DISEASE PROGRESS OF RHIZOCTONIA CROWN AND ROOT ROT ON SUGARBEET AND EFFECT OF QUADRIS APPLICATION TIMING

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Seedling damping-off and crown and root rot caused by *Rhizoctonia solani* AG 2-2 continue to be among the most common diseases on sugarbeet in the Red River Valley (RRV) and southern Minnesota. Control options include rotating with non-host crops (small grains), planting varieties with partial resistance, planting early to avoid favorably warm soil temperatures when young seedlings are highly susceptible, and the use of seed treatment, in-furrow, and postemergence fungicides.

Fungicides are effective in controlling Rhizoctonia in sugarbeet when applied in advance of infection, but are ineffective when applied after infections occur (11). Disease onset is therefore critical in proper timing of fungicide applications. The disease is favored by warm and wet soil conditions. Studies under controlled conditions (1) have shown the importance of soil temperature and moisture to disease development. Under field conditions, application of azoxystrobin (Quadris) at soil temperatures of 62-67 °F tended to give best results (8,9), but results varied for different years and locations (6,7,8,9,10). We have observed disease onset in our trials to vary depending on inoculum density and trial location (2,3). Soil temperature, inoculum density, and other environmental factors affected by location are all likely to influence the onset of disease and efficacy of fungicide application timings.

Sentinel plots planted to a susceptible variety can be used to detect disease, track movements of diseases, and follow progress of disease. They have been used extensively to track soybean rust (12) and have been used in sugarbeet for Cercospora fungicide resistance tracking (4) and disease management (5).

OBJECTIVES

Field trials were established using a Rhizoctonia-susceptible variety with and without Kabina seed treatment in multiple locations on different crop residues to determine onset and progress of Rhizoctonia crown and root rot and efficacy of azoxystrobin application timings.

MATERIALS AND METHODS

The trial was established at two sites in each of four locations: northern RRV (east of Drayton, ND), central RRV (north of Ada, MN), southern RRV (near Baker and Foxhome, MN), and southern Minnesota (near Clara City and north of Bird Island, MN). The two sites at each location allowed placement of the trial on two different crop residues: wheat and soybean in both the northern and central RRV and corn and soybean in both the southern RRV and southern Minnesota. Six-row plots were sown (4.3 to 4.8 inch seed spacing) to a Rhizoctonia-susceptible variety (5.2 RCRR rating in 2013 American Crystal Sugar Company variety trials) treated with Apron + Maxim + Tachigaren (45g). A different Rhizoctonia-susceptible variety (‘SV36938RR’) was sown in southern Minnesota. Starter fertilizer (3 GPA) was applied at planting in the central RRV (10-34-0) and in southern Minnesota (6-24-6). Treatments included five different timings of azoxystrobin applications and two sets of untreated controls on both Kabina-treated (14g/unit) seed and seed without Kabina. The azoxystrobin application timings were in-furrow, cotyledon- to 2-leaf, 4- to 6-leaf, 8- to 10-leaf, and post canopy closure. Two sets of untreated controls were included so that one set could be used for destructive sampling to follow progress of root symptoms while the other set could be kept intact for stand counts and harvest data. Data was collected on early-season stand, root rot ratings (0-7 scale) at various intervals, and sugarbeet yield and quality. Table 1 summarizes the dates for planting, treatment applications, and harvest for each site.

Table 1. Planting, fungicide application, and harvest dates for Rhizoctonia disease progress trial sites.

Trial location	Northern RRV		Central RRV		Southern RRV		Southern Minnesota	
Previous crop	Wheat	Soybean	Wheat	Soybean	Corn	Soybean	Corn	Soybean
Planting and in-furrow app.	May 23	May 23	May 15	May 15	May 29	May 30	May 27	May 24
Cot.- to 2-leaf	June 6	June 6	-	June 4	June 23	June 24	June 9	June 9
4- to 6-leaf	June 17	June 17[Z]	-	June 13	June 26	June 24	June 25	June 25
8- to 10-leaf	July 7	July 7	-	June 25	June 30	June 30	July 10	July 10
Post canopy closure	July 21	July 21	-	July 21	July 16	July 17	July 28	July 28
Harvest	Sept. 16	Sept. 16	-	Sept. 17	Sept. 22	Sept. 25	Sept. 18	Sept. 18

[Z] Due to wet field conditions, application was made to only rep 1 on June 17 and on reps 2-4 on July 7.

RESULTS AND DISCUSSION

Emergence in the central RRV site was poor. On wheat residue there was a herbicide carryover issue that resulted in extremely low stand and the site was abandoned. The soybean residue site was adjacent and had better emergence but high variability.

In the southern RRV, several significant rainfall events resulted in the drowning out of over one third of the corn residue site. Data was collected, but will not be reported due to lack of enough replicates for most treatments. At the soybean residue site, drainage was good, but the rain combined with high populations of *Aphanomyces cochlioides* resulted in tremendous stand loss due to that pathogen.

Disease onset and progress. Soil temperatures favorable for *Rhizoctonia* infection (mean 4-inch bare soil temperatures ≥ 60°F) were present within one week after planting at the nearest North Dakota Agricultural Weather Network station to each of the RRV sites and remained through the growing season. Emergence and stand establishment for plots not receiving any Quadris applications for six sites are summarized in Fig. 1. In the northern RRV on wheat residue, emergence and stand establishment were excellent for both Kabina-treated and standard seed, but stands at 3, 8, 12, and 14 weeks after planting were significantly higher (P = 0.05) for Kabina-treated than standard seed (Fig. 1A), a possible indication of pre-emergence or early damping-off. There was no observed drop in stand indicating onset of postemergence Rhizoctonia damping-off (Fig. 1A), and root rot ratings were very low all season long (data not shown). In the northern RRV on soybean residue, stands began to decline from 3 to 6 weeks after planting with a more rapid decline for the standard seed compared to the Kabina-treated seed (Fig. 1B). Rhizoctonia could be found at this time but average root rot ratings remained below 2 (0-7 scale) throughout the season (data not shown).

In the central RRV on soybean residue, emergence and stand establishment were low (Fig. 1C) and highly variable throughout the trial area. There were no significant differences between Kabina-treated and standard seed and no observed stand loss through 16 weeks after planting (Fig. 1C). Average root rot ratings remained below 2 throughout the season (data not shown).

In the southern RRV on soybean residue, emergence was good but stand loss occurred rapidly beginning 3 ½ weeks after planting due to a different soilborne pathogen, *Aphanomyces cochlioides* (Fig. 1D). Rhizoctonia damping-off or crown and root rot could not be found at this time.

In southern Minnesota on corn residue, emergence and stand establishment were excellent and there was no loss in stand through 13 weeks after planting (Fig. 1E). There were no stand differences between Kabina-treated and standard seed (Fig. 1E). Rhizoctonia was found at very low frequency and average root rot ratings remained low throughout the season (data not shown). In southern Minnesota on soybean residue, emergence and stand establishment were good and there was no stand loss or difference between Kabina-treated and standard seed through 13 weeks after planting (Fig. 1F). Rhizoctonia was found at very low frequency and average root rot ratings remained low throughout the season (data not shown).

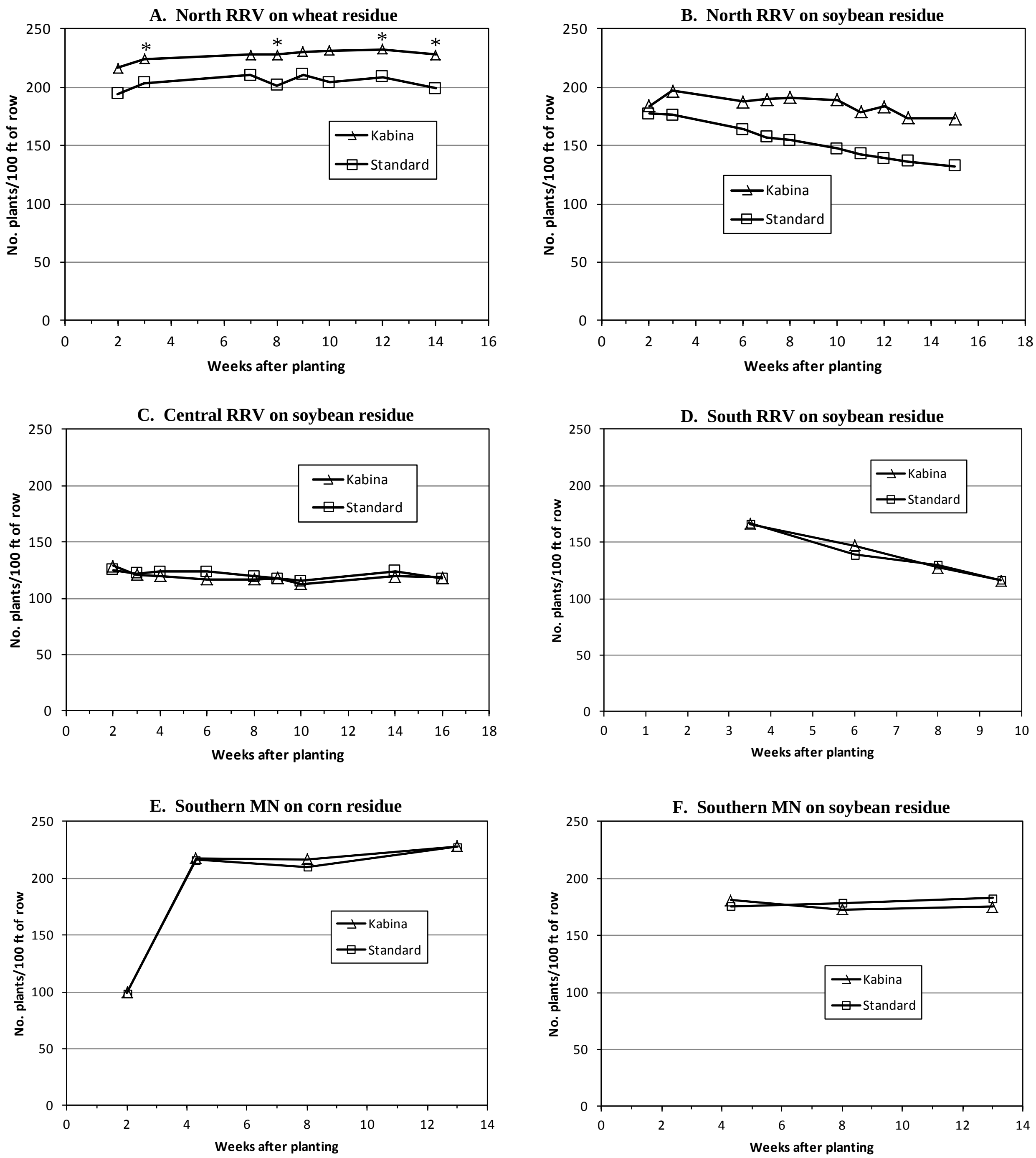

Fig. 1. Emergence and stand establishment for a Rhizoctonia-susceptible sugarbeet variety with and without Kabina seed treatment at locations across the Red River Valley (RRV) and in southern Minnesota. Stand loss in D) South RRV on soybean residue is due to *Aphanomyces cochlioides*. In A) North RRV on wheat residue asterisks indicate stand count dates with significant difference (P = 0.05) between Kabina-treated and standard seed. Differences at other locations were not statistically significant (P = 0.05).

Table 1. North RRV on wheat residue: Effect of Quadris application timings on Rhizoctonia crown and root rot and sugarbeet yield and quality. There were significant seed treatment by Quadris application timing interactions for yield and recoverable sucrose per acre, so data for Quadris application is shown separately for Kabina-treated and standard seed treatment.

Treatment (Apron + Maxim on all seed)	No. harv. roots/100 ft	RCRR (0-7)[V]	Yield (ton A^{-1})[W]	Sucrose %	Sucrose lb ton^{-1}	Sucrose lb A^{-1} [W]
Main effect of seed treatment[X]:						
Kabina-treated seed	120	0.3	24.3	18.0	340	8259
Standard seed treatment	108	0.4	23.8	17.6	329	7835
ANOVA [Y]	***	NS	NS	**	**	*
Kabina-treated seed[Z]:						
No Quadris	112	0.4	21.0 c	17.9	336	7043 d
In-furrow	120	0.2	23.7 b	18.0	339	8014 c
Cotyledon- to 2-leaf	117	0.3	25.6 ab	18.1	343	8779 ab
4- to 6-leaf	129	0.4	24.7 ab	17.9	336	8291 bc
8- to 10-leaf	121	0.3	24.5 b	18.0	338	8260 bc
Post canopy closure	125	0.3	26.5 a	18.4	346	9164 a
LSD (*P*= 0.05) [W]	NS	NS	2.0	NS	NS	663
Standard seed treatment[Z]:						
No Quadris	106	0.6	24.7 a	17.4	325	8046 a
In-furrow	109	0.5	24.3 a	16.8	310	7542 ab
Cotyledon- to 2-leaf	108	0.4	23.8 a	18.2	343	8173 a
4- to 6-leaf	109	0.3	24.5 a	17.7	333	8140 a
8- to 10-leaf	111	0.2	25.3 a	18.0	340	8591 a
Post canopy closure	104	0.5	20.0 b	17.5	326	6516 b
LSD (*P* = 0.05) [W]	NS	NS	2.9	NS	NS	1138
Seed trmt x Quadris timing interaction [Y]	NS	NS	***	NS	NS	***

V RCRR = Rhizoctonia crown and root rot; 0-7 scale (adjusted rating), 0 = root clean, no disease, 7 = root completely rotted and plant dead.
W Numbers followed by the same letter are not significantly different; LSD = Least Significant Difference, *P* = 0.05.
X Values represent mean of 24 plots (4 replicate plots across 6 at-planting treatments)
Y * = significant at *P* = 0.05, ** = significant at *P* = 0.01, *** = significant at *P* = 0.001, NS = not significantly different
Z Values represent mean of 4 replicate plots

Table 2. North RRV on soybean residue: Main effects of seed treatment and Quadris application timing on Rhizoctonia crown and root rot and sugarbeet yield and quality. There were no significant seed treatment by Quadris application timing interactions.

Main effect (Apron + Maxim on all seed)	No. harv. roots/100 ft[V]	RCRR (0-7)[W]	Yield (ton A^{-1})	Sucrose %	Sucrose lb ton^{-1}	Sucrose lb A^{-1}
Seed treatment[X]:						
Kabina-treated seed	91	0.9	21.7	16.2	298	6469
Standard seed treatment	85	0.8	20.7	16.2	299	6207
ANOVA [Y]	NS	NS	NS	NS	NS	NS
Quadris application timing[Z]:						
No Quadris	75 b	0.9	19.1	16.1	294	5656
In-furrow	97 a	1.0	22.3	16.0	293	6537
Cotyledon- to 2-leaf	87 ab	0.9	20.5	16.5	305	6267
4- to 6-leaf	95 a	0.9	22.2	16.5	304	6776
8- to 10-leaf	87 ab	0.6	21.1	16.0	293	6165
Post canopy closure	86 ab	0.8	22.1	16.3	300	6625
LSD (*P*= 0.05) [V]	12.3	NS	NS	NS	NS	NS
Seed trmt x Quadris timing interaction [Y]	NS	NS	NS	NS	NS	NS

V Numbers followed by the same letter are not significantly different; LSD = Least Significant Difference, *P* = 0.05.
W RCRR = Rhizoctonia crown and root rot; 0-7 scale (adjusted rating), 0 = root clean, no disease, 7 = root completely rotted and plant dead.
X Values represent mean of 24 plots (4 replicate plots across 6 at-planting treatments)
Y * = significant at *P* = 0.05, ** = significant at *P* = 0.01, *** = significant at *P* = 0.001, NS = not significantly different
Z Values represent mean of 8 plots (4 replicate plots across 2 seed treatments)

Table 3. Southern MN on corn residue: Main effects of seed treatment and Quadris application timing on Rhizoctonia crown and root rot and sugarbeet yield and quality. There were no significant seed treatment by Quadris application timing interactions.

Main effect (Apron + Maxim on all seed)	No. harv. roots/100 ft	RCRR (0-7) [W]	Yield (ton A^{-1})	Sucrose		
				%	lb ton^{-1}	lb A^{-1} [W]
Seed treatment[X]:						
Kabina-treated seed	141	0.4	22.2	12.9	215	4791
Standard seed treatment	136	0.5	22.8	13.0	215	4915
ANOVA [Y]	NS	NS	NS	NS	NS	NS
Quadris application timing[Z]:						
No Quadris	136	0.4	21.7	13.1	217	4724
In-furrow	141	0.5	22.0	12.9	213	4722
Cotyledon- to 2-leaf	139	0.5	22.5	12.9	213	4776
4- to 6-leaf	139	0.5	22.2	12.7	209	4648
8- to 10-leaf	136	0.5	23.1	13.0	219	5046
Post canopy closure	145	0.3	23.7	13.1	219	5204
LSD (*P*= 0.05) [Y]	NS	NS	NS	NS	NS	NS
Seed trmt x Quadris timing interaction [Y]	NS	NS	NS	NS	NS	NS

[W] RCRR = Rhizoctonia crown and root rot; 0-7 scale (adjusted rating), 0 = root clean, no disease, 7 = root completely rotted and plant dead.
[X] Values represent mean of 24 plots (4 replicate plots across 6 at-planting treatments)
[Y] NS = not significantly different
[Z] Values represent mean of 8 plots (4 replicate plots across 2 seed treatments)

Table 4. Southern MN on soybean residue: Main effects of seed treatment and Quadris application timing on Rhizoctonia crown and root rot and sugarbeet yield and quality. There were no significant seed treatment by Quadris application timing interactions.

Main effect (Apron + Maxim on all seed)	No. harv. roots/100 ft	RCRR (0-7) [W]	Yield (ton A^{-1})	Sucrose		
				%	lb ton^{-1}	lb A^{-1} [W]
Seed treatment[X]:						
Kabina-treated seed	123	0.9	20.7	14.6	244	5052
Standard seed treatment	125	0.9	21.9	14.5	243	5290
ANOVA [Y]	NS	NS	*	NS	NS	*
Quadris application timing[Z]:						
No Quadris	120	1.1	20.6	14.3	238	4876
In-furrow	123	1.0	20.8	14.8	248	5149
Cotyledon- to 2-leaf	130	0.9	21.2	14.8	249	5251
4- to 6-leaf	123	0.8	21.6	14.6	243	5216
8- to 10-leaf	130	0.8	21.8	14.6	243	5282
Post canopy closure	125	1.0	22.0	14.4	239	5250
LSD (*P*= 0.05) [Y]	NS	NS	NS	NS	NS	NS
Seed trmt x Quadris timing interaction [Y]	NS	NS	NS	NS	NS	NS

[W] RCRR = Rhizoctonia crown and root rot; 0-7 scale (adjusted rating), 0 = root clean, no disease, 7 = root completely rotted and plant dead.
[X] Values represent mean of 24 plots (4 replicate plots across 6 at-planting treatments)
[Y] NS = not significantly different, * = significantly different at $P = 0.05$
[Z] Values represent mean of 8 plots (4 replicate plots across 2 seed treatments)

Effect of Quadris application timings on yield and quality. Harvest data for sites in the northern RRV on wheat and soybean residue are summarized in Tables 1 and 2, respectively, and for sites in southern MN on corn and soybean residue are summarized in Tables 3 and 4, respectively. In the northern RRV on wheat residue, Kabina-treated seed was significantly (P = 0.05) higher than standard seed for number of harvested roots, percent sugar, and recoverable sugar per acre (Table 1). There were significant seed treatment by Quadris application timing interactions for yield and recoverable sucrose per acre (Table 1). On Kabina-treated seed, Quadris applied post canopy closure had the highest yield and recoverable sugar per acre while plots that did not receive Quadris had the lowest yield and recoverable sugar per acre (Table 1). With standard seed on the other hand, Quadris applied post canopy closure had the lowest yield and recoverable sugar per acre and all other treatments were similar (Table 1). Overall, disease pressure from *R. solani* was too low for Quadris applications to have much of an effect.

In the northern RRV on soybean residue, there were no seed treatment by Quadris application timing interactions and no significant differences in any yield parameters for seed treatment or Quadris applications with the exception of the number of harvested roots (Table 2). The number of harvested roots was significantly higher for Quadris applications in-furrow, or at 4- to 6-leaf compared to plots not receiving Quadris (Table 2). Other treatments were intermediate. There was disease pressure from *R. solani*, but it was highly variable across the plot area leading to a lack of statistical significance.

In southern MN on corn residue, there were no significant interactions or differences in any harvest parameters (Table 3). Rhizoctonia crown and root rot ratings were very low with averages for all treatments less than 1 (Table 3). Yields were good but low percent sugars due to late planting and early harvest kept recoverable sugar per acre around 5000 pounds (Table 3). Disease pressure from *R. solani* was observed only in a few small spots.

In southern MN on soybean residue, there were no significant interactions, but yield and recoverable sugar per acre were higher for standard seed than for Kabina-treated seed (Table 4). There were no significant differences among Quadris application timings with yields ranging from 20.6 to 22.0 tons A^{-1} and percent sugar ranging from 14.3 to 14.8 (Table 4). Disease pressure from *R. solani* was not observed.

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