INTEGRATED MANAGEMENT OF RHIZOCTONIA ON SUGARBEET WITH VARIETAL RESISTANCE, AT-PLANTING TREATMENTS, 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 (1, 4-5,7). Disease can occur throughout the growing season and reduces plant stand, root yield, and quality. Warm and wet soil conditions favor infection. Disease management 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 (R) and a moderately susceptible (MS) variety with new available seed treatments alone and in combination with two postemergence azoxystrobin application timings 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 three locations, one at the University of Minnesota, Northwest Research and Outreach Center, Crookston, one at Wahpeton (MDFC), ND and one at Renville (SMBSC), MN. All locations were fertilized for optimal yield and quality. At each location, a combination of a R and MS variety treated with penthiopyrad (Kabina ST), fluxapyroxad (Systiva), sedaxane (Vibrance), or untreated was planted in four replicate plots. Plots were set up in a split-split plot design at the Crookston and Renville sites. Main plots were varieties, the first split was seed treatments, and the last split was postemergence azoxystrobin timings. At the Wahpeton location, the same combination of treatments was set up in a randomized complete block design. Seed treatments and rates are summarized in Table 1 and were applied by Germains Seed Technology, Fargo, ND. Each variety by seed treatment combination was planted in triplicate, so that at the 4- or 8-leaf stage, one plot of each variety by seed 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 treatment at planting with each postemergence azoxystrobin timing and without postemergence azoxystrobin. Two-year average Rhizoctonia ratings in American Crystal Sugar Company tests for the R and MS varieties were 3.8 and 4.7, respectively (8).

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 03 at 4.5-inch seed spacing. Counter 20G (8 lb A^{-1}) was applied at planting for control of sugarbeet root maggot. Glyphosate (4.5 lb product ae/gallon) was applied on May 11, 17, and 24, and June 2 and 13 (22 oz A^{-1}) for control of weeds. Postemergence azoxystrobin timings were applied in a 7-inch band in 10 gallon/A using 4002 nozzles and 39 psi on June 8 and 23 (5 and 7 weeks after planting). Cercospora leaf spot was controlled by Supertin + Topsin M (6 + 7.5 oz product in 19 gallons of water/A) applied with 8002 flat fan nozzles at 100 psi on August 8.

MDFC 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 24 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 7. This weed control application was repeated again on June 22nd (less the graminicide). Postemergence azoxystrobin was applied in a 7-inch band on June 21 (4-leaf stage, 4 weeks after planting) or June 28 (8-leaf stage, 5 weeks after planting). Cercospora leafspot was controlled by separate applications of TPTH/Topsin (5 & 7.6 oz A^{-1}, respectively) on July 19, Inspire (7 oz A^{-1}) on August 2nd, Priaxor (6.7 oz A^{-1}) on August 15th and TPTH/Copper (5 oz A^{-1} & 2 pt oz A^{-1}, respectively) as last application. All fungicides for CLS control were applied utilizing a 3pt-mounted sprayer dispersing the products in broadcast pattern at a water volume of 15 GPA with TeeJet 8002 flat fan nozzles at 80 psi.

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 (2-year average rating = 3.8) and moderately susceptible (2-year average rating = 4.7) variety, and all treatment combinations in triplicate, with one set receiving a postemergence 7-inch band application of azoxystrobin (14.3 fl oz A^{-1}) at 4- or 8-leaf stage. Standard rates of Apron + Thiram and 45 g/unit Tachigaren were on all seed.

Application	Product	Active ingredient	Rate
None	-	-	-
Seed	Kabina ST	Penthiopyrad	14 g a.i./unit seed
Seed	Systiva	Fluxapyroxad	5 g a.i./unit seed
Seed	Vibrance	Sedaxane	1.5 g a.i./unit seed

Table 2. Monthly precipitation in inches at three sites during 2016 crop season based on weather stations.

	Precipitation in inches		
Month	NWROC	MDFC	SMBSC
May	6.68	1.46	3.93
June	1.78	0.93	4.16
July	3.50	4.85	5.54
August	3.34	3.88	8.77
September	1.58	3.74	4.84
Total	**16.88**	**14.86**	**27.24**

SMBSC 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 18 at 4.5-inch seed spacing. Weeds were controlled by application of Sequence (2.5 pint A^{-1}) + Powermax (9 oz A^{-1}) + Selectmax (12 oz A^{-1}) on June 7 and Powermax (22 oz A^{-1}) + Selectmax (12 oz A^{-1}) on June 28. Postemergence azoxystrobin timings were applied on June 16 and 23 (4 and 5 weeks after planting, respectively). Fungicides were applied for controlling Cercospora leaf spot on July 14 (3.5 oz A^{-1} Gem), July 26 (13 oz A^{-1} Eminent), Aug 08 (8 oz A^{-1} Agritin), and Aug 23 (13 oz A^{-1} Eminent).

At NWROC stand counts were done beginning 2 weeks after planting through 8 weeks after planting. At Wahpeton stand counts were done 2 through 6 weeks after planting. At Renville stand counts were done 3, 5, and 8 weeks after planting. The trial was harvested September 20 at the NWROC and Renville and September 21 at Wahpeton. 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).

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 no significant (P = 0.05) two way or three way interactions for stand or harvest data. R and MS varieties had similar stands until 3 weeks after planting (WAP), and from 4 to 7 weeks R variety had higher stands compared to MS variety and by 8 weeks both varieties had similar stands (Fig. 1A). At-planting (seed) treatments and untreated control had similar stands until 4 WAP and all the three seed treatments had higher stands compared to untreated control from 5 to 8 WAP (Fig. 1B). Harvest data is based on 3 replications only. MS variety had higher yield and also higher sugar loss to molasses (SLM) compared to the R variety. Root rot rating, yield, and other harvest parameters are not significantly different for the seed treatments and untreated control. Root rot severity and percent incidence (percent of roots with a disease rating of > 2.0) was significantly higher in the treatments without postemergence Quadris application, intermediate in 4-leaf Quadris, and lowest in the 8-leaf Quadris application (Table 3). Yield and Recoverable sugar A^{-1} (RSA) was higher for 8-leaf Quadris application compared to no Quadris. Percent sucrose and recoverable sucrose T^{-1} (RST) were not significantly different between Quadris and no Quadris application (Table 3).

MDFC site: There were no significant (*P* = 0.05) two way or three way interactions for stand or harvest data. From 2 to 6 weeks after planting (WAP) R variety had higher stands compared to MS variety (Fig. 2A). At 2 WAP Systiva and Kabina had higher stands compared to Vibrance and untreated control. By 5 and 6 WAP Systiva and Kabina had highest stands, intermediate for Vibrance and lowest for untreated control (Fig. 2B). Higher yield and recoverable sugar A^{-1} (RSA) and lower purity was observed for the MS variety compared to the R variety. Root rot rating, yield, and other harvest parameters were not significantly different for the seed treatments and untreated control (Table 4). Quadris application (4- and 8-leaf) had lower root rot severity and percent disease incidence and higher percent sugar, recoverable sucrose T^{-1} (RST) and RSA compared to no Quadris (Table 4).

SMBSC site: There were no significant (*P* = 0.05) two way or three way interactions for stand data. There was no significant difference between R and MS varieties for early season stands (Fig. 3B). At 3 and 5 weeks after planting (WAP) Vibrance and Systiva had highest stands, intermediate for Kabina and lowest for untreated control (Fig. 3B). By 8 WAP a similar trend was observed with Vibrance and Systiva with highest stands, Systiva and Kabina intermediate, and lowest for untreated control. Heavy rainfall in Renville caused extensive water damage to sugarbeet plants eventually compromising three replicates and thus harvest data is not reported.

DISCUSSION

NWROC site: At the NWROC site, early planting (May 03) into cool and dry soils resulted in uneven emergence. However, a 4.45 in. rainfall on May 31 resulted in better and uniform emergence later on. The month of June received much less rainfall and moderate rainfall in July and August resulted in low to moderate late season disease pressure. Four inch soil temperatures reached 65 °F by May 23, followed by 61-65 °F until June 07, and > 65 °F from June 08. The yield was higher for MS variety compared to R variety and it could be because of the difference in yield potential among the two varieties. With low early season disease pressure there was no significant benefit from any seed treatments compared to untreated control. The benefit from postemergence Quadris application was not evident in 2014 and 2015 because of relatively dry late season in both years (2,6). However, with moderate rainfall in July and August, Rhizoctonia was active during late season resulting in significant differences between no Quadris and 4- or 8-leaf Quadris application. Postemergence Quadris application increased the number of harvested roots, decreased root rot severity and incidence, increased yield and RSA.

MDFC site: The planting was done into warm soils resulting in some early season disease pressure at this site. Overall, the best sugar yield was obtained with MS variety compared to R variety which also resulted in higher RSA. Among at-planting seed treatments, Kabina and Systiva performed better followed by Vibrance and lowest stands were observed for untreated control. Even though some stands were lost early in the season the stand loss was not significant enough to see yield differences between seed treatments and untreated controls. Moderate rainfall in June-Aug resulted in some late season disease pressure which was clearly observed in the plots with no Quadris and 4- or 8-leaf Quadris application. Four or 8-leaf Quadris application resulted in lower root rot severity and incidence, higher % sucrose, RST and RSA compared to no Quadris application.

SMBSC site: Both R and MS varieties lost some stands until 6 weeks after planting and there was slight early season disease pressure at this site. Among at-planting seed treatments, Vibrance and Systiva performed better followed by Kabina and lowest stands were observed for untreated control. As this site received excellent rainfall throughout the growing season, we would have expected to see some nice differences among seed treatments and postemergence Quadris applications if the plots were not compromised because of excess rainfall in August.

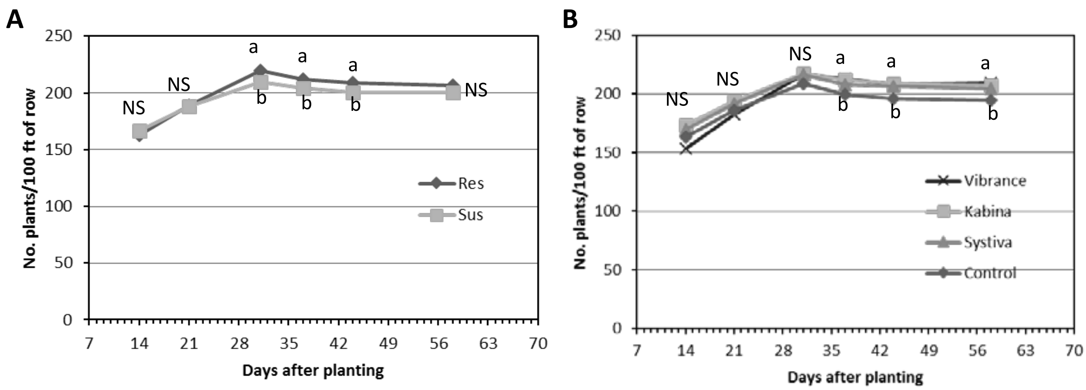

Fig. 1. NWROC site: Emergence and stand establishment for **A**) resistant and moderately susceptible sugarbeet varieties and **B**) fungicide treatments on seed or untreated control. For each stand count date, values sharing the same letter are not significantly different (*P* = 0.05); NS = not significantly different. Data shown in **A** represent mean of 48 plots averaged across at-planting and postemergence treatments and in **B** represent mean of 24 plots averaged across varieties and postemergence treatments.

Table 3. 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 in a field trial sown May 3, 2016.

Main effect (Apron + Maxim on all seed)	No. harv. roots/100 ft[T]	RCRR (0-7)[TU]	RCRR % incidence[TV]	Yield ton A^{-1}[T]	Sucrose[T] %	Sucrose[T] lb ton^{-1}	Sucrose[T] lb A^{-1}
Variety[W]							
Resistant	160	1.2	13	28.6	15.4	296	8302
Moderately Susceptible	163	1.4	18	32.1	15.2	282	9036
ANOVA p-value	0.2918	0.1148	0.1604	0.0336	0.4882	0.1896	0.0976
LSD (*P* = 0.05)	NS	NS	NS	2.9	NS	NS	NS
At-planting treatments[X]							
Untreated control	156	1.3	13	29.7	15.2	284	8407
Kabina ST @14 g a.i./unit	170	1.0	14	31.1	15.4	287	8899
Systiva @ 5 g a.i /unit	157	1.4	14	30.1	15.5	290	8710
Vibrance @ 1.5 g a.i./unit	164	1.4	20	30.5	15.2	284	8659
ANOVA p-value	0.154	0.2511	0.0913	0.6904	0.6924	0.798	0.5569
LSD (*P* = 0.05)	NS	NS	NS	NS	NS	NS	NS
Postemergence fungicide[Y]							
None	155 b	1.8 a	24 a	29.5 b	15.3	286	8408 b
4-leaf Quadris @ 14.3 fl. oz./A	164 a	1.2 b	15 b	30.4 ab	15.3	284	8635 ab
8-leaf Quadris @ 14.3 fl. oz./A	166 a	0.8 c	8 c	31.2 a	15.4	288	8964 a
ANOVA p-value	0.0174	<0.0001	<0.0001	0.0178	0.6788	0.6921	0.0171
LSD (*P* = 0.05)	7.3	0.35	5.1	1.1	NS	NS	373

[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] RCRR = Rhizoctonia crown and root rot; percent of roots with rating greater than two

[W] Values represent mean of 36 plots (3 replicate plots across 4 at-planting treatments and 3 postemergence treatments)

[X] Values represent mean of 18 plots (3 replicate plots across 2 varieties and 3 postemergence treatments)

[Y] Values represent mean of 24 plots (3 replicate plots across 2 varieties and 4 at-planting treatments)

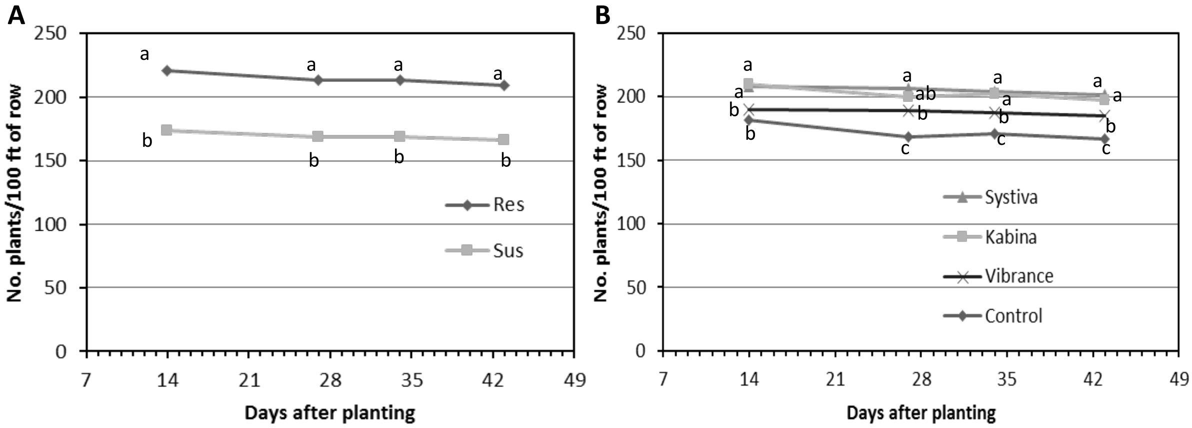

Fig. 2. MDFC site: Emergence and stand establishment for **A**) resistant and moderately susceptible sugarbeet varieties and **B**) fungicide treatments on seed or untreated control. For each stand count date, values sharing the same letter are not significantly different (*P* = 0.05); NS = not significantly different. Data shown in **A** represent mean of 48 plots averaged across at-planting and postemergence treatments and in **B** represent mean of 24 plots averaged across varieties and postemergence treatments.

Table 4. **MDFC 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 in a field trial sown May 24, 2016.

Main effect	RCRR	RCRR %	Yield	Sucrose[T]		
(Apron + Maxim on all seed)	(0-7)[TU]	incidence[TV]	ton A^{-1}[T]	%	lb ton^{-1}	lb A^{-1}
Variety[W]						
Resistant	0.3	5	22.7	14.2	225	5106
Moderately Susceptible	0.4	7	25.0	14.2	221	5526
ANOVA p-value	0.0686	0.2308	0.0003	0.6790	0.193	0.0062
LSD (*P* = 0.05)	NS	NS	1.2	NS	NS	297
At-planting treatments[X]						
Untreated control	0.4	7	22.8	14.3	227	5173
Kabina ST @14 g a.i./unit	0.3	6	24.2	14.1	219	5320
Systiva @ 5 g a.i /unit	0.3	5	24.4	14.3	225	5481
Vibrance @ 1.5 g a.i./unit	0.3	6	23.8	14.2	222	5289
ANOVA p-value	0.6489	0.843	0.2522	0.4411	0.2497	0.5366
LSD (*P* = 0.05)	NS	NS	NS	NS	NS	NS
Postemergence fungicide[Y]						
None	0.6 a	12 a	23.0	13.9 b	217 b	5013 b
4-leaf Quadris @ 14.3 fl. oz./A	0.2 b	4 b	24.1	14.4 a	227 a	5471 a
8-leaf Quadris @ 14.3 fl. oz./A	0.2 b	3 b	24.3	14.4 a	225 a	5463 a
ANOVA p-value	0.0005	0.0009	0.2036	0.0072	0.0142	0.0199
LSD (*P* = 0.05)	0.2	4.8	NS	0.29	6.8	363

[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] RCRR = Rhizoctonia crown and root rot; percent of roots with rating greater than two

[W] Values represent mean of 48 plots (4 replicate plots across 4 at-planting treatments and 3 postemergence treatments)

[X] Values represent mean of 24 plots (4 replicate plots across 2 varieties and 3 postemergence treatments)

[Y] Values represent mean of 32 plots (4 replicate plots across 2 varieties and 4 at-planting treatments)

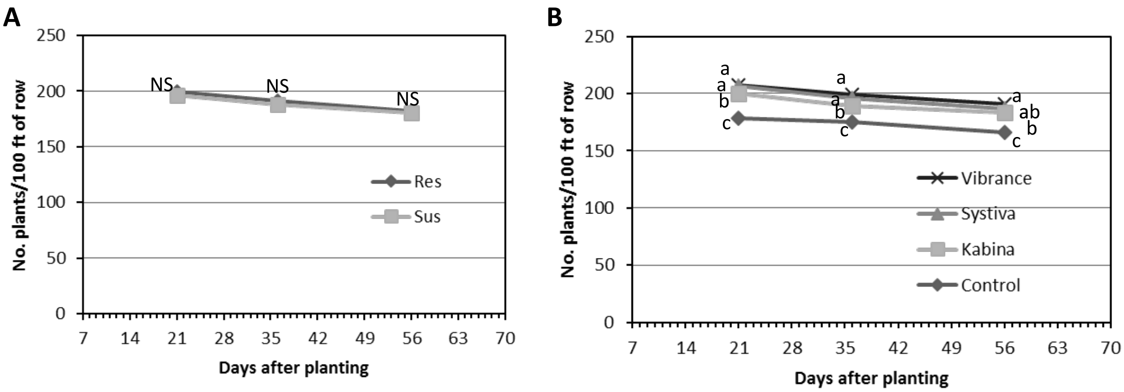

Fig. 3. SMBSC site: Emergence and stand establishment for **A**) resistant and moderately susceptible sugarbeet varieties and **B**) fungicide treatments on seed or untreated control. For each stand count date, values sharing the same letter are not significantly different (P = 0.05); NS = not significantly different. Data shown in **A** represent mean of 48 plots averaged across at-planting and postemergence treatments and in **B** represent mean of 24 plots averaged across varieties and postemergence treatments.

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