	240	2483
Rhizoctonia-inoculated control	54	4.5	10.5	12.9	1.6	225	2342
LSD (*P* = 0.05)	9	1.0	3.5	2.4	NS	49	1114

[y] Inoculum of *R. solani* AG-2-2 (16 grams per 30 ft row) applied along row at canopy closure and then row was cultivated to bury inoculum in crown; Quadris applied by broadcast (0.15 lb active ingredient/A); 4 replicates/treatment). LSD = Least Significant Difference; if significant, LSD value provided for mean separation; NS = not significant.

[z] Root rot rating at harvest (October 2, 2001) based on a 0-7 scale, 0 = root clean and healthy, 7 = root completely rotted and foliage dead.

Numbers of harvested beets in all plots inoculated with *R. solani* were equal and significantly lower compared to the untreated control (Table 1). Root rot ratings were highest in control plots inoculated with *R. solani* and not treated with Quadris and lowest in the untreated control. Plots inoculated with *R. solani* and treated with Quadris resulted in significantly lower root rot ratings than those not treated with Quadris, but disease ratings were similar for plots receiving two or three applications of the product. *R. solani*-inoculated plots treated with Quadris had higher yields than the inoculated control plot without Quadris. Plots receiving three applications of the product resulted in significantly higher tons per acre and recoverable sugar per acre than *R. solani*-inoculated plots not treated with Quadris. The untreated control had the lowest root rot ratings and highest yield and recoverable sugar per acre compared to other treatments. Results of this trial corroborate those of a similar trial conducted in 1999.

Broadcast applications. There were no significant differences in the number of harvested beets, root rot rating and yield for plots inoculated with *R. solani* and treated with Quadris at row closure and 2 weeks later compared to the untreated control (Table 2). These results confirm those of a similar trial conducted in 1999. Plots treated with Quadris at onset of symptoms, and control plots that were inoculated with *R. solani* and not treated with Quadris, resulted in equal and significantly higher root rot ratings, fewer harvested beets and reduced yields than plots inoculated with *R. solani* and treated with Quadris at canopy closure and the untreated control.

DISCUSSION

When *R. solani* AG-2-2 infected sugarbeet plants early in the season (before row closure) and conditions were favorable for infection and spread of disease (soil warm and wet), even three band applications of Quadris did not satisfactorily control disease or result in adequate, economic sugar yields. Previous research has shown that sugarbeet roots of varieties susceptible and resistant to Rhizoctonia root and crown rot become more resistant to the pathogen as plants develop and mature throughout the season. For instance, a 6-week-old root is more susceptible to infection by *R. solani* than a 12-week-old root and will have higher disease ratings. Thus, when early-season infections of *R. solani* occur, sugarbeet plants are highly susceptible and if soil conditions favor disease development, repeated band applications of Quadris do not adequately control disease.

Optimal control of Rhizoctonia root and crown rot occurred when Quadris was broadcast-applied at row closure before symptoms of disease were observed. Although older beets have some natural resistance to *R. solani* AG-2-2 compared to younger plants, they can become infected. Our results show that if a producer waits until early symptoms of Rhizoctonia root and crown rot occur on older beets, two applications of Quadris will not stop disease from developing on infected plants. Thus, Quadris appears to be most strategically suited for broadcast application at row closure, as a preventative measure against root and crown rot. It is unknown, however, how long the product persists and protects against infections occurring after canopy closure later in the season. Also, it is unknown if one application of Quadris at row closure, or later, will prevent spread of Rhizoctonia root and crown rot from diseased to adjacent, healthy plants.

Quadris is a strobilurin fungicide and this class of fungicides has a high risk of developing resistance in fungal pathogens because they have a specific, single-site mode of action. Strobilurin fungicides inhibit mitochrondial respiration by binding to a target site in the cytochrome bc_1 complex, thereby blocking electron transfer and ATP synthesis. Several strobilurin fungicides (Quadris, Flint, Headline [a.k.a. BAS 500] and Stratego [Tilt+Flint]) are registered for control of Cercospora leaf spot on sugarbeet. These fungicides also are registered for crops commonly rotated with sugarbeet, e.g., Quadris for control of late blight of potato and Headline for control of foliar diseases on small grains and potatoes. Application of Quadris to control late blight of potato for two seasons has already resulted in development of resistance of *Phytophthora infestans* to the fungicide. With widespread application of strobilurin fungicides to sugarbeet, as well as rotation crops, there is concern that populations of *R. solani* and *Cercospora beticola* will develop resistance to the strobilurin fungicides. For this reason, only one application of a strobilurin fungicide is recommended for Cercospora leaf spot control in 2002. For producers concerned about controlling Cercospora leaf spot, as well as Rhizoctonia root and crown rot, one broadcast application of Quadris at row closure may be the best option.

CONCLUSIONS

1. Band applications of Quadris did not provide adequate full-season control of Rhizoctonia root and crown rot when disease started early in the season and environmental conditions were favorable for infection and disease development.

2. Broadcast applications of Quadris most effectively protected sugarbeet plants from Rhizoctonia root and crown rot when applied at row closure but the fungicide was not effective in stopping this disease when applied on plants showing early symptoms (limited darkening of petioles on the crown).

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