RHIZOCTONIA ON SUGARBEET FOLLOWING ROTATION CROPS

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Rhizoctonia solani (= *R. solani*) is a common, soilborne fungal pathogen of crops grown throughout the world. The fungus is composed of different populations called anastomosis groups or AGs, which attack certain crops and plant parts (6,9). Rhizoctonia root and crown rot (RRCR) of sugarbeet is caused by *R. solani* AG 2-2, which is further divided into two subpopulations (called intraspecific groups or ISGs) named AG 2-2 IIIB and AG 2-2 IV. The ISGs are differentiated by their growth at 95 ^{0}F; the AG 2-2 IIIB population grows at 95 ^{0}F, while AG 2-2 IV does not. The ISGs also differ in that *R. solani* AG 2-2 IIIB is more aggressive in attacking sugarbeet than AG 2-2 IV (7,12).

In the Red River Valley (RRV) and southern Minnesota, RRCR on sugarbeet has been increasing in prevalence and severity in the last decade. Infections occur from 54 to 95 ^{0}F (optimal temperatures are from 68 to 86 ^{0}F) and seldom occur below 59 ^{0}F (6). Build-up of inoculum in the region is attributed to increased production of soybean and edible bean crops, which are susceptible to stem and root rot caused by *R. solani* AG 2-2 IIIB (2,7).

Cereal crops (e.g., wheat, barley, corn) are considered non-hosts for *R. solan*i AG 2-2 and thus, are recommended for rotation with broadleaf crops (sugarbeet, soybean, sunflower) in the upper Midwest. Rotation with cereal crops decreases populations of *R. solani.* Reports from Europe, however, indicate *R. solani* AG 2-2 IIIB causes root and stalk rot of corn and also is the primary cause of Rhizoctonia root and crown rot of sugarbeet (3). In the southeastern U.S.A., *R. solani* AG 2-2 IIIB causes a root and brace rot on corn (10,11) but this disease has not been reported in the upper Midwest. Although *R. solani* AG 2-2 IV is the primary cause of root and crown rot on sugarbeet (6), the recent report from Europe that AG 2-2 IIIB is attacking sugarbeet raises concerns about whether increased production of corn and bean crops in Minnesota and North Dakota is increasing *R. solani* AG 2-2 IIIB. Presence and distribution of the two ISGs in the sugarbeet growing regions of the RRV and southern Minnesota are unknown.

Our laboratory has identified both ISGs of *R. solani* (AG 2-2 IIIB and AG 2-2 IV) from sugarbeet in the RRV and southern Minnesota. Preliminary pathogenicity tests confirm *R. solani* AG 2-2 IIIB as very aggressive in attacking soybean, edible bean, and sugarbeet compared to *R. solani* AG 2-2 IV, which causes moderate root rot on these crops (12). We also have found that *R. solani* AG 2-2 IIIB causes lesions on corn roots with no above ground symptoms or decreases in yield. With increasing acreage planted to soybean and corn in the RRV (and both of these crops commonly grown in southern Minnesota), it is essential to understand the influence of crops rotated with sugarbeet on build-up of the pathogen, so crops can be rotated to minimize RRCR.

OBJECTIVES

Our objectives were to conduct field trials to determine pathogenicity of *R. solani* AG-2-2 IIIB and AG 2-2 IV on 1.) rotation crops (corn, wheat, soybean) grown in 2006 and 2.) the following, 2007 sugarbeet crop. This report summarizes a repeat of the trial conducted in 2005 and 2006 (12).

MATERIALS AND METHODS

Rotation crops. Field trials were established in 2005 and 2006 at the University of Minnesota, Northwest Research and Outreach Center, Crookston in a split-plot trial of four replicates. Each year, main plots were inoculated in mid May with *R. solani* AG 2-2 IIIB, *R. solani* AG 2-2 IV, and not inoculated. Inoculum of *R. solani* was grown on sterile barley grain for 3 weeks, air-dried, sprinkled over each main plot (11.3 ounces per 33 x 30 ft), and incorporated with a Melroe multiweeder to about a 2-inch depth. Rotation crops then were sown as subplots of main plots and included spring wheat 'Knudson', soybean 'GoldCountry 923RR', and corn 'Pioneer 39D81' (90 lb, 60 lb, and 30,000 seed per acre, respectively). Each crop was fertilized, treated with pesticides, and maintained following recommended practices. Results for root rot assessment, isolation of *R. solani* from roots, and yields have been published (12).

Sugarbeet crops. Two sugarbeet varieties (Beta 1301R and Beta 1305R, tolerant and susceptible to RRCR, respectively) were sown on May 19, 2006 and April 27, 2007 as sub-subplots within the previous years' rotation crop. Sugarbeet seed of each variety was sown at 2.6 inches in rows 30 feet long and 22-inches apart (3-row plots per variety). Plots were fertilized at recommended rates and the insecticide Counter (1.0 lb a.i. per acre) was applied over the row at planting. Roundup (1 quart per acre) was applied pre-emergent and Select + MSO (12 ounce + 1 pint per acre, respectively) about 2 weeks after planting. Microrates of the herbicides Betamix + UpBeet + Stinger + Select + MSO (0.5-0.7 pt + 0.125 oz + 35 ml + 90-120 ml + 1-1.5 pt per acre, respectively) at four intervals, five to six days apart. Herbicides were applied with a tractor-mounted sprayer and TeeJet 8003 flat fan nozzles at 30 psi. Stands were thinned, where needed, to the equivalent of 200 plants per 100 feet of row about 5 weeks after planting. Plots were cultivated in late June or early July. Cercospora leaf spot was controlled by applications of SuperTin, Eminent, or Headline (5, 13 and 9 oz per acre, respectively), as needed.

Stands were counted at regular intervals after emergence until plots were thinned. Four middle rows of each plot were harvested on September 27, 2006 and September 28, 2007. Marketable roots were counted and 20 were randomly selected from each sub-subplot and rated for RRCR with a 0 to 7 scale, where 0 = healthy and 7 = root completely rotted and foliage dead. Ten roots also were randomly selected and analyzed for yield and quality by American Crystal Sugar Company Quality Laboratory, East Grand Forks, MN.

Weather data. Daily maximum air temperatures, soil temperatures at 4-inches, and precipitation were collected from planting to harvest of sugarbeet trials in 2006 and 2007. Data were recorded by an automatic weather station at the University of Minnesota, Northwest Research and Outreach Center, Crookston – West Farm.

Data analysis. Data were subjected to analysis of variance and if significant ($P = 0.05$), means were separated by Least Significant Difference (LSD).

RESULTS

Weather data. In 2006, maximum air temperatures (Fig. 1A) typically were in a range favorable for *R. solani* AG 2-2 to infect sugarbeet plants throughout the season; even soil temperatures at the 4-inch depth were above 59 ^{0}F within a few days after planting (Fig. 1B). During the 2006 trial, precipitation totaled 8.25 inches, with 0.88 inches within 1 month after planting (data not shown). In 2007, maximum air temperatures within the first month after planting (Fig. 1A) fluctuated widely from favorable to unfavorable for *R. solani* AG 2-2 to infect sugarbeet; during this period, soil temperatures at the 4-inch depth were below 59 ^{0}F (Fig. 1B). Precipitation during the 2007 trial totaled 16.09 inches, with 2.66 inches falling within 1 month after planting (data not shown).

Sugarbeet stand establishment. Rhizoctonia damping-off was more active in 2006 than in 2007 because of more favorable temperatures within the first month after planting in 2006. The same trends, however, occurred for sugarbeet seedling stands in 2007 as reported for the 2006 trial (see 2006 Sugarbeet Research and Extension Reports, 37:182-191). Thus, results are reported in this section for the 2007 sugarbeet crop.

In 2007, Rhizoctonia damping-off of sugarbeet seedlings started about 3 weeks after planting in plots inoculated with *R. solani* AG 2-2 on May, 2006 compared to the non-inoculated control, which maintained excellent stands (Fig. 2). Overall, sugarbeet stands (averaged across sugarbeet variety and previous rotation crop) were significantly higher in the non-inoculated control than in both *Rhizoctonia*-inoculated plots (Fig. 2A). Sugarbeet stands were significantly lower in plots inoculated with *R. solani* AG 2-2 IIIB compared to *R. solan*i AG 2-2 IV.

Rhizoctonia damping-off occurred in both sugarbeet varieties (values averaged across soil inoculations and previous rotation crops) (Fig. 2B). Stands were significantly higher for the *Rhizoctonia*-tolerant variety (Beta 1301R) than for the susceptible variety (Beta 1305R) for stand counts through 32 days after planting, when plots were thinned.

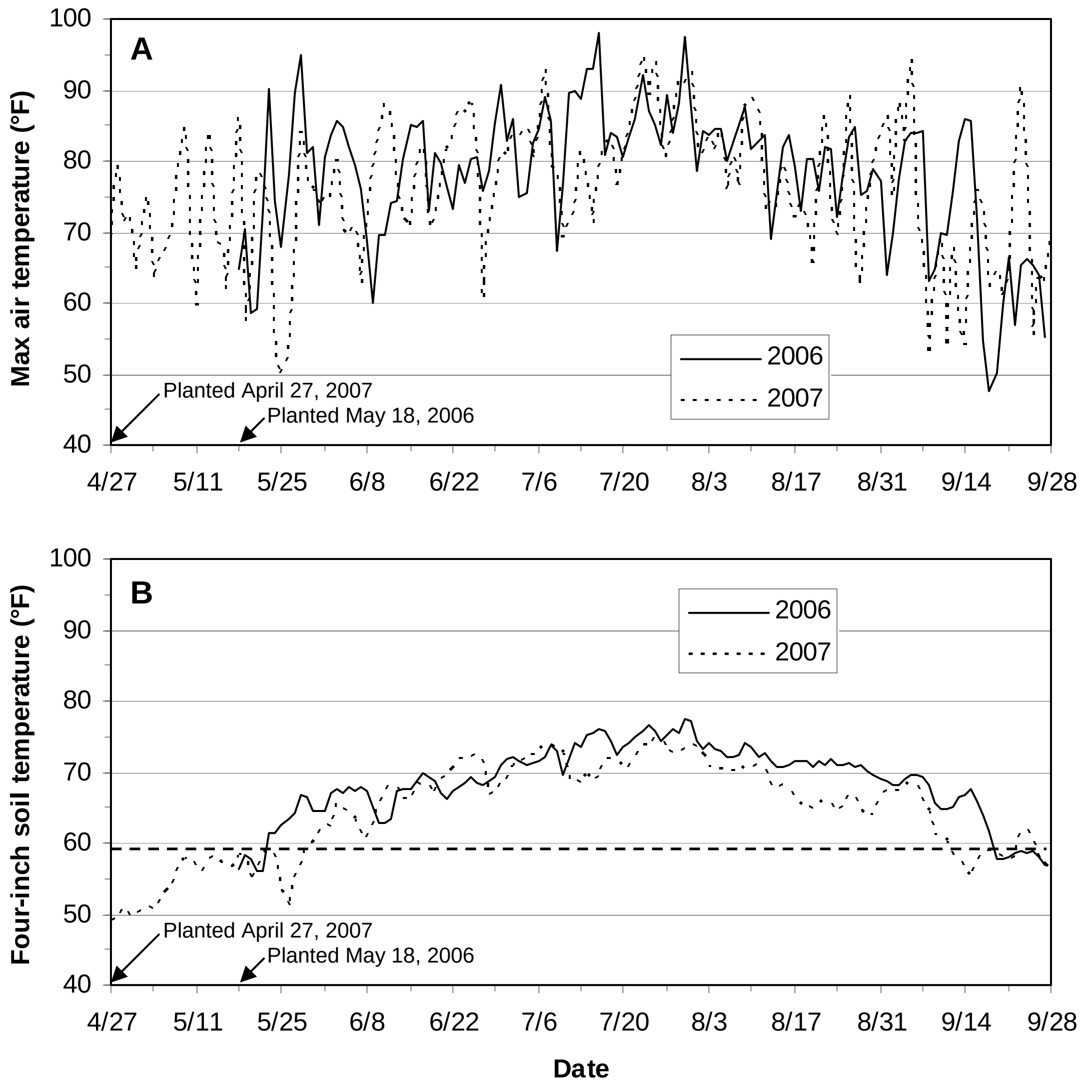

Fig. 1. Temperatures recorded at the University of Minnesota, Northwest Research and Outreach Center, Crookston during the 2006 and 2007 sugarbeet experiments for A.) maximum air temperature and B) soil temperature at a 4-inch depth; infections seldom occur below 59 ^{0}F (noted by dashed line).

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There were no losses in sugarbeet stands in the non-inoculated control plots previously sown to wheat, soybean, and corn (Fig. 3). Rhizoctonia damping-off of sugarbeet was most severe in plots inoculated with *R. solani* AG 2-2 IIIB the previous year and losses were significantly greater and equal when following corn and soybean compared to wheat. There were intermediate losses of sugarbeet stands in plots inoculated with *R. solani* AG 2-2 IV the previous year and were unaffected by previous crop.

Sugarbeet harvest data. In 2006, RRCR was more severe than in 2007, which affected sugarbeet yields and quality, so harvest data are presented for both years in Table 1. For most variables measured in each year, there were no significant interactions between *Rhizoctonia*-inoculated and non-inoculated soil treatments, sugarbeet variety, or previous crop, so data are presented separately for each of these “main treatments”.

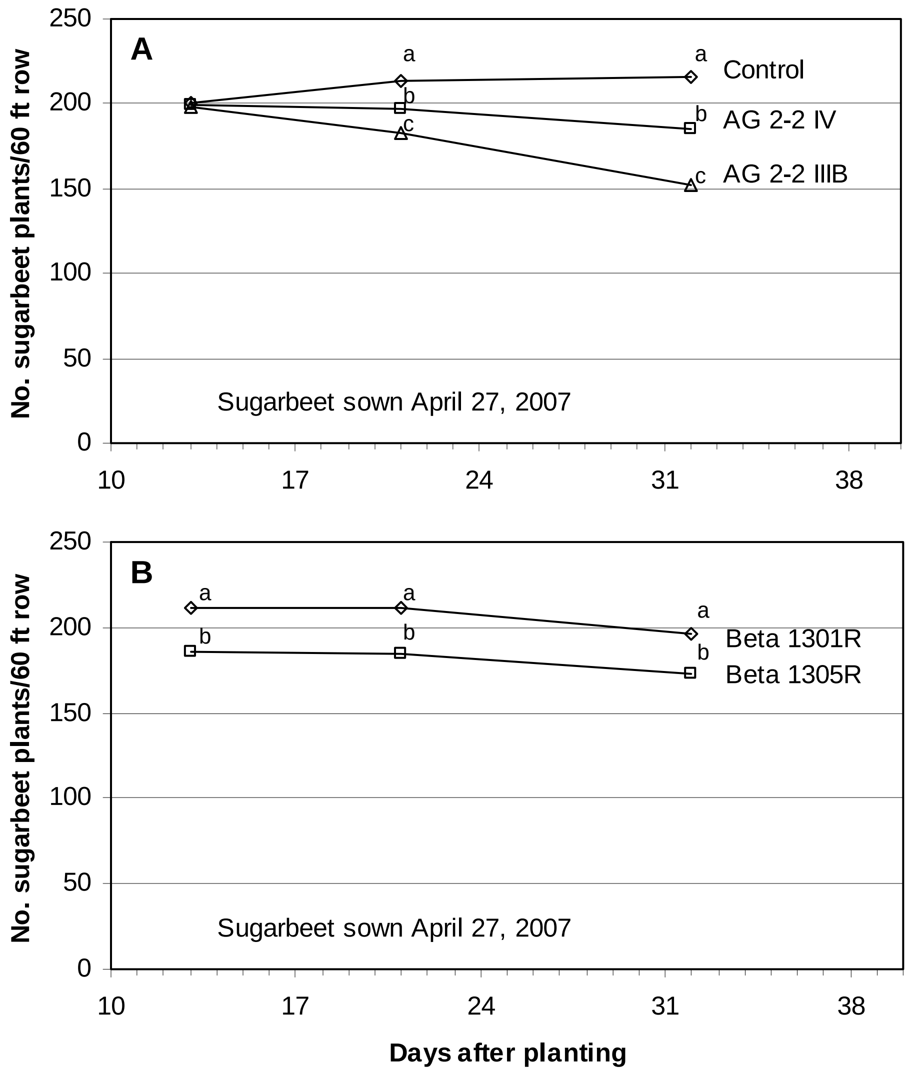

Fig. 2. Sugarbeet seedling stands in plots sown April 27, 2007 that were previously soil-inoculated on May 18, 2006 with *Rhizoctonia solani* AG 2-2 IIIB, *R. solani* AG 2-2 IV (11.3 ounces per 990 ft^2), or not inoculated (control); these main plots were arranged in a randomized block design (replicated four times) and then sown with wheat, soybean, and corn as subplots; **A.)** stands in *Rhizoctonia*-inoculated and control plots averaged across two sugarbeet varieties (Beta 1301R and 1305R, tolerant and susceptible to *R. solani*, respectively) and previous rotation crop (each value is an average of 24 plots); **B.)** stands of each sugarbeet variety averaged across *Rhizoctonia*-inoculated and control plots and rotation crops (each value is an average of 36 plots). For each figure and date, values followed by the same letter are not significantly different ($P = 0.05$).

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In 2006 and 2007, RRCR ratings were low and significantly less in the non-inoculated control than in plots where soil had been inoculated the previous year with *R. solani* AG 2-2 IV and AG 2-2 IIIB (values were averaged across sugarbeet variety and previous crop). Disease ratings of 1.4 and 1.6 in non-inoculated plots in 2006 and 2007, respectively, indicated roots were nearly symptom-free and healthy. For both years, roots harvested from plots inoculated with *R. solani* AG 2-2 IIIB the previous year had significantly more disease than in plots inoculated with *R. solani* AG 2-2 IV. Overall sugarbeet yields and quality were higher in 2007 than in 2006 because of less RRCR and a longer growing season in 2007 (planted 3 weeks earlier than in 2006). In both years, numbers of harvestable roots and pounds of sucrose per ton followed the same trends with significant differences among the soil treatments; values were highest in the non-inoculated control, lowest in the *R. solani* AG 2-2 IIIB-inoculated plots; and intermediate in the *R. solani* AG IV-inoculated plots. In 2006 there also were significant differences among soil treatments for tons of root per acre, percent sucrose, pounds of recoverable sucrose per acre, and gross return per

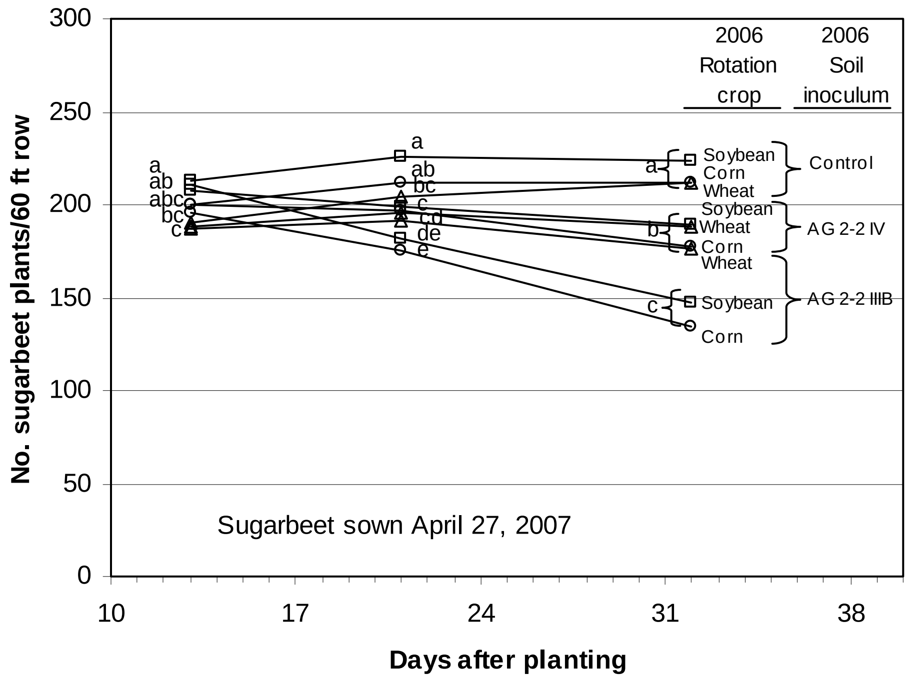

Fig. 3. Sugarbeet stands in 2007 averaged across two varieties Beta 1301R and 1305R (tolerant and susceptible to *Rhizoctonia solani*, respectively) sown in plots previously soil-inoculated on May 18, 2006 with *R. solani* AG 2-2 IIIB, *R. solani* AG 2-2 IV (11.3 ounces per 990 ft^2), and a non-inoculated control and then sown with wheat, soybean, and corn as subplots (arranged in a split plot design and replicated four times). Each value is based on an average of eight plots. For each date, values followed by the same letter are not significantly different, (P = 0.05).

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acre; best results were in the non-inoculated control, lowest in plots previously inoculated with *R. solani* 2-2 IIIB, and were intermediate for *R. solani* AG 2-2 IV. In 2007, results were somewhat higher but statistically the same in the non-inoculated control and plots previously inoculated with *R. solani* AG 2-2 IV for tons of roots per acre, percent sucrose, pounds of recoverable sucrose per acre, and gross return per acre – and both treatments were significantly higher compared to plots inoculated with *R. solani* AG 2-2 IIIB.

In 2006, RRCR ratings were the same for both the tolerant and susceptible sugarbeet varieties (values were averaged across soil inoculum and previous crops) because disease was so severe (Table 1). In 2007, disease was less severe than in 2006 and average RRCR ratings were significantly lower in the tolerant than in the susceptible variety. Yield and quality differed between the two varieties, especially in 2007. Overall, the tolerant variety (Beta 1301R) tended to have lower percent sucrose and pounds of sucrose per ton and higher tons of roots and pounds of recoverable sucrose per acre in both years. Gross return of dollars per acre tended to be highest for the tolerant variety than the susceptible variety, but differences were not statistically different in 2006 or 2007.

The effect of growing sugarbeet after wheat, soybean, and corn was not significantly different in 2006 and 2007 for RRCR ratings, numbers of roots at harvest, percent sucrose, and pounds of sucrose per ton (Table 1). In 2006, root yields and pounds of recoverable sucrose per acre were significantly higher following wheat compared to soybean and corn, which where statistically the same; in 2007 these variable were not significantly affected by previous crop. In 2006, gross return per acre was significantly higher following wheat compared to corn and intermediate following soybean. In 2007, gross return per acre was statistically the same for sugarbeet following the three rotation crops, but was highest following soybean and lowest following corn.

Table 1. Ratings for Rhizoctonia, yield, and quality of two sugarbeet varieties grown in 2006 and 2007 in plots that in the previous year (2005 and 2006, respectively) were inoculated with *R. solani* AG 2-2 IV, *R. solani* AG IIIB, or not inoculated and then sown with a full-season crop of spring wheat, soybean, and corn.

Main treatment[U]	**Rhizoctonia**[Z] **root & crown rot (0-7 scale)**		**No. roots/60 ft row @ harvest**		**Yield (T/A)**		**% Sucrose**		**Sucrose (lb/T)**		**Recov. suc (lb/A)**		**Gross return ($/A)**	
	2006	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
Inoculum[V]														
Non-inoculated	1.4 a	1.6 a	105 a	100 a	24.1 a	29.1 a	16.5 a	16.9 a	299 a	315 a	7213 a	9162 a	803 a	1038 a
R. solani AG 2-2 IV	3.5 b	2.3 b	63 b	85 b	18.5 b	28.9 a	15.6 b	16.7 a	278 b	310 b	5213 b	8907 a	536 b	988 a
R. solani AG 2-2 III B	6.3 c	4.8 c	22 c	54 c	7.5 c	24.6 b	13.9 c	16.3 b	239 c	299 c	1806 c	7360 b	145 c	788 b
LSD (*P* = 0.05)[Y]	0.8	0.5	13	10	4	4	0.6	0.3	14	9	1128	1150	119	129
Sugarbeet variety[W]														
1301R (resistant)	3.7	2.7	65	85 a	17.3	29.4 a	15.1 a	16.2 a	268 a	299 a	4855	8790 a	499	942
1305R (susceptible)	3.8	3.2	62	74 b	16.1	25.7 b	15.5 b	17.1 b	276 b	317 b	4623	8164 b	490	934
LSD (*P* = 0.05)[Y]	NS	0.3	NS	5	NS	1.4	0.2	0.2	6	6	NS	428	NS	NS
Previous crop[X]														
Wheat	3.4	2.8	70	84	18.9 a	28.0	15.6	16.6	279	307	5371 a	8595	562 a	948
Soybean	3.9	2.7	61	80	15.1 b	27.7	15.1	16.8	267	312	4627 b	8617	482 ab	964
Corn	4.0	3.3	58	75	15.0 b	26.9	15.2	16.6	269	305	4234 b	8219	439 b	901
LSD (*P* = 0.05)[Y]	NS	NS	NS	NS	2	NS	NS	NS	NS	NS	666	NS	87	NS

[U] For the 2006 sugarbeet crop, soil had been inoculated with *R. solani* AG 2-2 IV, *R. solani* AG 2-2 IIIB (11.3 oz per 990 ft^2) or not inoculated on May 17, 2005) and then sown with wheat, soybean, and corn. For the 2007 sugarbeet crop, soil had been inoculated and non-inoculated as above, on May 18, 2006 and then sown with the three same rotation crops.

[V] Each value is averaged across previous crop and sugarbeet variety.

[W] Each value is averaged across soil inoculation and previous crop; 1301R is resistant to *R. solani* AG 2-2 while 1305R is susceptible.

[X] Each value averaged across soil inoculum and both sugarbeet varieties.

[Y] For each column, values followed by a different letter are significantly different (*P* = 0.05); NS = not significantly different.

[Z] Rhizoctonia root and crown rot ratings based on a 0 to 7 scale, where 0 = root and foliage healthy and 7 = root completely rotted and foliage dead.

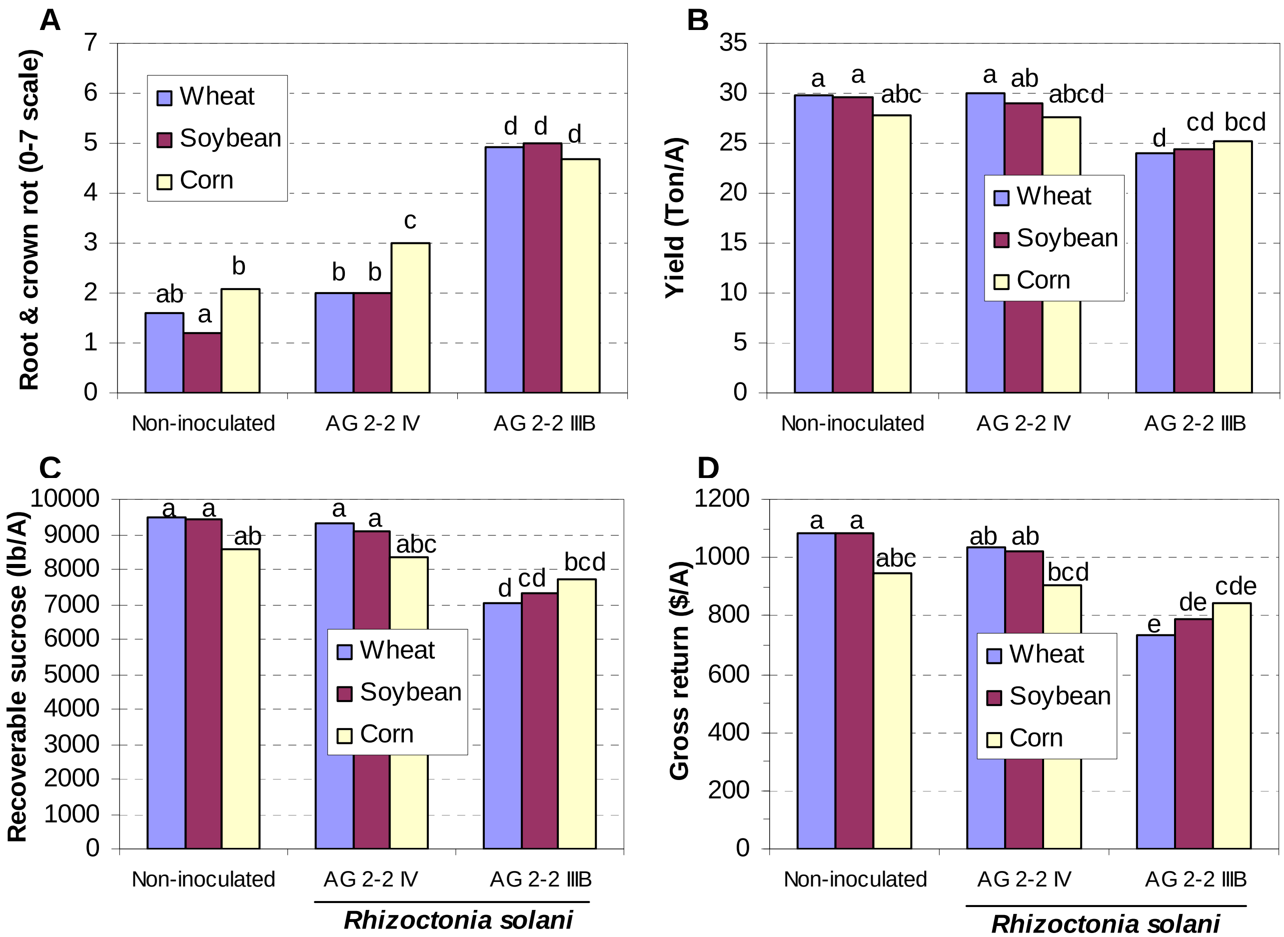

Fig. 4. Sugarbeet harvest data in 2007 presented by main treatment (soil inoculated on May 18, 2006 with *Rhizoctonia solani* AG 2-2 IIIB, *R. solani* AG 2-2 IV [11.3 ounces per 990 ft^2], or not inoculated) and by previous crop (sown on May 18, 2006 with wheat, soybean, corn) for: **A.)** Rhizoctonia root and crown rot ratings (0-7 scale, 0 = healthy, 7 = root completely rotted and foliage dead), **B.)** yield (tons of roots per acre), **C.)** pounds of recoverable sucrose per acre, and **D.)** gross economic return per acre. Each bar is based on an average of eight replicates (averaged across two sugarbeet varieties). For each graph, bars with the same letter are not significantly different, $P = 0.05$).

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Effects of the 2006 rotation crop grown in *Rhizoctonia*-inoculated and non-inoculated plots on the subsequent, 2007 sugarbeet crop are illustrated in Figure 4. Very little RRCR occurred in the non-inoculated control and ratings were significantly lowest when sugarbeet followed soybean compared to corn, and intermediate after wheat (Fig. 4A). Disease also was low on sugarbeet roots in plots inoculated with *R. solani* AG 2-2 IV and planted to wheat and soybean, but RRCR was significantly higher following corn. Ratings for RRCR were equally severe in plots previously inoculated with *R. solani* AG IIIB, regardless of rotation crop. Yields (tons per acre) of sugarbeet were similar in the non-inoculated control and plots previously inoculated with *R. solani* AG 2-2 IV and sown with wheat, soybean and corn but were lower in plots previously inoculated with *R. solani* AG 2-2 IIIB, regardless of rotation crop (Fig. 4B). Pounds of recoverable sucrose per acre were similar and significantly higher for the non-inoculated control and plots previously inoculated with *R. solani* AG 2-2 IV compared to plots inoculated with *R. solani* AG 2-2 IIIB; rotation crop did not significantly affect sugarbeet quality (Fig. 4C). Gross return of dollars per acre was highest in the non-inoculated control and plots inoculated with *R. solani* AG 2-2 IV, especially when sown to wheat or soybean (Fig. 4D). Economic benefits were lowest when sugarbeet was sown in plots inoculated the previous year with *R. solani* AG 2-2 IIIB, regardless of rotation crop (Fig. 4D).

DISCUSSION

This field research illustrates that *R. solani* AG 2-2 IIIB is more aggressive in causing damping-off and RRCR on sugarbeet than *R. solani* AG 2-2 IV. Panella (8) also reported *R. solani* AG 2-2 IIIB as more aggressive in causing RRCR on sugarbeet compared to *R. solani* AG 2-2 IV in greenhouse trials.

The role of wheat, soybean, and corn in altering populations of *R. solani* AG 2-2 IIIB and AG 2-2 IV on a subsequent sugarbeet crop was somewhat inconsistent in 2006 and 2007. When these rotation crops were grown in *Rhizoctonia*-inoculated and non-inoculated plots in 2005 and 2006 trials, yields of each crop were unaffected and there were no above-ground symptoms of Rhizoctonia diseases (12). In both years, there was an increase in root rot lesions only on corn grown in plots inoculated with *R. solani* AG 2-2 IIIB. This was the first report of *R. solani* AG 2-2 IIIB causing lesions on corn in the Midwest, although the disease has previously been reported in the southeastern United States (10,11) and in Europe (3). Furthermore, isolation of *R. solani* AG 2-2 IIIB and 2-2 IV from wheat roots averaged 5 and 2%, respectively; from soybean averaged 16 and 12%, respectively; and from corn averaged 33 and 5%, respectively (12). These results indicate wheat is a non-host for *R. solani* AG 2-2; soybean increases population levels of *R. solani* AG 2-2 IIIB and 2-2 IV (even when roots were symptomless); and corn increases populations of *R. solani* AG 2-2 IIIB. Effects of rotation crops likely are magnified over time, or as these crops are continually grown in rotation with sugarbeet. In 2006, sugarbeet grown after wheat in plots with *R. solani* AG 2-2 IV the previous season had significantly less disease and improved yield and quality compared to a previous crop of soybean or corn, which were similar. In 2007, there was less disease pressure and results were not as clear-cut. In 2006, sugarbeet sown in plots inoculated in 2005 with *R. solani* AG 2-2 IIIB suffered severe disease and losses in yield and quality, regardless of rotation crop. Yield and quality were significantly higher (but not economically acceptable) following wheat compared to corn, and intermediate following soybean. In 2007, disease was less severe on sugarbeet grown in plots previously inoculated with *R. solani* AG 2-2 IIIB and previous crop had no affect. These outcomes suggests when populations of *R. solani* AG 2-2 IIIB are high, wheat (a crop likely to be a non-host) needs to be grown for more than one season to significantly decrease populations of the pathogen to "safe" levels. That is, the influence of rotation crops in decreasing or increasing populations of *R. solani* AG 2-2 IIIB (and less so for *R. solani* AG 2-2 IV) may take several growing seasons. Our Rhizoctonia Nursery is managed so that inoculated plots are taken out of sugarbeet production at the end of an experiment and sown to spring wheat for three growing seasons – they then are "safe" to plant to sugarbeet and have a minimum of RRCR. Experiments currently are being designed to test the long-term effect of crop rotations when population levels of both ISGs of *R. solani* AG 2-2 are at high levels.

Severity of Rhizoctonia diseases on sugarbeet in our trials was considerably higher in 2006 than in 2007. A major difference between the two years was planting date – May 18, 2006 and April 27, 2007. The early planting date in 2007 meant that air and soil temperatures were too low for *R. solani* AG 2-2 to cause much damage (even in soil with high population levels of the pathogen) compared to more favorable air and soil temperatures encountered when planting mid May of 2006 (Fig. 1). Jacobsen et al. (4) and Khan et al. (5) reported that control of *R. solani* AG 2-2 is most effective when azoxystrobin (Quadris) is applied when soil temperatures are 60 to 65 ^{0}F at 4-inches, presumably to prevent infection. In 2006, these conditions occurred shortly after planting. Early planting of sugarbeet in 2007 likely delayed infections - and on older roots, infections are less severe (1). Early planting date is factor in reducing/managing RRCR and may explain why the disease is not a major pathogen in the Southern Minnesota Beet Sugar Cooperative where sugarbeet has been grown in rotation with corn and soybean since the cooperative was formed in the mid 1970s.

To date, over 700 cultures of *R. solani* AG 2-2 have been collected from sugarbeet with RRCR throughout the RRV and southern Minnesota. Field histories also are being collected for each sample (typically wheat, soybean, or corn). Identifications are in progress and based on a temperature differential assay where AG 2-2 IIIB grows at 95 ^{0}F but AG 2-2 IV does not (and supplemented by a molecular analysis).

Crop rotation is an effective practice for managing plant diseases and improving crop production. Benefits of crop rotations are complicated and vary among regions (and fields) because of many factors including whether *R. solani* AG 2-2 IIIB or *R. solani* AG 2-2 IV are present, population densities, planting date, and variety. Surveys will continue to identify the distribution and prevalence of *R. solani* AG 2-2 IIIB and AG 2-2 IV in the RRV and southern Minnesota. This information is critical in adopting crop rotation practices that avoid or delay build-up of inoculum and to manage disease in fields where *R. solani* is established.

CONCLUSIONS

1. Rhizoctonia diseases of sugarbeet are significantly more severe when soil is infested with *R. solani* AG 2-2 IIIB than with *R. solani* AG 2-2 IV.

2. Rotation crops affect population levels of *R. solani* AG 2-2 IIIB and AG 2-2 IV but may take more than one season to significantly increase or decrease the pathogen.

3. Corn roots are infected by *R. solani* AG 2-2 IIIB and may build-up population levels in soil.

4. When population levels of *R. solani* AG 2-2 IIIB are high, one year of a nonhost crop (wheat) is inadequate to reduce pathogen population and damage to a subsequent sugarbeet crop.

ACKNOWLEDGEMENTS

We thank the Sugarbeet Research and Education Board of Minnesota and North Dakota for partial funding of this research; Betaseed for providing sugarbeet seed; Jeff Nielsen and Todd Cymbaluk, University of Minnesota, Northwest Research and Outreach Center, Crookston for planting, maintaining, and harvesting plots; Mary Johnshoy for isolating and maintaining cultures of *R. solani*; Jeff Nielsen for performing statistical analysis of data; and American Crystal Sugar Company Quality Laboratory, East Grand Forks, MN for conducting sugarbeet yield and quality analyses.

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