SURVIVAL OF RHIZOCTONIA SOLANI AG 2-2 ON CORN ROOTS

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Rhizoctonia root and crown rot (RRCR) of sugarbeet is caused by the soilborne fungus *Rhizoctonia solani*. The fungus is composed of genetically isolated populations called anastomosis groups or AGs (2). The AG population causing RRCR of sugarbeet is *R. solani* AG 2-2, which is further divided into the intraspecific groups (ISGs) AG 2-2 IIIB and AG 2-2 IV (2,4). Both ISGs cause RRCR on sugarbeet: AG 2-2 IV is reported as the primary cause (4), while AG 2-2 IIIB is the more aggressive population (3).

Reports from Europe (1) indicate *R. solani* AG 2-2 IIIB is an aggressive root rot pathogen in rotations of corn and sugarbeet. In the southeastern U.S.A., *R. solani* AG 2-2 IIIB causes a crown root and brace root rot on corn. In recent field trials in the Red River Valley (RRV), we found that *R. solani* AG 2-2 IIIB caused lesions on roots of a conventional corn variety that displayed no aboveground symptoms or effects on yield, while *R. solani* AG 2-2 IV rarely infected roots (7,8,9). Consequently, these reports have raise concerns about the presence and role of *R. solani* AG 2-2 IIIB and AG 2-2 IV in corn and sugarbeet rotations in the RRV and southern Minnesota.

A wide range of commercial corn varieties are sold in the RRV and southern Minnesota including conventional as well as transgenic (Roundup Ready and insect resistance - with traits for feed or ethanol production). Availability of short-season varieties in the RRV has resulted in increased corn acreage in recent years. In southern Minnesota, however, sugarbeet frequently follows field corn (75% acres), sweet corn (10%), soybean (10%), and other crops (5%). Producers in the RRV and southern Minnesota are reporting increases in RRCR of sugarbeet. The relationship of this disease to corn varieties grown the previous season is unknown.

OBJECTIVES

We established field trials in the RRV and southern Minnesota to determine 1.) pathogenicity and survival of *R. solani* AG 2-2 IIIB and AG 2-2 IV on varieties of corn with different genetic traits, and 2.) effects on a subsequent sugarbeet crop. This report summarizes results for the first year of a two-year experiment.

MATERIALS AND METHODS

Field trials were established in the spring of 2007 at the University of Minnesota, Northwest Research and Outreach Center, Crookston and by the Southern Minnesota Beet Sugar Cooperative in a field near Gluek, Minnesota. Main plots 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 and air-dried in the greenhouse for 48 hours). Transgenic corn varieties (Roundup Ready, resistance to corn borer and root worm) with traits for feed or ethanol production were sown as subplots in each main plot (Table 1). Trials were arranged in a split-plot design with four replicates.

Red River Valley. At Crookston, main plots were 77 feet wide by 30 feet long. Plots were fertilized to 130 lb N A^{-1}acre; 30 lb P_2O_5 A^{-1} also was added. On May 17, 2007 main plots were inoculated with 26.4 oz of barley infested with *R. solani* AG 2-2 IV or *R. solani* AG 2-2 IIIB. *Rhizoctonia*-infested grains were sprinkled on the soil surface and incorporated with a Melroe multiweeder; control plots were not inoculated. Then, main plots were divided into seven, 11-ft wide subplots (6 rows, 22 inches apart), which were sown with six transgenic and one conventional corn variety (as sown in previous experiments) (Table 1). The herbicide Volley (2.25 pints A^{-1}) was applied pre-emergence on May 25. Plots were cultivated June 21 and hand-weeded on June 28.

To determine disease indices and isolate *R. solani* AG 2-2 from corn roots, 20 plants were dug within two rows of each corn variety on September 12 and 13, 2007. Roots were washed with a pressure washer and rated for rot using

Table 1. Corn varieties planted at the University of Minnesota, Northwest Research and Outreach Center (NWROC), Crookston on May 17, 2007 and by the Southern Minnesota Beet Sugar Cooperative in a field near Gluek on May 15, 2007. Plots previously had been inoculated with *Rhizoctonia solani* AG 2-2 IV, *R. solani* AG 2-2 III, or were not inoculated (control).

NWROC (Red River Valley)		Southern Minnesota			
Variety	Maturity (days)	Variety	Maturity (days)	Genetics[Y]	End use[Z]
Proseed GVRP80	80	DKC 38-92	88	RR	Feed
DKC 35-51	85	DKC 41-64	91	RR + Bt	Feed
DKC 41-57	91	DKC 41-57	91	RR + Bt + CRW	Feed
DKC 35-18	85	DKC 48-52	98	RR	Ethanol
DKC 33-11	83	DKC 42-95	92	RR + Bt	Ethanol
DKC 42-91	92	DKC 42-91	92	RR + Bt + CRW	Ethanol
Pioneer 39D81	81			Conventional	

[Y] RR = Roundup Ready, Bt = Bt gene for corn borer resistance, CRW = gene for corn root worm resistance

[Z] Feed varieties have no special processing characteristics; Ethanol varieties are high fermentable corn for ethanol processing.

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a 1-5 scale (1 = less than 2% of roots were discolored or decayed, 5 = rot system rotted and plant dead or dying [6]). Three, 1-inch length segments of root from each plant were surface-treated in 0.5% NaOCl for 15 sec, rinsed twice in sterile deionized water, and placed on a semi-selective medium (modified tannic acid) for isolation of *R. solani*. Cultures of *R. solani* were transferred to potato dextrose agar for further identification.

Corn yield estimates were made by hand-harvesting all ears within 10 feet of each of two center rows per plot on October 12. Ears were placed in a bin dryer. Yield was adjusted to 15.5% moisture and calculated based on 56 pounds per bushel.

Southern Minnesota. At Gluek, main plots (inoculated with *R. solani* AG 2-2 IV or AG 2-2 IIIB and the non-inoculated control) were 66 feet wide by 35 feet long. Plots were fertilized, as recommended for the region. After plots were inoculated, six transgenic corn varieties were sown per plot (Table 1) on May 15, 2007, as described above. Plots were treated with Roundup to control weeds. Corn roots were sampled and ears harvested on October 3, as described above.

RESULTS

For both locations, there were no significant interactions between soil inoculum and corn variety, so these main treatments will be presented separately.

Red River Valley. At Crookston, root rot ratings of corn were low and similar among plots inoculated with *R. solani* AG 2-2 IV, AG 2-2 IIIB, and the non-inoculated control (Table 2). Isolation of *R. solani* from roots was unaffected by soil inoculation with either population of *R. solani* or in the non-inoculated control, although frequency of isolation tended to be highest in plots inoculated with *R. solani* AG 2-2 IIIB (Table 2). Corn yields were unaffected by inoculation of soil with *R. solani* compared to non-inoculated soil (Table 2).

Corn variety had no significant effect on root rot rating or percent isolation of *R. solani* from roots (Table 2). Yields were significantly higher for DKC 42-91 compared to Proseed GVRP80, DKC 33-11, and DKC 35-51 and the other varieties were intermediate (Table 2).

Southern Minnesota. At Gluek, root rot ratings were slightly higher (Table 3) than at Crookston (Table 2) but overall, were low and similar among plots inoculated with either population of *R. solani* and the non-inoculated control. Rating was difficult because a killing frost occurred about 4 weeks before plots were assessed for disease, so roots were discolored and senesced earlier than expected. Despite this problem, isolation of *R. solani* from roots was significantly higher in plots inoculated with *R. solani* AG 2-2 IIIB (19%) compared to plots inoculated with AG 2-2 IV and the non-inoculated control, which were equally low (4 and 6%, respectively) (Table 3).

Root rot ratings were significantly different among varieties (Table 3). Isolation of *R. solani* from roots varied from 4 to 18%, but was statistically the same among varieties (Table 3). Corn yields were somewhat lower than average and varied from 129 to 161 bushel A^{-1}, but were statistically the same among varieties (Table 3).

Table 2. Disease ratings, isolation of *Rhizoctonia solani* from roots, and yields of corn planted on May 17, 2007 in plots previously inoculated (same day) with *R. solani* AG 2-2 IV, *R. solani* AG 2-2 IIIB, or not inoculated at the University of Minnesota, Northwest Research and Outreach Center, Crookston.

Main treatment	Root rot rating[U]	% Plants with *R. solani* [V]	Yield (bu/A)[W]
Inoculum[X]			
Non-inoculated (control)	1.5	11	173
R. solani AG 2-2 IV	1.8	17	170
R. solani AG 2-2 IIIB	2.1	20	166
LSD (P = 0.05)[Y]	NS	NS	NS
Corn Variety[Z]			
Proseed GVRP80	1.8	25	159
DKC 35-51	1.7	12	169
DKC 41-57	1.8	15	170
DKC 35-18	1.9	17	172
DKC 33-11	1.8	15	164
DKC 42-91	1.6	12	183
Pioneer 39D81	1.9	19	171
LSD (P = 0.05)[Y]	NS	NS	13.5

U Corn plants were dug from plots on September 12 and 13, 2007; roots were washed and rated with a 1-5 scale where 1 = less than 2% root surface with lesions and 5 = roots completely rotted and plant dead (6). Each value for effect of inoculum is an average of 560 plants (20/corn variety/replicate). Each value for corn variety is an average of 240 plants (20/soil inoculum treatment/replicate).

V Segments of roots (three, ~1-inch long) per plant were excised after disease assessment, surface-sterilized with bleach, and cultured on a semi-selective medium (modified tannic acid medium) for isolation of *R. solani*.

W Plots were harvested October 12, 2007; yields were adjusted to 15.5% moisture and calculated based on 56 pounds per bushel.

X *R. solani* AG 2-2 IV and *R. solani* AG 2-2 IIIB were grown on sterile barley grains for 3 weeks and air-dried. Plots were inoculated on May 17, 2007 by sprinkling infested barley grains onto the soil surface (26.4 oz per 2,310 ft^2, the control was not inoculated) and incorporated with a Melroe multiweeder. Plots were arranged in a randomized block design with four replicates.

Y Corn varieties were sown May 17, 2007 as subplots (6 rows, 22 inches apart and 30 feet long) within each soil inoculum main plot.

Z LSD = Least significant difference, P = 0.05; for each column, values followed by the same letter are not significantly different; NS = not significantly different.

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Table 3. Disease ratings, isolation of *Rhizoctonia solani* from roots, and yields of corn planted on May 15, 2007 in plots previously inoculated (same day) with *R. solani* AG 2-2 IV, *R. solani* AG 2-2 IIIB, or not inoculated at Gluek in southern Minnesota.

Main treatment	Root rot rating[U]	% Plants with *R. solani* [V]	Yield (bu/A)[W]
Inoculum[X]			
Non-inoculated (control)	2.2	6	145
R. solani AG 2-2 IV	2.3	4	152
R. solani AG 2-2 IIIB	2.4	19	138
LSD (P = 0.05)[Z]	NS	4.8	NS
Corn Variety[Y]			
DKC 38-92	2.6	10	139
DKC 41-64	2.4	14	129
DKC 41-57	2.2	18	142
DKC 48-52	2.4	8	161
DKC 42-95	2.2	4	151
DKC 42-91	2.1	4	148
LSD (P = 0.05)[Z]	0.17	NS	NS

U Corn plants were dug from plots on October 3, 2007; roots were washed and rated with a 1-5 scale where 1 = less than 2% root surface with lesions and 5 = roots completely rotted and plant dead (6). Each value for effect of inoculum is an average of 480 plants (20/corn variety/replicate). Each value for corn variety is an average of 240 plants (20/soil inoculum treatment/replicate).

V Segments of roots (three, ~1-inch long) per plant were excised after disease assessment, surface-sterilized with bleach, and cultured on a semi-selective medium (modified tannic acid medium) for isolation of *R. solani*.

W Plots were harvested October 3, 2007; yields were adjusted to 15.5% moisture and calculated based on 56 pounds per bushel.

X *R. solani* AG 2-2 IV and *R. solani* AG 2-2 IIIB were grown on sterile barley grains for 3 weeks and air-dried. Plots were inoculated on May 15, 2007 by sprinkling infested barley grains onto the soil surface (26.4 oz per 2,310 ft^2, the control was not inoculated) and incorporated. Plots were arranged in a randomized block design with four replicates.

Y Corn varieties were sown May 15, 2007 as subplots (6 rows, 22 inches apart and 30 feet long) within each soil inoculum main plot.

Z LSD = Least significant difference, P = 0.05; for each column, values followed by the same letter are not significantly different; NS = not significantly different.

DISCUSSION

Populations of *R. solani* AG 2-2 IV and AG 2-2 IIIB had no affect on aboveground symptoms or yields compared to a non-inoculated control in trials at both locations, which confirms results of previous trials in the RRV (7,8,9). The significantly higher isolation of *R. solani* from roots in plots inoculated with *R. solani* AG 2-2 IIIB than in plots inoculated with AG 2-2 IV and the non-inoculated control also confirms results of previous trials at Crookston (8,9), but there were no differences in isolation of *R. solani* among soil treatments in the 2007 trials at Crookston.

The effect of corn variety on root rot ratings, percent recovery of *R. solani*, and yields were variable among both locations and showed no conclusive trends. In southern Minnesota, soil moisture was very low at silking, so yields were lower than expected. Overall, 2007 results followed previous reports where no aboveground symptoms or yield losses in *Rhizoctonia*-inoculated plots occurred on corn compare to the non-inoculated control. In contrast, Sumner (5) reported that all varieties of dent corn evaluated in the southeastern USA were susceptible to *R. solani* AG 2-2 IIIB.

In 2008, these trials will be sown with sugarbeet and evaluated for damping-off and root and crown rot caused by *R. solani* AG 2-2. This will be a more direct method to assess the impact of corn variety on build-up and survival of *R. solani* AG 2-2 IV and AG 2-2 IIIB on roots.

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LITERATURE CITED

1. Ithurrart, M.E., G. Buttner, and J. Petersen. 2004. Rhizoctonia root rot in sugar beet (*Beta vulgaris* ssp. *altissima*) – Epidemiological aspects in relation to maize (*Ze mays*) as a host plant. J. Plant Disease Protection 111:302-312.

2. Ogoshi, A. 1987. Ecology and pathogenicity of anastomosis and intraspecific groups of *Rhizoctonia solani* Kuhn. Annu. Rev. Phytopathol. 25:125-143.

3. Panella, L. 2005. Pathogenicity of different anastomosis groups and subgroups of *Rhizoctonia solani* on sugarbeet (Abstr.) J. Sugar Beet Res. 42:53.

4. Sneh, B., L. Burpee, and A. Ogoshi. 1991. Identification of *Rhizoctonia* species. American Phytopathological Society, APS Press, St. Paul, MN. 133 pp.

5. Sumner, D.R. and D.K. Bell. 1982. Root diseases induced in corn by *Rhizoctonia solani* and *Rhizoctonia zeae*. Phytopathology 72:86-91.

6. Sumner, D.R. 1999. Rhizoctonia crown and brace root rot. Pages 12-13 *in*: Compendium of Corn Diseases, 3rd edition. D.G. White, ed. American Phytopathological Society, APS Press, St. Paul, MN.

7. Windels, C.E. and J.R. Brantner. 2005. Previous crop influences Rhizoctonia on sugarbeet. 2004a Sugarbeet Res. Ext. Rept. 35:227-231.

8. Windels, C.E. and J.R. Brantner. 2006. Crop rotation effects on Rhizoctonia solani AG 2-2. 2005 Sugarbeet Res. Ext. Rept. 36:286-290.

9. Windels, C.E. and J.R. Brantner. 2007. Rhizoctonia inoculum and rotation crop effects on a following sugarbeet crop. 2006 Sugarbeet Res. Ext. Rept. 37:182-191.