# POSTEMERGENCE 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 caused by 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 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

A field trial was 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

Trials were established at two sites: one at the University of Minnesota, Northwest Research and Outreach Center (NWROC), Crookston and two trials at a site near St. Thomas, ND. Both sites were naturally infested with low population densities of *R. solani*. The trial at both sites was sown with a susceptible variety (2-year RCRR rating = 4.4) in six-row plots (22-inch row spacing). Quadris treatments included 5- and 7-inch bands and broadcast applications at four rates including 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 $A^{-1}$, respectively). Note: For fields with 22-inch rows, broadcast applications at 5, 7.5, 10, and 14.5 fl oz product $A^{-1}$ equal less than **<u>one-third</u>** of a 7-inch band application (Table 1 and Fig. 1). Labeled rates for Quadris application are 0.4 to 0.7 fl oz product $A^{-1}$ (= 9.5 to 16.6 fl oz $A^{-1}$ for 22-inch rows) applied in a 7-inch band. A no fungicide control also was included. Treatments were arranged in a randomized block design with four replicates.

**NWROC site.** The trial was sown April 27 at a 2.4-inch seed spacing with 35 foot rows. Counter 20G (6.8 lb $A^{-1}$) was applied at planting for control of root maggot and glyphosate (4.5 lb product ae $gallon^{-1}$) was applied on May 22 and June 15 (22 oz $A^{-1}$) for control of weeds. 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.

Plots were thinned to the equivalent of 175 plants per 100 ft of row on May 25. Quadris applications were made on May 30 when plants were in the 4- to 6-leaf stage and the 4-inch soil temperature maximum was 56.5 °F, but had reached its highest temperature of 63.4 °F on May 18. Stand counts were taken after thinning and at 8 days after Quadris application. 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).

**St. Thomas site.** Because of space availability, two trials were sown side-by-side May 7 at a 4.5-inch seed spacing and 30 foot rows. Counter 20G (6.8 lb $A^{-1}$) was applied at planting for control of root maggot and glyphosate (Power Max, 28 fl oz $A^{-1}$ + Border, 1 gal/100) was applied May 23, June 13, and July 19 by the grower cooperator for control of weeds. For additional root maggot control, chlorpyrifos (Govern 4E, 24 fl oz $A^{-1}$) was applied June 2 and 11 by the grower cooperator. Cercospora leafspot was controlled by Super Tin 80WP + Inspire XT (6 + 7 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 9 and Headline (9.6 fl oz $A^{-1}$ + Wetcit, 32 fl oz/100 gallons) applied by the grower cooperator on August 27.

The two side-by-side trials were treated exactly the same except for the date (and thus plant stage) on which Quadris applications were made. Trial 1 received Quadris applications on May 31 when plants were in the 2-leaf stage and mean 4-inch soil temperature was 64 °F. Quadris applications were made on trial 2 on June 6 when plants were in the 4- to 6-leaf stage and mean 4-inch soil temperature was 77 °F. Stand counts were taken in trial 1 on the day of Quadris applications, 6, and 15 days later and in trial 2 on the day of Quadris applications and 9 days later. The center two rows of plots were harvested September 19 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 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).

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**Table 1.** Postemergence Quadris application methods, rates, and amount of product hitting sugarbeet foliage.

| | Approximate amount of product contacting 4- to 6-leaf sugarbeet[z] | | | |
|---|---|---|---|---|
| | Application rate (fl oz $A^{-1}$) | | | |
| Application method | 5.0 | 7.5 | 10.0 | 14.5 |
| 5-inch band | 5.0 | 7.5 | 10.0 | 14.5 |
| 7-inch band | 3.6 | 5.4 | 7.1 | 10.4 |
| Broadcast | 1.1 | 1.7 | 2.3 | 3.3 |

[z] Approximate amount of product hitting foliage when applied to 4- to 6-leaf sugarbeet; assumes 5-inch canopy of 4- to 6-leaf sugarbeet.

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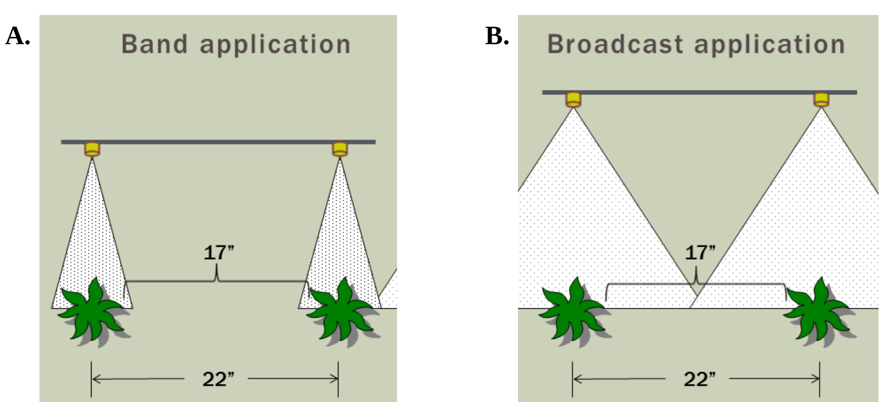


**Fig. 1.** Diagrammatic representation of relative amount of spray hitting plants with A) band and B) broadcast applications. Assuming a plant canopy of 5 inches for 4- to 6-leaf sugarbeet, more than two thirds (17/22) of the broadcast spray ends up on the soil between rows.

**Table 2.** 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 at the NWROC, Crookston that was naturally infested with a low population density of *Rhizoctonia solani*.

| Treatment | No. harvested roots/100 ft | RCRR (0-7) | Yield (T $A^{-1}$) | Sucrose % | Sucrose lb $ton^{-1}$ | Sucrose lb recov. $A^{-1}$ | Revenue (\$ $A^{-1}$) |
|---|---|---|---|---|---|---|---|
| Control (no fungicide) | 169 | 1.2 | 20.9 | 20.3 | 377 | 7898 | 1498 |
| Application method | | | | | | | |
| 5-inch band | 173 | 1.3 | 23.5 | 21.0 | 392 | 9207 | 1799 |
| 7-inch band | 179 | 1.2 | 23.8 | 20.9 | 389 | 9282 | 1807 |
| Broadcast | 168 | 1.2 | 22.9 | 20.4 | 377 | 8638 | 1641 |
| Broadcast vs. band[z] | NS | NS | NS | ** | ** | ** | ** |
| 5-inch vs. 7-inch band[z] | NS | NS | NS | NS | NS | NS | NS |
| Application rate | | | | | | | |
| 5.0 fl oz product $A^{-1}$ | 173 | 1.4 | 22.6 | 20.8 | 388 | 8773 | 1703 |
| 7.5 fl oz product $A^{-1}$ | 173 | 1.2 | 24.0 | 20.7 | 384 | 9192 | 1770 |
| 10.0 fl oz product $A^{-1}$ | 178 | 1.1 | 24.1 | 20.8 | 386 | 9291 | 1798 |
| 14.5 fl oz product $A^{-1}$ | 169 | 1.2 | 23.1 | 20.8 | 386 | 8913 | 1725 |
| Rate linear[z] | NS | * | NS | NS | NS | NS | NS |
| Rate quadratic[z] | 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 $P = 0.01$, NS = not significant.

## RESULTS

Data for the no fungicide control are shown for comparison (Tables 2, 3, and 4), but are not included in the statistical analysis to have balance for orthogonal contrasts. There were no significant interactions for application method by rate of Quadris (Tables 2, 3, and 4), so main effects (application method and rate of Quadris) will be discussed separately.

**NWROC site.** Disease pressure was very low and there were no statistical differences between broadcast and band or between 5- and 7-inch band applications for number of roots harvested, RCRR, and root yield. Percent sucrose, sucrose $ton^{-1}$, pounds of recoverable sucrose $A^{-1}$, and revenue were significantly higher for band applications than broadcast applications (Table 2).

There was a significant ($P = 0.05$) linear effect of Quadris rate on RCRR, although this effect may not have been biologically meaningful. RCRR ranged from 1.4 to 1.1, all very low levels of disease. There were no significant effects (linear or quadratic) of Quadris rate on any of the harvest parameters other than a significant quadratic response for yield (Table 2). All rates increased revenue over the no fungicide control enough to pay for the cost of the product (Table 5).

**St. Thomas site.** Disease pressure was low to moderate at St. Thomas. In trial 1, where Quadris was applied at the 2-leaf stage, there were no significant ($P = 0.05$) effects of application method or Quadris rate on RCRR rating or yield and sugar parameters (Table 3). There were, however, significantly higher numbers of harvested roots in the broadcast-applied plots compared to the band-applied plots. Although there were no statistical differences among Quadris rates, increase in revenue over the no fungicide control was enough to cover the cost of the fungicide for all rates (Table 5).

**Table 3.** Effect of various rates and application methods of Quadris (azoxystrobin) **applied at the 2-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 at near St. Thomas, ND that was naturally infested with a low population density of *Rhizoctonia solani*.

| Treatment | No. harvested roots/100 ft | RCRR (0-7) | Yield ($T A^{-1}$) | Sucrose % | Sucrose lb $ton^{-1}$ | Sucrose lb recov. $A^{-1}$ | Revenue ($\$ A^{-1}$) |
|---|---|---|---|---|---|---|---|
| Control (no fungicide) | 134 | 2.7 | 18.7 | 17.7 | 321 | 5908 | 995 |
| Application method | | | | | | | |
| 5-inch band | 129 | 2.8 | 19.1 | 18.5 | 339 | 6408 | 1105 |
| 7-inch band | 137 | 2.3 | 19.7 | 18.5 | 339 | 6548 | 1121 |
| Broadcast | 146 | 2.4 | 19.3 | 18.3 | 334 | 6408 | 1095 |
| Broadcast vs. band[z] | * | NS | NS | 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 $A^{-1}$ | 133 | 2.7 | 18.7 | 18.7 | 344 | 6361 | 1113 |
| 7.5 fl oz product $A^{-1}$ | 132 | 2.5 | 19.0 | 18.4 | 337 | 6345 | 1091 |
| 10.0 fl oz product $A^{-1}$ | 146 | 2.3 | 20.0 | 18.7 | 342 | 6786 | 1185 |
| 14.5 fl oz product $A^{-1}$ | 137 | 2.4 | 19.9 | 17.9 | 326 | 6326 | 1040 |
| 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 $P = 0.01$, NS = not significant.

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**Table 4.** Effect of various rates and application methods of Quadris (azoxystrobin) **applied at the 4- to 6-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 near St. Thomas, ND that was naturally infested with a low population density of *Rhizoctonia solani*.

| Treatment | No. harvested roots/100 ft | RCRR (0-7) | Yield ($T A^{-1}$) | Sucrose % | Sucrose lb $ton^{-1}$ | Sucrose lb recov. $A^{-1}$ | Revenue ($\$ A^{-1}$) |
|---|---|---|---|---|---|---|---|
| Control (no fungicide) | 110 | 3.3 | 17.2 | 18.0 | 328 | 5715 | 955 |
| Application method | | | | | | | |
| 5-inch band | 142 | 2.2 | 22.7 | 17.7 | 319 | 7090 | 1145 |
| 7-inch band | 145 | 2.3 | 20.6 | 18.0 | 327 | 6720 | 1131 |
| Broadcast | 131 | 2.4 | 21.1 | 17.6 | 319 | 6633 | 1075 |
| Broadcast vs. band[z] | NS | NS | NS | 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 $A^{-1}$ | 135 | 2.6 | 20.0 | 17.1 | 306 | 6018 | 932 |
| 7.5 fl oz product $A^{-1}$ | 137 | 2.4 | 20.7 | 18.0 | 327 | 6705 | 1120 |
| 10.0 fl oz product $A^{-1}$ | 143 | 2.1 | 22.1 | 18.0 | 327 | 7145 | 1190 |
| 14.5 fl oz product $A^{-1}$ | 143 | 2.2 | 23.0 | 18.0 | 327 | 7388 | 1225 |
| Rate linear[z] | NS | NS | NS | * | * | * | ** |
| Rate quadratic[z] | 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 $P = 0.01$, NS = not significant.

**Table 5.** Benefit over no-fungicide control in revenue per acre for Quadris treatment rates minus product cost in field trials at the University of Minnesota, NWROC, Crookston and St. Thomas, ND that were naturally infested with low population densities of *Rhizoctonia solani*.

| Quadris rate | Product cost | Benefit over no fungicide[z] ($ $A^{-1}$) | | |
|---|---|---|---|---|
| (fl oz product $A^{-1}$) | ($ $A^{-1}$) | NWROC site | St. Thomas 2-leaf | St. Thomas 4- to 6-leaf |
| 5.0 | 12.50 | 192 | 105 | -36 |
| 7.5 | 18.75 | 253 | 77 | 146 |
| 10.0 | 25.00 | 275 | 165 | 210 |
| 14.5 | 36.25 | 191 | 9 | 234 |

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

In trial 2, where Quadris was applied at the 4- to 6-leaf stage, there were no significant differences among application methods for RCRR rating or harvest parameters (Table 4, top). There were, however, significant effects of Quadris rate on percent sucrose, pounds of sucrose $ton^{-1}$, recoverable sucrose $A^{-1}$, and revenue (Table 4, bottom). The strong linear effect of Quadris rate on revenue is also shown in Table 5, where the 5 oz rate of Quadris had lower revenue than the no fungicide control, but there was increasing benefit over the no fungicide control as Quadris rate went from 7.5 to 14.5 fl oz $A^{-1}$.

## DISCUSSION

Disease pressure was low to moderate in the three trials. Average RCRR rating for the no fungicide control was 1.2 at the NWROC site and 2.7 and 3.3 (0-7 scale) at St. Thomas for trials 1 and 2, respectively. At a rating of 1, there are only scattered, superficial, non-active lesions that don’t affect yield or quality. Even under low disease pressure at the NWROC site, all rates of Quadris resulted in enough revenue increase to cover the cost of the product. With a rating of 1.2 for the no fungicide control, the benefits of Quadris at the NWROC site may not be fully explainable by disease control. At a rating of 3, there are lesions affecting 6 to 25% of the root. Similar to the NWROC site, even though there was no significant effect of rate when applied at the 2-leaf stage in the St. Thomas trial, all rates resulted in enough revenue increase to cover the cost of the product. In trial 2, where disease pressure was slightly higher, and Quadris was applied at the 4- to 6-leaf stage, rate of Quadris significantly affected results and only the three highest rates (7.5, 10, and 14.5 fl oz $A^{-1}$) resulted in enough revenue increase to cover the cost of the product.

Interestingly, differences among application methods were only observed at the low-disease NWROC site where band applications increased sucrose yields and revenue compared to broadcast applications. At St. Thomas, application method did not affect results in either trial. Growers who apply Quadris broadcast should note that an application rate of 14.5 fl oz product $A^{-1}$ (in 22-inch row fields) equals about one-third the amount applied in a 7-inch band (or equals 4.8 fl oz product $A^{-1}$ applied in a 7-inch band).

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 roots or crowns; however, applying Quadris when soil temperatures reach 65 °F at the 4-inch depth is a helpful tool. At St. Thomas, however, average 4-inch soil temperatures reached 65 °F on May 13 and disease was not observed until much later in the season. It is likely that both trials in St. Thomas received Quadris applications too early. While soil temperature surely plays a role, there appears to be more factors involved in onset of RCRR.

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