Susceptibility of Sugar Beet and Beans to *Rhizoctonia solani* AG-2-2 IIIB and AG-2-2 IV

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ABSTRACT

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Isolates of *Rhizoctonia solani* AG-2-2 from diseased sugar beet, table beet, and three bean species were identified to intraspecific group (ISG) based on growth at 35°C and evaluated for pathogenicity on sugar beet and beans. The ISG for seven isolates from pinto bean, soybean, and table beet was AG-2-2 IIIB, and for eight isolates from broad bean and sugar beet was AG-2-2 IV. Severity of Rhizoctonia root and crown rot on sugar beet (0 to 7 scale) differed in two seasons. Isolates of *R. solani* AG-2-2 IIIB (n = 6) averaged disease ratings of 4.2 and 5.3 in 1988 and 1989, respectively; and isolates of AG-2-2 IV (n = 8) averaged 2.0 and 4.0 in 1988 and 1989, respectively. Isolates of *R. solani* AG-2-2 IIIB (n = 5) and AG-2-2 IV (n = 3) evaluated on navy bean, pinto bean, soybean, and broad bean caused stem rot (1 to 5 scale) on all bean crops. Isolates of *R. solani* AG-2-2 IIIB from pinto bean and soybean were more pathogenic across all bean crops in both seasons ($\bar{x}$ = 4.7, n = 4) compared with the AG-2-2 IIIB isolate from table beet ($\bar{x}$ = 3.6, n = 1) and isolates of AG-2-2 IV ($\bar{x}$ = 3.4, n = 3). Overall, isolates of *R. solani* AG-2-2 IIIB and AG-2-2 IV were pathogenic to sugar beet and bean crops, so close rotation of these crops should be avoided. Also, the host range of our isolates of AG-2-2 was unrelated to ISG.

Rhizoctonia solani Kühn AG-2-2 causes damping-off of seedlings and root and crown rot of sugar beet (*Beta vulgaris* L.) in Minnesota and North Dakota (32). A rotation of sugar beet for a minimum of 3 years with nonhost crops is recommended to allow inoculum of *R. solani* AG-2-2 to decrease (18,31). Seed treatment fungicides (31) and a few *Rhizoctonia*-tolerant sugar beet cultivars also are available (R. A. Steen, American Crystal Sugar Co., Moorhead, MN, *personal communication*).

In 1987, cultures of *R. solani* AG-2-2 were isolated from diseased roots and basal stems of broad bean (*Vicia faba* L.) and pinto bean (*Phaseolus vulgaris* L.) from fields in Minnesota and North Dakota that had been planted to sugar beet the previous season. Several reports confirm that AG-2-2 causes root and stem rot of vegetable legume crops (1,5,29) and soybean (*Glycine max* (L.) Merr.) (9,14). Some producers in Minnesota and North Dakota grow broad bean, soybean, navy bean (*P. vulgaris*), and pinto bean in rotation with sugar beet.

Ogoshi (15) subdivided *R. solani* AG-2-2 into two intraspecfic groups (ISG) based on pathogenic specialization as reported by Watanabe and Matsuda (30). In Japan, isolates of AG-2-2 IIIB (rush type) cause sheath blight of mat rush (*Juncus effusus* L. var. *decipiens*) and false sheath blight of rice (*Oryza sativa* L.); isolates of AG-2-2 IV (root rot type) cause root and crown rot of sugar beet (15,25). Isolates of AG-2-2 IIIB represent a high-temperature group capable of growing at 35°C, whereas isolates of AG-2-2 IV do not grow at 35°C (25). Recently, researchers have identified pathogenic cultures of *R. solani* AG-2-2 from soybean as IIIB (9,13,14). Engelkes and Windels (4) reported that an isolate of *R. solani* AG-2-2 from pinto bean gave a higher root rot rating on sugar beet than did an isolate from sugar beet, but the cultures were not identified to ISG. Schuster and Harris (23) reported that isolates of *R. solani* from sugar beet were nonpathogenic to field beans, but anastomosis grouping of their isolates is unknown. Ruppel (18) reported that an isolate of *R. solani* AG-2 that was pathogenic to sugar beet also was pathogenic to bean.

To determine the importance of *R. solani* AG-2-2 on bean crops and sugar beet, our objectives were to determine the ISG of cultures isolated from these crops and to determine their pathogenicity on cultivars of sugar beet, broad bean, navy bean, pinto bean, and soybean in the field. Brief reports have been published (2,3).

MATERIALS AND METHODS

Isolates. Seventeen isolates of *R. solani* AG-2-2 tested for pathogenicity on sugar beet in 1988 and 1989 included four from pinto bean, three from broad bean, and eight from sugar beet roots collected in Minnesota and North Dakota, and two from soybean collected in Illinois (9). Eight AG-2-2 isolates tested for pathogenicity on beans in 1989 and 1990 included two each from broad bean, pinto bean, and soybean, one from sugar beet (These seven isolates were the most pathogenic isolates on sugar beet in the 1988 field trial.), and an isolate from table beet in New York. (This isolate was pathogenic on snap bean [5] and was added to our culture collection in the second year of pathogenicity tests on sugar beet.) The isolates were stored on autoclaved barley grain at 5 ± 0.5°C (20) in tubes sealed with cigarette paper (26) and stainless steel caps and transferred annually.

Identification of ISG. A 0.9-cm-diameter disk from the margin of a 5-day-old colony of *R. solani* on potato-dextrose agar (PDA; Difco Laboratories, Detroit, MI) was transferred to the edge of a 100 × 15 mm petri dish containing 20 ml of PDA; dishes were placed in plastic boxes (40 × 27 × 17 cm) and incubated at 35°C. After 24 h (to allow the agar and fungus to equilibrate to incubator temperatures), a baseline was drawn on the bottom of the petri dish at the colony margin. Hyphal growth then was measured from the baseline to the colony margin after 144 h. There were four replicates for each isolate.

Isolates of *R. solani* AG-2-2 that were evaluated for pathogenicity were identified to ISG, except for the following three isolates, which died: 87-36-7 was from broad bean (and had always grown slowly), and 87-36-16 and 87-19-a were from sugar beet.

Field plot conditions. Experimental plots were at the Northwest Experiment Station, University of Minnesota, Crookston, in a Bearden silty clay loam soil. Cultivar was the main plot variable, and AG-2-2 isolate was the subplot variable in split-plot designs with four replicates of sugar beet and three replicates of beans. Each trial was repeated.

Seeds of sugar beet cultivars Maribo Ultramono and ACH 184 (provided by

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American Crystal Sugar) and breeding line FC 712 (provided by E. G. Ruppel, USDA-ARS Crops Research Laboratory, Fort Collins, CO) were treated with metalaxyl at 300 mg a.i./kg (Ciba Corp., Greensboro, NC). Maribo Ultramono is susceptible to *R. solani*; ACH 184 and FC 712 are moderately tolerant. Three hundred seeds of each cultivar were planted per 9-m row in four-row plots (56 cm apart) with a cone planter on 17 May 1988 and 16 May 1989. Plots were fertilized according to soil test recommendations for a yield goal of 44.8 t/ha (17). To control the sugar beet root maggot, clorpyrifos at 2.24 kg a.i./ha (Dow Chemical Co., Midland, MI) was applied in-furrow at planting. Plants were thinned to 20 cm between plants at 4 weeks after seeding.

Eight bean cultivars (seed provided by J. Vaagene, Burger & Co., Hattan, ND) commonly grown in Minnesota and North Dakota were evaluated: Outlook and Primus broad bean, Fleetwood and C-20 navy bean, Pindak and Nodak pinto bean, and McCall and Ozzie soybean. Seeds were dusted with captan (Chevron Chemical Co., San Francisco, CA) at 0.72 g a.i. per kg of seed. Cultivars were sown on 23 May 1989 and 21 May 1990 with a cone planter and thinned to 10 cm between plants at 4 weeks after planting. Plants were treated with a solution of 0.2 kg of iron plus 0.4 kg of zinc per ha for each of two applications to correct a micronutrient deficiency.

Inoculation. Inoculum was grown on kernels of dent corn that were soaked in distilled water for 12 h, drained, and autoclaved at 121°C for 60 min on two consecutive days (24). Two 1.5-cm-diameter disks from the margin of a 5-day-old colony of *R. solani* on PDA were placed in a jar (473 ml) containing about 200 kernels. For the control, two disks of PDA were placed in jars containing kernels. Inoculum was incubated at 25 ± 5°C for 10 to 21 days and shaken every 2 days.

Sugar beet plants were inoculated by placing two *Rhizoctonia*-infested corn kernels on roots of 12-week-old plants, 5 cm below the soil surface, in 1988. (Two and three colonized kernels produced similar root rot ratings, but they were greater than ratings obtained with one kernel per root [*unpublished*].) Disease levels were low in 1988, so 8-week-old plants were inoculated 3 cm below the soil surface in 1989 to increase disease pressure (4). Eight consecutive beets were inoculated per isolate; isolates were separated within rows by a 1.5-m-long barrier of uninoculated beets. Two sterile corn kernels were placed on roots of control plants. Soil was hilled around crowns to favor disease development (22), and plots were irrigated with 2.5 cm of water per week with an overhead sprinkler.

Ten consecutive bean seedlings in the unifoliolate stage were inoculated per cultivar and AG-2-2 isolate by placing one *Rhizoctonia*-infested corn kernel on the stem 1 cm below the soil surface. (Half, one, and two colonized kernels per plant produced similar disease severities on Ozzie soybean seedlings in the greenhouse [*unpublished*].) Isolates were separated within rows by a 1.5-m-long barrier of uninoculated plants. Inoculum doses of one sterile corn kernel per plant were placed on stems of control plants. Plots were irrigated with 2.5 cm of water per week.

Evaluation. Sugar beet roots were hand harvested and evaluated 9 weeks after inoculation (WAI) in 1988. Roots were evaluated at 4 WAI in 1989 because disease was severe. Soil was removed and percent root surface area rotted was rated on a 0 to 7 scale: 0 = no visible lesions; 1 = superficial, arrested lesions at point of inoculation; 2 = less than 5%, shallow, dry rot canker; 3 = 5 to 24%, deep, dry rot canker; 4 = 25 to 49%, extensive rot; 5 = 50 to 89%, rot extending well into root interior; 6 = 90 to less than 100%, most foliage dead; and 7 = 100%, plant dead (E. G. Ruppel, *personal communication*).

Bean plants were evaluated 16 to 18 days after inoculation (DAI) in 1989 and 12 to 13 DAI in 1990. Plants were washed, and percent basal stem surface area girdled was rated on a 1 to 5 scale: 1 = no visible lesion; 2 = less than or equal to 25%, one or few pin-point dark spots; 3 = 25 to 49%, necrotic lesions less than 0.5 cm long; 4 = 50 to 74%, necrotic lesions greater than 0.5 cm long; and 5 = 75 to 100%, foliage necrotic (24).

Statistical analyses. Analyses of variance of sugar beet root rot and bean stem rot data (8,27) were performed with Statistical Analysis System (SAS Institute, Cary, NC) general linear model procedure. Ratings for control plants were near zero and therefore excluded (8). There were significant differences between years, so data are presented for each year. Significant differences between means of plot variables were tested by least significant differences (LSD) for a split-plot design (27).

RESULTS

Identification of ISG. Isolates of *R. solani* AG-2-2 from pinto bean, soybean, and table beet were identified as IIIB, but they varied in rate of growth at 35°C (Fig. 1). Isolate 87-36-1 from pinto bean grew more slowly than the other isolates of IIIB, but in earlier evaluations at 35°C, this isolate grew 0.5 cm in 24 h (4). Isolates of *R. solani* AG-2-2 from broad bean and sugar beet did not grow at 35°C and thus were identified as IV (data not shown).

Pathogenicity on sugar beet. Aboveground symptoms of Rhizoctonia root and crown rot of sugar beet included yellowing and sudden wilting of leaves at 6 and 3 WAI in 1988 and 1989, respectively. Belowground, roots turned dark brown to gray as rot spread from the crown over the root surface. Rotted roots often had slightly sunken lesions or cracks and sclerotia.

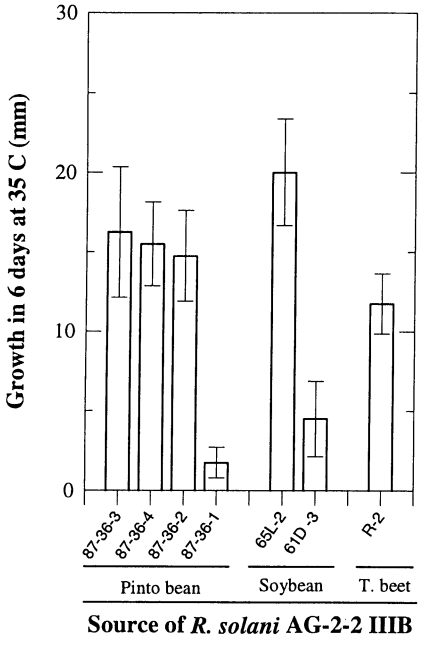

Fig. 1. Average hyphal growth of seven isolates of *Rhizoctonia solani* AG-2-2 IIIB from pinto bean, soybean, and table beet (T. beet) on potato-dextrose agar after 6 days at 35°C.

Table 1. Analyses of variance for effects of year, cultivar, and *Rhizoctonia solani* AG-2-2 isolate on root rot of sugar beet and stem rot of beans

	Sugar beet		Beans	
Source of variation	**df**	**SS[z]**	**df**	**SS[z]**
Total	3,263	14,118	3,839	5,691
Year (Y)	1	1,946**	1	555**
Replicate/Y	6	138	4	27
Cultivar or crop (C)	2	1,676**	7	851**
C × Y	2	35**	7	46**
Error a	12	113	28	25
AG-2-2 isolate (I)	16	4,551**	7	1,682**
Y × I	16	489**	7	346**
C × I	32	399**	49	280**
Y × C × I	32	175*	49	64
Error b	288	1,016	224	263
Sampling error	2,856	3,581	3,456	1,552

[z] Sum of squares, ** = $P < 0.01$ and * = $P < 0.05$.

Analyses of variance are presented for root rot data in Table 1. There were statistically significant effects ($P < 0.05$) of year, cultivar, and AG-2-2 isolate (plot variables) and interactions among these variables on *Rhizoctonia* disease severity (marked with asterisks). Conclusive statements about the main effects cannot be made because of significant interactions, so only significant interactions will be presented.

Disease pressure differed in the two seasons (Table 2), and isolates of *R. solani* AG-2-2 IIIB averaged higher root rot ratings ($\bar{x}$ = 4.2 and 5.3 in 1988 and 1989, respectively) than did isolates of AG-2-2 IV ($\bar{x}$ = 2.0 and 4.0 in 1988 and 1989, respectively). Isolates of *R. solani* AG-2-2 tended to be less pathogenic on the two *Rhizoctonia*-tolerant cultivars (ACH 184, FC 712) than on the susceptible cultivar (Ultramono) in both seasons. Both of the unidentified isolates from sugar beet were pathogenic and usually resulted in root rot ratings within the range of the AG-2-2 IV isolates. The unidentified isolate (87-36-7) from broad bean resulted in ratings of less than 1 on all cultivars in both years, indicating that it was nonpathogenic (6).

Pathogenicity on beans. Wilting was the first aboveground symptom of Rhizoctonia root and stem rot of beans, and it occurred within 1 week after inoculation of soybean and broad bean cultivars. Leaves became necrotic within a few days after initial wilt symptoms appeared. Reddish brown lesions girdled basal stems of the four bean crops at, or slightly below, the soil line. Infected roots showed a light discoloration in association with pruned taproots, secondary roots, and/or root hairs.

Based on ANOVA, there were statistically significant effects ($P < 0.05$) of year, crop, and AG-2-2 isolates, as well as significant interactions between bean crop and year, year and isolate of AG-2-2, and bean crop and isolate of AG-2-2 (Table 1). Because of the interactions, main effects are inconclusive.

Disease was more severe in 1989 than in 1990, but all isolates of *R. solani* AG-2-2 caused stem rot on the four bean crops (Table 3). Data are combined for both cultivars of each bean crop because they did not differ significantly in disease ratings. Isolates of *R. solani* AG-2-2 varied in pathogenicity across the four bean crops. In 1989, broad bean was equally susceptible to all isolates of *R. solani* AG-2-2, but in 1990, this crop was most susceptible to all isolates of AG-2-2 IIIB and one isolate of AG-2-2 IV from broad bean. In 1989 and 1990, navy bean, pinto bean, and soybean were equally susceptible to all isolates of *R. solani* AG-2-2 IIIB from pinto bean and soybean, and usually were less susceptible to the isolate of IIIB from table beet and all isolates of AG-2-2 IV.

DISCUSSION

Isolates of *R. solani* AG-2-2 IIIB (from pinto bean, soybean, and table beet) and AG-2-2 IV (from sugar beet and broad bean) were pathogenic to sugar beet, navy bean, pinto bean, soybean, and broad bean. Also, others have identified some of these isolates as AG-2-2 IIIB (61D-3 and 65L-2 from soybean) and AG-2-2 IV (86-72-7 and 86-42-4 from sugar beet) by isozyme polymorphism and DNA restriction analyses (10), and by cellular fatty acid composition (28). Sixteen isolates of *R. solani* AG-2-2 collected from sugar beet in Minnesota and North Dakota (not included in the research reported here) have been confirmed as AG-2-2 IV (10,28), which is consistent with Ogoshi's characterization of isolates of AG-2-2 that typically cause root and crown rot of sugar beet (15,25).

Although *R. solani* AG-2-2 IIIB and AG-2-2 IV are genetically distinct (9), isolates of IIIB and IV, apparently, have a wider host range than originally observed in Japan (15,30). Recently, isolates of *R. solani* AG-2-2 from soybean in Ohio (13), Illinois (9), and North Dakota (14) were reported as IIIB. Nelson et al. (14) further reported that the IIIB isolates from soybean also were pathogenic to dry bean, mustard, flax, sunflower, and corn. Liu and Sinclair (9) found that the IIIB isolates from soybean (61D-3 and 65L-2) produced crown and root rot on inoculated plant species in the *Chenopodiaceae, Fabaceae,* and *Poaceae.* Previously, we reported that an isolate of *R. solani* AG-2-2 from pinto bean was more pathogenic to sugar beet than an isolate from sugar beet (4). The

Table 2. Root rot ratings of sugar beet cultivars inoculated with isolates of *Rhizoctonia solani* AG-2-2 IIIB and AG-2-2 IV from beans and sugar beet in two field trials

Isolate of *R. solani*	Isolate source	Root rot rating[v,w]							
		1988[x]				1989[y]			
		Ultramono	ACH 184	FC 712	$\bar{x}$	Ultramono	ACH 184	FC 712	$\bar{x}$
AG-2-2 IIIB									
87-36-1	Pinto bean	5.4	3.7	3.9	4.3	5.9	5.5	5.4	5.6
87-36-2	Pinto bean	5.3	4.2	4.0	4.5	6.2	5.7	5.4	5.8
87-36-4	Pinto bean	5.3	4.4	4.0	4.6	5.2	4.7	4.8	4.9
87-36-3	Pinto bean	5.0	3.8	3.6	4.1	6.2	5.6	5.2	5.7
65L-2	Soybean	5.2	4.0	2.8	4.0	5.7	4.6	4.1	4.8
61D-3	Soybean	4.9	2.5	3.0	3.5	5.4	4.8	4.6	4.9
AG-2-2 IV									
87-36-9	Broad bean	4.2	1.6	1.4	2.4	5.2	4.2	3.3	4.2
87-36-11	Broad bean	2.7	1.9	1.4	2.0	5.2	3.7	2.2	3.7
86-73-5	Sugar beet	3.7	1.1	1.0	1.9	5.3	3.8	2.9	4.0
87-40-5	Sugar beet	3.5	2.7	0.9	2.4	4.1	4.0	2.8	3.6
87-24-4A	Sugar beet	3.1	1.5	1.5	2.0	5.1	2.3	2.2	3.2
86-72-7	Sugar beet	3.1	1.5	1.1	1.9	5.5	4.6	2.8	4.3
87-4-70	Sugar beet	2.9	1.9	1.3	2.0	5.4	4.6	3.0	4.3
86-42-4	Sugar beet	2.3	0.8	1.1	1.4	5.6	4.4	3.5	4.5
Unidentified[z]									
87-36-16	Sugar beet	3.9	1.8	1.0	2.2	5.8	5.2	3.6	4.9
87-19-a	Sugar beet	2.4	1.3	0.9	1.5	4.2	2.3	1.8	2.8
87-36-7	Broad bean	0.2	0.1	0.7	0.3	0.3	0.2	0.4	0.3
	$\bar{x}$	3.7	2.3	2.0	2.7	5.1	4.1	3.4	4.2

[v] Maribo Ultramono is susceptible and ACH 184 and FC 712 are tolerant to Rhizoctonia root and crown rot.
[w] Each value (other than $\bar{x}$) average of 32 roots; rating based on a 0 to 7 scale (0 = healthy, 7 = plant dead).
[x] LSD ($P = 0.05$) = 1.3 to compare among cultivars within the same isolate, 1.6 to compare among isolates within the same cultivar, 2.9 to compare the same or different isolates among cultivars.
[y] LSD ($P = 0.05$) = 1.3 to compare among cultivars within the same isolate, 0.6 to compare among isolates within the same cultivar, 2.6 to compare the same or different isolates among cultivars.
[z] Isolates died before intraspecific group was determined.

Table 3. Stem rot ratings of four bean crops inoculated with isolates of *Rhizoctonia solani* AG-2-2 IIIB and AG-2-2 IV from beans and sugar beet in two field trials

Isolate of *R. solani*	Isolate source	Stem rot rating of bean crops[x]									
		1989[y]					1990[z]				
		Navy	Pinto	Soy	Broad	x̄	Navy	Pinto	Soy	Broad	x̄
AG-2-2 IIIB											
87-36-2	Pinto bean	4.8	4.9	5.0	5.0	4.9	4.2	4.3	4.6	5.0	4.5
87-36-4	Pinto bean	4.6	5.0	5.0	5.0	4.9	4.1	4.1	4.4	5.0	4.4
61D-3	Soybean	4.7	4.9	4.9	5.0	4.9	3.7	4.4	4.7	4.8	4.4
65L-2	Soybean	4.5	4.9	4.9	5.0	4.8	4.0	4.2	4.8	4.9	4.5
R-2	Table beet	3.0	3.4	4.0	4.5	3.7	2.3	3.0	4.3	4.5	3.5
AG-2-2 IV											
87-36-9	Broad bean	3.5	4.0	4.2	4.9	4.2	1.4	2.1	2.5	3.4	2.4
87-36-11	Broad bean	3.0	4.4	4.2	5.0	4.2	2.4	3.2	3.9	4.8	3.6
87-40-5	Sugar beet	3.2	3.5	4.0	4.8	3.9	1.6	1.7	1.9	3.1	2.1
	x̄	3.9	4.4	4.5	4.9	4.4	3.0	3.4	3.9	4.4	3.7

[x] Each value (other than x̄) based on an average of 60 plants; ratings based on a 1 to 5 scale (1 = healthy, 5 = shoot dead).
[y] LSD ($P = 0.05$) = 0.3 to compare among crops within the same isolate, 0.5 to compare among isolates within the same crop, 1.4 to compare the same or different isolates among crops.
[z] LSD ($P = 0.05$) = 0.8 to compare among crops within the same isolate, 0.7 to compare among isolates within the same crop, 2.0 to compare the same or different isolates among crops.

isolates from pinto bean (87-36-1) and sugar beet (87-4-70) later were confirmed as IIIB and IV, respectively (C. A. Engelkes, *unpublished*).

The isolate of *R. solani* AG-2-2 IIIB designated as R-2 originally was cultured from table beet in central New York by Galindo et al. (5). This isolate was tested only on bean crops in our field trials and was somewhat less pathogenic than the other IIIB isolates but was equal to, or more pathogenic than, the IV isolates. Galindo et al. (5) found that R-2 was highly pathogenic on snap bean hypocotyls and leaves, but they were unable to identify it to AG with their tester strains. We have noted that R-2 anastomoses more frequently with other isolates of IIIB than with isolates of IV. This observation suggests that the ISG of AG-2-2 used as a tester strain may facilitate or hinder identification of an unknown isolate of AG-2-2.

There was variability in pathogenicity of isolates of *R. solani* AG-2-2, which is consistent with other reports (13,14). Our isolates from pinto bean (IIIB) were especially pathogenic to all crops tested. They were selected from a field where sugar beet and pinto bean were grown alternately for several years. The rotation may have resulted in host selection of the most pathogenic isolates (18,21,23). Unfortunately, we did not attempt to culture *R. solani* from rotted sugar beet plants in this field to determine if they also were infected by AG-2-2 IIIB. The nonpathogenic isolate of *R. solani* AG-2-2 IV (87-36-7) from broad bean grew slowly in the laboratory.

The sugar beet cultivars used in this study differed in resistance to Rhizoctonia root and crown rot, but there was no information available for the bean cultivars in regard to resistance to Rhizoctonia root and stem rot. The interaction of AG-2-2 isolates with plant genotypes is of practical importance and may explain variable disease reactions (12,16). We are unaware, however, of evaluations of germ plasm with isolates of AG-2-2 where the ISG group has been identified. In 1995 field trials, isolate R-9 of *R. solani* AG-2-2 (used to evaluate sugar beet germ plasm for resistance to Rhizoctonia root and crown rot in the USDA-ARS program at Fort Collins) was as pathogenic to sugar beet as our four isolates of AG-2-2 IIIB from pinto bean (C. E. Windels, *unpublished*; L. Panella and E. G. Ruppel, *personal communication*). Recently, the R-9 isolate was identified as *R. solani* AG-2-2 IIIB (C. E. Windels, *unpublished*). Apparently, sugar beet germ plasm screened for resistance to AG-2-2 IIIB has resistance to AG-2-2 IV.

Rhizoctonia root and crown rot was more severe on sugar beet in 1989 than in 1988. Roots were inoculated at 8 weeks after planting in 1989 versus 12 weeks after planting in 1988. Younger roots are more susceptible to this disease than are older roots (4,19). Also, inoculum was applied to roots at a 3-cm depth in 1989 versus a 5-cm depth in 1988. Shallow inoculum placement likely favored entrance of AG-2-2 at the base of leaf petioles (22). Resistance to Rhizoctonia root and crown rot was best expressed in 1988 when disease pressure was moderate.

In conclusion, isolates of *R. solani* AG-2-2 IIIB and AG-2-2 IV were pathogenic to bean crops and sugar beet, so close rotation of these crops should be avoided. This research, as well as other recent evidence (9,14), indicates that host range is unrelated to the intraspecific groups AG-2-2 IIIB and AG-2-2 IV described by Ogoshi (15). These intraspecific groups, however, are genetically related and have been separated by DNA base sequence homology (7), isozyme polymorphism and DNA restriction analyses (10), zymogram analysis (11), cellular fatty acids (28), and growth at 35°C (25). Further studies are needed to understand the biology and pathology of these intraspecific groups.

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