

Susceptibility of Rotation Crops to a Root Rot Isolate of *Rhizoctonia solani* from Sugar Beet and Survival of the Pathogen in Crop Residues

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ABSTRACT

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Mean seedling survival in pasteurized soil infested with a sugar beet root rot isolate of *Rhizoctonia solani* (anastomosis group 2 [AG-2]) ranged from 1.3 to 4.7% for highly susceptible barley, bean, corn, red beet, and soybean plants and from 20.8 to 56.9% for moderately susceptible muskmelon, sorghum, sugar beet, and wheat plants. Pigweed (*Amaranthus retroflexus*), a common weed in beet fields, had 75% survival. Alfalfa was a nonhost in this study. Lesions from surviving hosts yielded *R. solani* AG-2 isolates that caused rot of 2-mo-old sugar beet roots. Survival of barley, bean, corn, and sorghum plants 2, 4, and 8 wk old at inoculation ranged from 67.5 to 100% with low levels of inoculum; bean and corn showed a trend toward increased survival with increased age. Of 91 fungal isolates from lesions of surviving barley, bean, corn, and sorghum across all ages, only 16, 41, 53, and 51%, respectively, proved to be *R. solani*; all but one *R. solani* isolate were in AG-2, and all AG-2 types rotted 2-mo-old sugar beet roots. Ground residues of infected barley, bean, and sorghum in soil at 20°C yielded *R. solani* AG-2 after 8 but not 12 wk of incubation; residues of corn yielded the pathogen up to 6 wk. The soil-residue mixtures of bean, corn, and sorghum still were conducive for sugar beet damping-off after 12 wk, even though the pathogen could not be recovered by soil-dilution techniques. No sugar beet damping-off occurred in the barley residue-soil mix after 12 wk. Results indicate that more than pathogen susceptibility must be considered in selecting cropping sequences to control *Rhizoctonia* root rot in sugar beet and that persistence of the pathogen in crop residues may be dependent on the crop species.

Crop rotation has been recommended as a control of sugar beet (*Beta vulgaris* L.) root rot caused by *Rhizoctonia solani* Kühn (*Thanatephorus cucumeris* (Frank) Donk) (10,13). Maxson (10) stated that any small-grain crop reduced *Rhizoctonia* root rot in sugar beet in 3- to 4-yr rotations; however, he recommended an alfalfa-potato-sugar beet sequence in potato-growing areas. In all the crop sequences tested by Schuster and Harris (13), either potatoes or beans preceded sugar beet. Disease reduction was attributed more to length of the beefree period than to the crop species that preceded sugar beet. Root rot incidence was low in 4- or 6-yr rotations and highest

in sugar beet monoculture or 2-yr rotations.

Ideally, nonhost crop species usually should precede the crop for which protection is desired. Maxson (9) considered sugar beet, potato, alfalfa, sweet clover, and bean as "host crops," whereas he considered small grains and corn as "non-host crops." He reported 3-50% more root rot in sugar beet following host than following nonhost crops. Greenhouse and field inoculations by Schuster and Harris (13) with seven isolates of *R. solani* indicated that corn and bean were nonhosts of the sugar beet pathogen, but some isolates were pathogenic to potato. In 4- or 6-yr rotations, however, it made little difference in disease incidence whether potatoes or bean preceded sugar beet.

R. solani is an ubiquitous pathogen of many crop and weed species, including alfalfa, barley, bean, corn, potato, sorghum, and wheat (15). These crops usually are used in rotations with sugar beet in Colorado and adjacent states, but little damage attributable to *R. solani* infection has been observed in any crop immediately succeeding sugar beet heavily infected with the pathogen. Even in our breeding nurseries where severe, artificial epidemics were established, succeeding barley crops showed no evidence of losses caused by *Rhizoctonia*. Three possibilities exist: 1) Rotation crops are truly nonhosts of sugar beet isolates of *R. solani*; 2) crops such as barley and corn escape infection because

they are planted early, when cool soil temperatures preclude *Rhizoctonia* activity, and become resistant with maturity; or 3) the saprophytic persistence of the fungus within crop residues depends on the crop species involved. This study was conducted to examine more closely the role of rotation crops in the epidemiology of *Rhizoctonia* root rot in sugar beet.

MATERIALS AND METHODS

Preliminary tests indicated that 10 Colorado sugar beet root isolates of *R. solani* (all anastomosis group 2 [AG-2]) induced similar rates of damping-off of several plant species. Thus, isolate R-9, which has been used for several years to initiate epidemics of root rot in breeding nurseries at Fort Collins, CO, was used in further studies. Dry, ground, barley-grain inoculum (about 82 propagules of *R. solani* per gram) was prepared as described by Pierson and Gaskill (12).

Isolate R-9 was tested for its ability to cause seedling damping-off in alfalfa, barley, bean, corn, muskmelon, pigweed (*Amaranthus retroflexus* L.), red beet, sorghum, soybean, sugar beet, and wheat. Pasteurized greenhouse soil (three parts soil, one part each of sand and peat moss) was placed in plastic pots (7.5 × 7.5 cm) to within 1.5 cm of the rim. Twenty seeds of each test species were evenly distributed over the soil surface along with about 0.8 cm³ of ground inoculum (about 26 propagules per pot). Seeds and inoculum then were covered with an additional 0.5-cm layer of pasteurized soil. Pots were irrigated immediately and thereafter as needed. Controls consisted of seed covered with autoclaved grain inoculum and soil. Greenhouse temperatures ranged from 22 to 28°C. Seedling survival was recorded at 28 days, and soil was washed carefully from survivors to detect any lesions characteristic of *R. solani* infections. Reisolations were made from these lesions, and *Rhizoctonia* isolates were tested for pathogenicity on 2-mo-old sugar beet. Four replicates were used in a randomized block design in each of two trials.

Barley, bean, corn, and sorghum were used to test the effect of plant age on susceptibility to *R. solani* isolate R-9. Seed of each crop species were sown in 10-cm-diameter clay pots of autoclaved greenhouse soil to provide 2-, 4-, and 8-wk-old plants at inoculation. Plants were thinned to two per pot after emergence.

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At inoculation, 1 cm of autoclaved soil containing 200 µg of viable barley-grain inoculum per gram of soil (about 16 propagules per kilogram of soil) was added to each pot. Seed (six per pot) of the various species also were planted in sterile soil with 1 cm of infested soil on top to provide a "0" age group. Ten replicates were used in a randomized block design in each of two trials. Greenhouse temperatures and irrigations were as described previously.

Plant survival was recorded 30 days after inoculation. Survivors were harvested, washed, and examined for stem or root lesions. After the first trial, plant tissues with lesions were excised, washed for 1 hr in running tap water, dipped in 70% ethyl alcohol, surface-disinfested in 1% sodium hypochlorite for 10 min, rinsed three times in sterile distilled water, and plated on Ko and Hora's (7) selective medium. Within 48 hr, all emerging fungi were transferred to and maintained on potato-dextrose agar slants and identified to genus. Typical *Rhizoctonia* spp. isolates were tested for pathogenicity in sugar beet (cultivar S301-H) by wound-inoculating the taproots of 2-mo-old plants growing individually in 10-cm-diameter clay pots of pasteurized soil. The anastomosis group of each *Rhizoctonia* isolate was determined (11).

To determine survival of *R. solani* in colonized tissues of barley, bean, corn, and sorghum, pots containing 4-wk-old plants were infested as described before, except the rate of inoculum was doubled to ensure ample infections. After 30 days, plants were harvested and sections of stem and root with typical lesions were excised, triturated in a blender, and mixed 1:10 (v/v) with sterile greenhouse

potting soil that had a moisture potential of -0.3 bar. The soil-residue mixtures were maintained in plastic beakers with perforated paperboard lids in an incubator at 20 C. Periodic additions of sterile water maintained the mixtures at their original moisture level. After 2, 4, 6, 8, and 12 wk, the mixtures were remixed and samples from each used to make soil dilutions for the determination of viable *Rhizoctonia* propagules according to the method of Ko and Hora (7). After the 12-wk samples were assayed, 10 sugar beet seeds were planted in each beaker to determine damping-off potential of the mixtures. This experiment was repeated once.

RESULTS

Test species. All test species except alfalfa were susceptible to varied degrees to the AG-2 sugar beet root rot isolate of *R. solani*. Based on percent survival of controls grown in uninfested soil, mean seedling survival of the test species in two trials was as follows: alfalfa, 143.4%; barley, 1.3%; bean, 1.5%; corn, 1.4%; muskmelon, 55.4%; pigweed, 75.0%; red beet, 3.9%; sorghum, 56.9%; soybean, 4.7%; sugar beet, 20.8%; and wheat, 25.0%. Several surviving seedlings of bean, corn, pigweed, red beet, sorghum, soybean, and wheat showed typical *Rhizoctonia*-like lesions at the soil line; isolations from these lesions always yielded AG-2 *R. solani* isolates that were pathogenic in sugar beet roots.

Plant age. Bean and corn, and to some extent barley and sorghum, showed increased survival with increased age of plant at inoculation (Table 1). Survival of 2- to 8-wk-old barley and sorghum plants was significantly greater than seedling survival ("0" age), but differences among

other age groups and plant species were not significant. There was a trend in surviving plants toward more lesions with increased age; however, such lesions yielded varied percentages of *R. solani* isolates without an apparent association with plant age. Over all plant ages, only 16, 41, 53, and 51% of the isolates (91 total) from barley, bean, corn, and sorghum, respectively, were *Rhizoctonia* spp. Of these isolates, one was in AG-3 and was nonpathogenic to sugar beet; all others were in AG-2 and caused root rot of 2-mo-old sugar beet. Other isolates from lesions included *Fusarium* spp., *Helminthosporium* spp., *Mucor* spp., and *Trichoderma* spp.

Survival in plant residues. *R. solani* was recovered from soil-residue mixtures of barley, bean, and sorghum after 8 but not 12 wk of incubation; soil-residue mixtures of corn yielded the pathogen up to 6 wk. Although the pathogen was not recovered after 12 wk of incubation of any soil-residue mixture, mean percent damping-off of sugar beet in the bean, corn, and sorghum mixtures was 37.5, 32.5, and 72.5%, respectively. No damping-off occurred in the barley mixture. Soil dilution assays for *Rhizoctonia* were unable to detect the low population densities that apparently persisted after 12 wk in the bean, corn, and sorghum mixtures.

DISCUSSION

The R-9 root rot isolate of *R. solani* from sugar beet (and several other isolates not reported here) evoked responses in several test species ranging from nonpathogenic in alfalfa to highly susceptible in barley, bean, corn, red beet, and soybean. From 25 to 79% damping-off occurred in other species tested. Lesions from surviving plants of all susceptible species yielded typical *R. solani* AG-2 capable of inducing root rot in sugar beet. Thus, contrary to Maxson (9), small grains and corn were hosts of the pathogen, whereas alfalfa was a nonhost in this study. Similarly, isolates used by Schuster and Harris (13) were nonpathogenic to alfalfa, although they also were nonpathogenic to bean and corn, and a sugar beet isolate used by Grisham (4) was pathogenic to carrot and *St. Augustinegrass* but not to corn.

Generally, rotation with nonhosts is practiced to reduce disease incidence in a subsequent host crop, although under certain conditions monoculture has led to pathogen suppression in some soils (1). Results of the host range study, then, would indicate that of those species tested, alfalfa is the only nonhost crop to use immediately preceding sugar beet and that small grains, bean, and corn would be poor choices where *Rhizoctonia* root rot is endemic. However, my observations and those of personnel of the Great Western Sugar Company (9) and many sugar beet growers throughout the Great

Table 1. Effect of plant age on susceptibility of barley, bean, corn, and sorghum to a root rot isolate of *Rhizoctonia solani* (AG-2) from sugar beet and subsequent recovery of the pathogen from lesions of surviving plants

Test species	Age at inoculation (wk)	Survival ^a (%)	Survivors with lesions ^a (%)	Lesions yielding <i>R. solani</i> ^b (%)
Barley	0	86.0	18.3	30.0
	2	95.0	40.0	9.1
	4	97.5	55.0	20.0
	8	95.0	66.7	6.3
Bean	0	48.3	61.3	50.0
	2	67.5	100.0	33.3
	4	70.0	66.7	16.7
	8	97.4	85.0	63.2
Corn	0	69.3	39.0	87.5
	2	87.5	55.0	27.3
	4	90.0	72.2	63.6
	8	97.5	75.0	33.3
Sorghum	0	78.9	16.7	66.7
	2	100.0	84.2	37.5
	4	95.0	70.0	21.4
	8	100.0	100.0	76.2

^a Means of two trials, 10 replicates per trial.

^b Isolations from survivals of trial 1 only.

Plains (*personal communications*) indicate that *Rhizoctonia* root rot incidence is reduced with cropping sequences using small grains or corn preceding sugar beet and is increased following alfalfa. Greenhouse studies and field observations by Coons and Kotila (2) also showed that corn reduced and alfalfa increased sugar beet damping-off when these crops preceded sugar beet, although the identity of the pathogen(s) was not stated. Alfalfa preceding sugar beet in Nebraska resulted in more damping-off of sugar beet by *R. solani* (3). Obviously, more than susceptibility to a pathogen must be considered in establishing cropping sequences in sugar beet rotations.

How alfalfa predisposes sugar beet to damping-off and root rot is not yet understood. The nitrogen-fixing property of alfalfa might lead one to hypothesize that excessive nitrogen may be responsible for increased disease, as reported in some other host-*Rhizoctonia* systems (5,16). Our recent field studies showed, however, that *Rhizoctonia* root rot of sugar beet was unaffected by either nitrogen rate or nitrogen fertilizer carrier (6). Conceivably, although not directly affected, alfalfa roots and residues may support larger increases in inoculum density of *R. solani* than other crops preceding sugar beet. Population density of the cotton Fusarium wilt pathogen, for example, was greater following barley (a nonhost) than following cotton (14). Population density studies of *R. solani* before and after various cropping sequences in sugar beet rotations may clarify the role of alfalfa in predisposing the plants to this pathogen.

At an extremely low population density of *R. solani* propagules, survival of emerged seedlings and plants 2, 4, and

8 wk old at inoculation was quite high (Table 1); however, there was a definite trend toward increased survival with increased age of bean and corn, and to some extent, of barley and sorghum. Where barley or corn is used in rotation with sugar beet in the Great Plains, these crops are planted when soil temperatures favor the host over the pathogen (12 C) (8). As the plants grow, an increased tolerance to the pathogen would account for the minimal *Rhizoctonia* disease problems in these crops. Conversely, beans are planted in June when soil temperatures reach 20–30 C, which favors both pathogen and host. Thus, *Rhizoctonia* root rot of bean can cause serious losses in Colorado when plants are infected at an early stage.

Even at the low inoculum level of *R. solani* in pasteurized soil, barley, bean, corn, and sorghum plants were susceptible at all ages up to 8 wk, and the pathogen persisted in buried crop residue for at least 6–8 wk. Recovery of *R. solani* from lesions was quite variable, however, ranging from 6 to 88% of the lesions, with only 16% of the lesions in barley yielding the pathogen. Undoubtedly, persistence of *R. solani* in crop residues is somewhat dependent on the crop species; however, studies are needed on survival in residues in nonpasteurized field soil under different environmental conditions before conclusions can be drawn about rotation crops serving as reservoirs of inoculum for *Rhizoctonia* root rot of sugar beet.

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