SWEET CORN IN ROTATION WITH SUGARBEET AS A POTENTIAL HOST OF *RHIZOCTONIA SOLANI* AG 2-2

Jason R. Brantner[1], Carol, E. Windels[1], Mark Bredehoeft[2], and Chris Dunsmore[2]

[1]University of Minnesota, Northwest Research and Outreach Center, Crookston and
[2]Southern Minnesota Beet Sugar Cooperative, Renville

Rhizoctonia crown and root rot (RCRR) is an increasing problem throughout sugarbeet-growing areas of Minnesota and North Dakota. The disease is caused by the soilborne fungus, *Rhizoctonia solani*, which is separated into different genetic populations called anastomosis groups (AGs) (4). The AG causing RCRR on sugarbeet is AG 2-2, which is further divided into the intraspecific groups (ISGs) AG 2-2 IV and AG 2-2 IIIB (4, 6). Both ISGs cause RCRR on sugarbeet, but AG 2-2 IV is reported as the primary cause (6) while AG 2-2 IIIB is reported as the more aggressive population (5).

In Europe, *R. solani* AG 2-2 IIIB is an aggressive root pathogen on both corn and sugarbeet in rotation (3). In the southeastern U.S.A., *R. solani* AG 2-2 IIIB causes a crown and brace root rot on corn (7, 8). Recent reports in Minnesota have demonstrated that corn is a host for *R. solani* AG 2-2 IIIB, and soybean for both ISGs, without any effects on yield or presence of aboveground symptoms (1, 10, 11, 12). In southern Minnesota, sugarbeet follows corn on 75% acres, sweet corn (10%), soybean (10%), and other crops (5%). Information is not available on the relationship of sweet corn to *R. solani* AG 2-2 ISGs.

OBJECTIVES

A field trial was established in southern Minnesota to determine 1) pathogenicity and survival of *R. solani* AG 2-2 IV and AG 2-2 IIIB on sweet corn compared to field corn, soybean, and wheat and 2) effects on a subsequent sugarbeet crop.

MATERIALS AND METHODS

2010 Rotation crops. A field trial was established in a split plot design with six replicates in the spring of 2010 near Gluek, Minnesota. Main plots (88 ft wide by 20 ft long) consisted of a non-inoculated control, inoculation with *R. solani* AG 2-2 IV, and inoculation with *R. solani* AG 2-2 IIIB. Inoculum of *R. solani* was grown for 3 weeks on sterilized barley, air-dried in the greenhouse, and hand-spread in plots (at an equivalent of 31 lb A^{-1}) and incorporated into soil on May 4. There were 11 ft by 20 ft buffers between each main plot. Main plots were divided into eight, 11 ft by 20 ft subplots which were sown on May 7, May 18 and June 30, to an early-, mid-, and late-maturing sweet corn variety, respectively. Field corn was planted on May 7, soybean on May 18, and wheat on May 19. Field corn and soybean were Roundup Ready varieties. Within main plots, there were 11 ft buffers between sweet corn and each field crop and between wheat and each RoundUp Ready crop. On June 27, weeds were controlled in sweet corn with Laudis and in field corn and soybean, with RoundUp Powermax (3 and 22 oz A^{-1}, respectively). Wheat plots were hand-weeded.

To obtain root disease ratings and plant samples to assay for *R. solani* AG 2-2, 10 plants of sweet corn and field corn and 20 plants of soybean and wheat were dug from each plot. Early- and mid-season sweet corn varieties and wheat were collected on August 4 and late-maturing sweet corn, field corn, and soybean were collected on August 24. Roots were washed and rated for root rot. Sweet corn and field corn were rated on a 1-5 scale where 1 = less than 2% of roots discolored or decayed, 5 = entire root system rotted and plant dead or dying (7). Soybean basal stems and roots were rated on a 1-5 scale where 1 = no symptoms and 5 = shoot dead and more than 75% of stem girdled (2). Wheat subcrown internodes were rated on a 0-3 scale where 0 = clean and healthy and 3 = more than 50% of the surface with lesions and discoloration (9).

After roots were assessed for disease, they were assayed to isolate *R. solani* AG 2-2. Four, 1-inch root segments were excised from each sweet corn and field corn plant, surface-treated 15 seconds in 0.5% sodium hypochlorite (bleach solution), rinsed twice in sterile deionized water, and placed on modified tannic acid medium. After 1 week, *R. solani* cultures were transferred to acidified potato dextrose agar for further identification. One-inch soybean basal stem segments and wheat subcrown internodes were cultured in the same way.

Yields of sweet corn and field corn were made by hand-harvesting all ears within 10 feet of two center rows per plot on August 24, September 14, and September 27 for early-, mid-, and late-maturing sweet corn varieties, respectively, and on September 27 for field corn. Ears of field corn were shelled with a stationary corn sheller. Wheat was harvested with a small plot combine. Soybean yield data were compromised by severe iron chlorosis in several plots and are not reported.

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

2011 Sugarbeet crop. Plots previously infested with *R. solani* and planted with rotation crops in 2010 as described above were fertilized to recommended levels and planted to sugarbeet 'HM 4017RR' at 4 9/16 inch spacing on May 19. Sugarbeet plots were 6 rows wide, spaced 22 inches apart, and were 20 feet long. Applications of RoundUp WeatherMAX (32 oz A^{-1} on June 16) and RoundUp PowerMAX (32 oz A^{-1} on July 7 and August 1) were made for weed control using a tractor-mounted sprayer and TeeJet 8003 flat fan nozzles at 40 psi. Cercospora leafspot was controlled with applications of Inspire (7 oz A^{-1}), Agritin (8 oz A^{-1}), and Gem (3.5 oz A^{-1}) on July 20, August 1, and August 19, respectively.

Stand counts were done on June 29 and the middle two rows of plots were harvested on October 6. Beets were lifted and laid in place. Twenty roots were randomly selected from each plot and rated for RCRR with a 0 to 7 scale, where 0 = healthy and 7 = root completely rotted and foliage dead. Roots were analyzed for yield and quality by Southern Minnesota Beet Sugar Cooperative, Renville, MN.

Data were subjected to analysis of variance (ANOVA) for main effects of inoculum and previous crop and interactions between inoculum and previous crop. Where significant (P = 0.05), means were separated by Least Significant Difference (LSD).

RESULTS

Root rot ratings were not significantly different (P = 0.05) among *R. solani*-inoculated and control treatments for all crops (Table 1). Root rot ratings averaged 2.8, 3.3, and 2.6 for early-, mid-, and late-maturing sweet corn, respectively, and 1.7, 3.1, and 2.3 for wheat, field corn, and soybean, respectively.

Recovery of *R. solani* AG 2-2 from all crops was very low (data not shown). The fungus was not recovered from roots of early- and late-maturing sweet corn or from field corn. In mid-maturing sweet corn *R. solani* was isolated from 1.7% of roots in non-inoculated plots and none in *Rhizoctonia*-inoculated plots. The fungus was recovered from 0.8% of wheat roots in *R. solani* AG 2-2 IV-inoculated plots and was not isolated from roots in the non-inoculated or AG 2-2 IIIB-inoculated plots. In soybean, *R. solani* was found in 0.8% of plants in AG 2-2 IV- and AG 2-2 IIIB-inoculated plots and none in the non-inoculated control.

Inoculum treatment had no effect on yield for early-, mid-, and late-maturing varieties of sweet corn (Table 2). Late-maturing sweet corn had the lowest yields (mean = 7.5 ton A^{-1}) compared to 10.9 and 11.1 ton A^{-1} for early- and mid-maturing varieties, respectively. Yields of wheat and field corn also were not affected by inoculum treatment (Table 2) and averaged 48 and 219 bu A^{-1}, respectively.

2011 Sugarbeet crop. There were no significant (P = 0.05) interactions between inoculum treatment and previous crop, so main effects are shown separately in Table 3. There were no significant effects of inoculum on early season stands and sucrose yields. Rhizoctonia crown and root rot ratings were equal and significantly (P = 0.05) higher in plots inoculated with *R. solani* AG 2-2 ISG IIIB and *R. solani* AG 2-2 ISG IV compared to ratings in non-inoculated plots (Table 3). Root yields were higher in plots previously inoculated with *R. solani* AG 2-2 IV compared to non-inoculated plots; plots inoculated with *R. solani* AG 2-2 IIIB were intermediate.

Table 1. Root rot ratings of sweet corn, wheat, field corn, and soybean sown into soil inoculated (before crops were planted) with *Rhizoctonia. solani* AG 2-2 IV, AG 2-2 IIIB, or not inoculated in 2010.

	Root rot rating					
	Sweet corn (1-5)[X]			Wheat	Field corn	Soybean
Soil treatment [W]	Early	Middle	Late	(0-3)[Y]	(1-5)[X]	(1-5)[Z]
Non-inoculated	2.8	3.4	2.4	1.7	3.1	2.5
R. solani AG 2-2 IV	2.9	3.4	2.6	1.6	3.0	2.3
R. solani AG 2-2 IIIB	2.8	3.3	2.7	1.7	3.1	2.3
ANOVA *P*-value	0.929	0.953	0.600	0.900	0.669	0.052

[W] Inoculum of *R. solani* was grown for 3 weeks on sterilized barley, air-dried in the greenhouse, and hand spread in plots on May 4 at an equivalent of 31 lb A^{-1}.

[X] Sweet corn and field corn were rated on a 1-5 scale where 1 = less than 2% of roots were discolored or decayed, 5 = entire root system rotted and plant dead or dying (7). Each number is an average of 60 plants (10 plants/plot x 6 replicates).

[Y] Wheat subcrown internodes were rated on a 0-3 scale where 0 = clean and healthy and 3 = more than 50% of the surface with lesions and discoloration (9). Each number is an average of 120 plants (20 plants/plot x 6 replicates).

[Z] Soybean basal stems and roots were rated on a 1-5 scale where 1 = no symptoms and 5 = shoot dead and more than 75% of stem girdled (2). Each number is an average of 120 plants (20 plants/plot x 6 replicates).

Table 2. Yield of sweet corn, field corn and soybean sown into soil inoculated (before crops were planted) with *Rhizoctonia solani* AG 2-2 IV, AG 2-2 IIIB, or not inoculated in 2010.

	Yield					
	Sweet corn (ton A^{-1})[X]			Wheat[Y]	Field corn[X]	Soybean[Z]
Soil treatment[W]	Early	Middle	Late	(Bu A^{-1})	(Bu A^{-1})	(Bu A^{-1})
Non-inoculated	11.8	11.4	7.3	46	228	-
R. solani AG 2-2 IV	9.9	11.1	7.2	48	212	-
R. solani AG 2-2 IIIB	11.0	10.8	8.1	48	217	-
ANOVA *P*-value	0.062	0.938	0.373	0.923	0.185	-

[W] Inoculum of *R. solani* was grown for 3 weeks on sterilized barley, air-dried in the greenhouse, and hand spread in plots on May 4 at an equivalent of 31 lb A^{-1}.

[X] Sweet corn and field corn yield estimates were made by hand-harvesting all ears within 20 feet of row per plot on August 24, September 14, and September 27 for early-, mid-, and late-maturing sweet corn varieties, respectively, and September 27 for field corn. Field corn ears were shelled with a stationary corn sheller.

[Y] Wheat yield estimates were made with a small plot combine.

[Z] Soybean yields are not reported as data was compromised by severe iron chlorosis in several plots.

There were no significant effects of previous crop on early season stands, RCRR, root yield, and recoverable sucrose per acre. There were, however, significant effects of previous crop on percent sucrose and recoverable sucrose per ton. Percent sucrose and recoverable sucrose per ton were significantly higher in plots following early, middle, and late-planted sweet corn and field corn (P = 0.05) compared to plots following wheat; percent sucrose and recoverable sucrose per ton were intermediate in plots following soybean (Table 3).

Table 3. Early season stand, root rot ratings, yield, and quality of sugarbeet sown May 19, 2011 in experiments inoculated in May, 2010 with *Rhizoctonia solani* AG 2-2 IV, AG 2-2 IIIB, or not inoculated and then planted to full-season crops of sweet corn, field corn, soybean, or wheat in a field near Clara City, MN.

Main effect	Stand/100 ft June 29[z]	RCRR (0-7)[z]	Yield T/A[z]	Sucrose[z] %	Sucrose[z] lb/ton	Sucrose[z] lb recov./A
Inoculum						
Non-inoculated control	196	1.7 b	28.5 b	16.4	260	7424
R. solani AG 2-2 IV	174	1.8 a	30.4 a	16.3	261	7959
R. solani AG 2-2 IIIB	188	1.8 a	29.9 ab	16.3	259	7733
LSD (*P* = 0.05)	NS	0.1	1.5	NS	NS	NS
Previous crop						
Early sweet corn	197	1.9	29.9	16.4 a	262 ab	7853
Middle sweet corn	190	1.8	29.2	16.5 a	262 ab	7657
Late sweet corn	178	1.8	29.5	16.7 a	268 a	7954
Field corn	192	1.8	30.1	16.4 a	263 ab	7910
Soybean	189	1.7	28.7	16.2 ab	256 bc	7362
Wheat	171	1.8	30.0	15.8 b	250 c	7496
LSD (*P* = 0.05)[z]	NS	NS	NS	0.5	11	NS

[z] For each column, numbers followed by the same letter are not significantly different according to Fisher's protected least significant difference (LSD, *P* = 0.05); NS = not significantly different.

DISCUSSION

In this experiment, inoculation of soil with *R. solani* AG 2-2 IV or 2-2 IIIB did not affect root rot or yield of sweet corn or any rotation crops compared to a non-inoculated control. Also, the fungus was infrequently recovered from roots of all crops, regardless of soil treatment. These results are not consistent with previous trials where root rot ratings of field corn were significantly higher in plots inoculated with *R. solani* AG 2-2 IIIB (11,12) and the fungus was isolated more frequently compared to non-inoculated plots. Previous trials also have shown consistent recovery of *R. solani* from soybean plants in plots inoculated with *R. solani* AG 2-2 IV and AG 2-2 IIIB compared to non-inoculated controls (1, 12). As in previous trials, growing wheat in *Rhizoctonia*-inoculated soil did not affect yield and the fungus was infrequently recovered compared to the non-inoculated control (11, 12). Inconsistencies in the 2010 trial compared to previous trials may reflect different environmental factors including soil moisture, temperature, and other pathogens and microbes present in the soil.

Inoculation of soil with *R. solani* AG 2-2 IV or 2-2 IIIB also did not have much of an effect on a subsequent sugarbeet crop. Root rot ratings were statistically lower in non-inoculated plots, but rating differences were not biologically meaningful. All treatments resulted in a mean RCRR rating <2 which is 'shallow rot, dry rot cankers, or active lateral lesions affecting ≤5% of root'. Yields were lower for the non-inoculated control plots compared to plots inoculated with *R. solani* AG 2-2 IV indicating that there was not enough pathogen population to cause damage to the sugarbeet crop. This is not surprising considering the lack of effect of inoculum treatments on the previous crops in 2010. This trial is being repeated in 2011-2012. Sugarbeets will be planted in 2012 and a report will be written for the 2012 Sugarbeet Research and Extension Reports.

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