INTEGRATED MANAGEMENT OF RHIZOCTONIA ON SUGARBEET WITH VARIETAL RESISTANCE, SEED TREATMENT, AND POSTEMERGENCE FUNGICIDES

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Rhizoctonia damping-off and crown and root rot (RCRR) caused by *Rhizoctonia solani* AG 2-2 have been the most common root diseases on sugarbeet in Minnesota and North Dakota for several years (2-4). Disease can occur throughout the growing season and reduces plant stand, root yield, and quality. Warm and wet soil conditions favor infection. Control options include rotating with non-host crops (cereals), planting partially resistant varieties, planting early when soil temperatures are cool, improving soil drainage, and applying fungicides as seed treatments, in-furrow (IF), or postemergence. An integrated management strategy should take advantage of multiple control options to reduce Rhizoctonia crown and root rot.

OBJECTIVES

A field trial was established to evaluate an integrated management strategy consisting of a resistant and a susceptible variety with new available seed treatments compared with in-furrow azoxystrobin alone and in combination with a postemergence azoxystrobin application for 1) control of early-season damping-off and RCRR and 2) effect on yield and quality of sugarbeet.

MATERIALS AND METHODS

The trial was established at two locations, one at the University of Minnesota, Northwest Research and Outreach Center, Crookston and another in a grower's field near Baker, MN. Both locations were fertilized for optimal yield and quality. At each location, a combination of a resistant and susceptible variety treated with metconazole + rizolex (= Metlock Suite), penthiopyrad (Kabina ST), metconazole + rizolex + penthiopyrad, sedaxane, or untreated or azoxystrobin in-furrow was planted in four replicate plots in a randomized complete block design. Seed treatments and rates are summarized in Table 1 and were applied by Germains Seed Technology, Fargo, ND. In-furrow azoxystrobin was applied down the drip tube in 6 gallons total volume A^{-1}. Each variety by at-planting treatment combination was planted in duplicate, so that at 5 weeks after planting, one plot of each variety by at-planting fungicide treatment combination received a postemergence 7-inch band application of azoxystrobin (14.3 fl oz product A^{-1}) while one was left as a stand-alone treatment. Controls for each variety included no seed or in-furrow fungicide treatment at planting with and without postemergence Quadris. Two-year average Rhizoctonia ratings in American Crystal Sugar Company tests for the resistant and susceptible varieties were 3.5 and 5.2, respectively (5).

NWROC site. Prior to planting, soil was infested with *R. solani* AG 2-2-infested whole barley (35 kg ha^{-1}). The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 21 at 4.5-inch seed spacing. Counter 20G (9 lb A^{-1}) was applied at planting for control of sugarbeet root maggot and 3 gallons A^{-1} starter fertilizer (10-34-0) was applied across all treatment combinations. Glyphosate (4.5 lb product ae/gallon) was applied on June 4, June 23, and September 3 (22 oz A^{-1}) for control of weeds. Postemergence azoxystrobin was applied in a 7-inch band in 10.5 gallon/A using a bicycle sprayer with 40015 nozzles and 26 psi on June 25 (5 weeks after planting). No fungicides were applied for controlling Cercospora leaf spot as the foliar disease was not observed in plots.

Baker site. The trial was sown in six-row plots (22-inch row spacing, 30-ft rows) on May 30 at 4.5-inch seed spacing. Glyphosate (4.5 lb product ae/gallon) tank-mixed with AMS (8.5 lbs A^{-1}) and Fusilade DX (12 oz A^{-1}) was applied on June 13. This weed control application was repeated again on July 1 (less the graminicide). Postemergence azoxystrobin was applied in a 7-inch band on June 24 (3.5 weeks after planting). Cercospora leafspot was controlled by separate applications of Inspire (7 oz A^{-1}) on August 1 and

Table 1. Application type, product names, active ingredients, and rates of fungicides used at planting in a field trial for control of *Rhizoctonia solani* AG 2-2 on sugarbeet. Each at-plant treatment was used in combination with a Rhizoctonia resistant (2013 rating = 3.3) and susceptible (2013 rating = 5.2) variety, and all treatment combinations were duplicated, with one set receiving a postemergence 7-inch band application of azoxystrobin (14.3 fl oz A^{-1}). Standard rates of Apron + Maxim and 45 g/unit Tachigaren were on all seed. In-furrow Quadris was applied down the drip tube in a total volume of 6 gal/A.

Application	Product	Active ingredient	Rate
None	-	-	-
Seed	Metlock Suite	Metconazole + Rizolex	0.21 + 0.5 g a.i./unit seed
Seed	Kabina ST	Penthiopyrad	14 g a.i./unit seed
Seed	Metlock Suite + Kabina ST	Metcon + Rizolex + Penthio	0.21 + 0.5 + 7 g a.i./unit seed
Seed	Sedaxane	Sedaxane	2.5 g a.i./unit seed
In-furrow	Quadris	Azoxystrobin	9.5 fl oz product A^{-1}

TPTH/Topsin (5 & 7.6 oz A^{-1}, respectively) on August 15. All fungicides for CLS control were applied utilizing a UTV-mounted sprayer dispersing the products in broadcast pattern at a water volume of 15 GPA with TeeJet 8002 flat fan nozzles at 80 psi.

Stand counts were done beginning 3 weeks after planting through 11 weeks after planting. The trial was harvested September 30 at the NWROC and September 25 at Baker. Data were collected for number of harvested roots (NWROC only), 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). Root rot ratings at Baker reflect scarring and malformations from earlier infections with *Aphanomyces cochlioides* which was severe in the field.

Data were subjected to analysis of variance using SAS Proc GLM (SAS Institute, Cary, NC) for main effects of variety, at-plant treatment, postemergence azoxystrobin application, and all possible interactions.

RESULTS

NWROC site: There were significant variety by at-planting treatment interactions for stand data, illustrated in Fig. 1. Emergence and stand establishment were higher with the resistant variety (Fig. 1A) than with the susceptible variety (Fig. 1B). In both varieties, seed treated with Kabina, Metlock Suite + Kabina, or sedaxane, or with in-furrow Quadris application resulted in higher emergence and stand establishment over 11 weeks than the untreated control and seed treated with Metlock Suite alone. The interaction is due to the relative effect of in-furrow Quadris on stand. In the resistant variety (Fig. 1A), stand in plots treated with Quadris in-furrow was lower than the top seed treatments, but higher than the untreated control. With the susceptible variety (Fig. 1B), however, plots treated with Quadris in-furrow were equal to the top seed treatments. These stand data trends continued through harvest so that the number of harvested roots was higher than the untreated control in plots treated with Quadris in-furrow and all seed treatments except Metlock Suite alone (Table 2). Postemergence Quadris application did not significantly affect stand data.

Rhizoctonia crown and root rot ratings were significantly lower with the resistant than the susceptible variety (Table 2). Similar to stand data, plots treated with Quadris in-furrow and all seed treatments except Metlock Suite alone resulted in RCRR ratings significantly (P = 0.05) lower than the untreated control (Table 2). Postemergence Quadris application did not affect RCRR rating. There was a statistical variety by at-planting by postemergence treatment interaction for RCRR rating (Table 2). For all treatment combinations, the resistant variety had a lower RCRR rating than the susceptible with the exception of Metlock Suite alone with no postemergence Quadris, where resistant and susceptible varieties had the same rating (data not shown).

There were no significant interactions for harvest parameters, and main effects are summarized in Table 2. The middle and later portions of the growing season were dry, allowing plants that survived to produce decent yields. Percent sucrose and pounds of sucrose ton^{-1} were not significantly different among any treatments (Table 2). Yield and recoverable sucrose A^{-1} were significantly (P = 0.05) higher for the resistant than the susceptible variety (Table

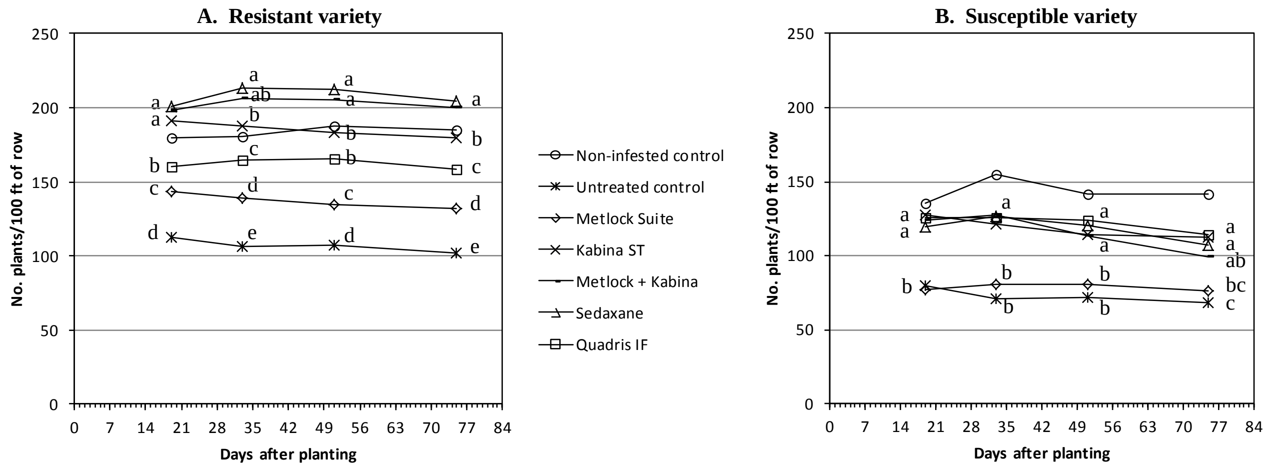

Fig. 1. Emergence and stand establishment for A.) resistant and B.) susceptible sugarbeet varieties treated with fungicides on seed or Quadris in-furrow and sown May 21, 2014 in a field trial infested with *Rhizoctonia solani* AG 2-2 IIIB (35 kg/ha) or not infested (non-infested control); non-infested control shown only for comparison, but not included in the statistical analysis to keep treatments balanced; there was significant (P = 0.05) variety by at-planting treatment interaction; data points represent mean of 8 plots (4 replicate plots across postemergence Quadris and no postemergence treatments); for each stand count date, values sharing the same letter are not significantly different (P = 0.05).

Table 2. NWROC site: Main effects of variety, at-planting (seed or in-furrow), and postemergence fungicide treatments on Rhizoctonia crown and root rot and sugarbeet yield and quality.

Main effect (Apron + Maxim on all seed)	No. harv. roots/100 ft[T]	RCRR (0-7)[U]	Yield ton A^{-1}	Sucrose %	Sucrose lb ton^{-1}	Sucrose lb A^{-1}
Variety[V]						
Resistant	133	2.7	24.5	17.1	316	7747
Susceptible	77	4.2	20.3	17.1	314	6426
ANOVA p-value	<.0001	<.0001	<.0001	0.977	0.574	<.0001
At-planting treatments[W]						
Untreated control	73 b	4.6 a	18.3 c	17.2	315	5795 c
Metlock suite @ 0.21 + 0.5 g a.i./unit[X]	80 b	4.2 a	21.4 b	17.0	312	6713 b
Kabina ST @14 g a.i./unit	117 a	2.9 b	23.9 a	17.5	324	7746 a
Metlock[Y] + Kabina @ 7 g a.i./unit	116 a	3.2 b	23.0 ab	16.8	309	7153 ab
Sedaxane @ 2.5 g a.i./unit	125 a	2.9 b	23.1 ab	17.2	317	7353 ab
Quadris @ 9.5 fl. oz./A	120 a	2.6 b	24.5 a	17.2	316	7757 a
ANOVA p-value	<.0001	<.0001	<.0001	0.237	0.162	<.0001
LSD (P = 0.05)	16.8	0.7	2.3	NS	NS	845
Postemergence fungicide[Y]						
None	105	3.4	22.3	17.1	316	7058
Quadris @ 14.3 fl. oz./A	106	3.4	22.5	17.1	314	7115
ANOVA p-value	0.779	0.958	0.708	0.862	0.592	0.814
Interactions[Z]						
Vty. x At-plant trmt.	*	NS	NS	NS	NS	NS
Vty. x PE fung.	NS	NS	NS	NS	NS	NS
At-plant x PE	NS	NS	NS	NS	NS	NS
Vty. x At-plant x PE	NS	*	NS	NS	NS	NS

[T] Numbers followed by the same letter are not significantly different; LSD = Least Significant Difference, P = 0.05.

[U] RCRR = Rhizoctonia crown and root rot; 0-7 scale (adjusted rating), 0 = root clean, no disease, 7 = root completely rotted and plant dead.

[V] Values represent mean of 48 plots (4 replicate plots across 6 at-planting treatments and 2 postemergence treatments)

[W] Values represent mean of 16 plots (4 replicate plots across 2 varieties and 2 postemergence treatments)

[X] Metlock suite = metconazole + rizolex @ 0.21 + 0.5 g a.i./unit.

[Y] Values represent mean of 48 plots (4 replicate plots across 2 varieties and 6 at-planting treatments)

[Z] * = significant at P = 0.05, NS = not significantly different

2). Among at-planting treatments, yield and recoverable sucrose A^{-1} were highest for plots treated with Quadris in-furrow, with Kabina, sedaxane, or Metlock Suite + Kabina seed treatments, intermediate for seed treated with Metlock Suite alone, and lowest in the untreated control (Table 2). Postemergence application of Quadris did not significantly ($P = 0.05$) affect harvest parameters.

Baker site. There were no significant ($P = 0.05$) interactions for stand or harvest data (data not shown). Stand was reduced for all treatments early in the season due to high rainfall amounts and severe Aphanomyces damping-off. *Aphanomyces* was isolated from both root and soil samples brought back to the laboratory at the NWROC. The impact of *Aphanomyces* was similar for both varieties (which have similar Aphanomyces ratings) and similar across all at-planting and postemergence treatments.

DISCUSSION

At the NWROC site, late planting (May 21) into warm and wet soils that had been inoculated with *R. solani* along with 6.8 inches of rainfall in June combined for very severe disease pressure. Most of the damage to the crop was from stand loss and early-season infections. Rainfall in July and August was 2.17 and 1.65 inches, respectively, both below average. Therefore, the differences due to at-planting treatment were tremendous, while postemergence Quadris did not provide any benefit. Among at-planting treatments, seed treatments containing penthiopyrad (Kabina or Metlock Suite + Kabina) or sedaxane resulted in the best stand with the resistant variety, while the same seed treatments and Quadris in-furrow resulted in the best stand on the susceptible variety. Overall, the best disease control and sugar yield was with a combination of resistant variety with an effective at-planting seed treatment or Quadris in-furrow. Under severe disease pressure, growers cannot expect to protect a susceptible variety, even with the best control options. For example, the average recoverable sucrose for the three effective seed treatments and Quadris in-furrow was 8159 pounds A^{-1} with the resistant variety compared to 7020 pounds A^{-1} with the susceptible variety, a difference of 1139 pounds A^{-1}.

Interestingly, the benefit of the resistant variety compared to the susceptible was apparent as early as the first stand count (19 days after planting). Although emergence in the 2013 American Crystal Sugar Company coded variety trials (5) was lower for the resistant (66%) than for the susceptible (73%) variety, under severe early-season Rhizoctonia pressure at the NWROC, emergence and early-season stand establishment were higher in the resistant variety, even without any at-planting (seed treatment or in-furrow) fungicide (Fig. 2A). When this same seed was planted at the Baker site, where there was early Aphanomyces disease pressure but no early Rhizoctonia pressure, emergence and stand establishment were higher for the susceptible variety (Fig. 2B). This suggests either some early expression of resistance in the field or some other soil or environmental factor favored emergence of the resistant variety at the NWROC. We also have observed stand differences between resistant and susceptible varieties within the first four weeks after planting under Rhizoctonia pressure in our 2013 inoculum density field trial (1). In previous trials under growth chamber conditions, however, we typically do not see any expression of plant resistance in the first few weeks after planting.

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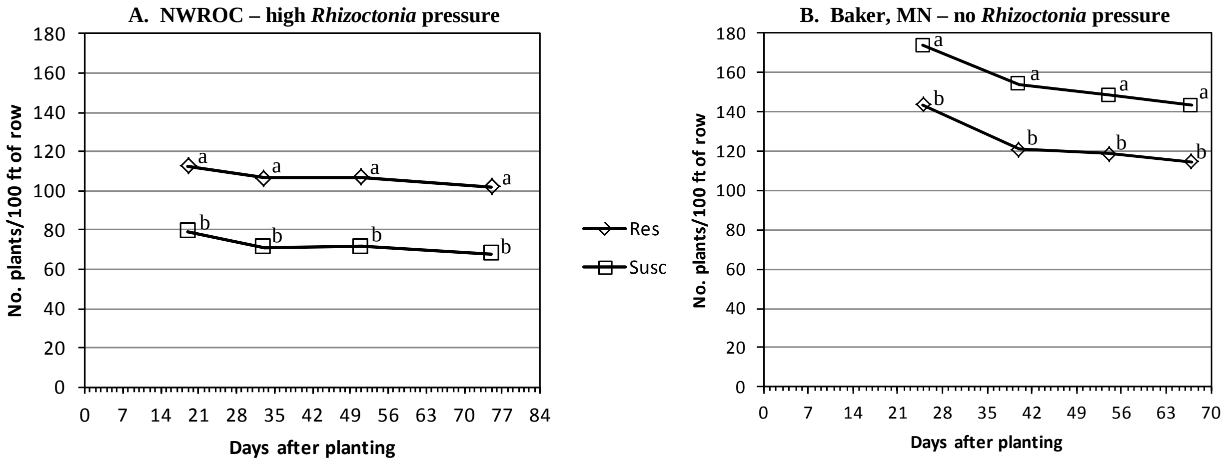

Fig. 2. Emergence and stand establishment for resistant and susceptible sugarbeet varieties sown with no at-planting fungicide treatment for *Rhizoctonia* control in a field trial **A)** at the NWROC infested with *R. solani* AG 2-2 IIIB (35 kg/ha) and **B)** near Baker, MN with early Aphanomyces disease pressure, but no Rhizoctonia pressure; data points represent mean of 8 plots (4 replicate plots across postemergence Quadris and no postemergence treatments); for each stand count date, values sharing the same letter are not significantly different (P = 0.05).

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