Prevalence and Pathogenicity of Anastomosis Groups of *Rhizoctonia solani* from Wheat and Sugar Beet in Texas

C. M. RUSH, Department of Plant Pathology, Texas Agricultural Experiment Station, Bushland 79012; D. E. CARLING, Agricultural and Forestry Experiment Station, University of Alaska Fairbanks, Palmer 99645; R. M. HARVESON, Texas Agricultural Experiment Station, Bushland 79012; and J. T. MATHIESON, DowElanco, Greenfield, IN 46140

ABSTRACT

Rush, C. M., Carling, D. E., Harveson, R. M., and Mathieson, J. T. 1994. Prevalence and pathogenicity of anastomosis groups of *Rhizoctonia solani* from wheat and sugar beet in Texas. Plant Dis. 78:349-352.

Ninety-eight isolates of *Rhizoctonia* spp., primarily *R. solani,* were isolated from wheat and sugar beets grown in the Texas Panhandle and typed for anastomosis group (AG). Of the 46 isolates from mature beet, 89% were AG2-2; of the 45 isolates from wheat, 95% were AG4; and most of the isolates obtained from beet seedlings were either AG4 or AG5. Two isolates of binucleate *Rhizoctonia* sp. also were recovered, one from mature sugar beet and one from beet seedlings. Randomly selected isolates from each AG were capable of colonizing wheat, corn, cotton, and sorghum residue saprophytically; and optimum temperature for growth of most isolates was between 20 and 30 C. In pathogenicity studies, isolates of AG2-2 and AG4 reduced emergence and final stand of sugar beet seedlings, and isolates of AG2-2 caused severe root rot on mature sugar beet. On wheat, none of the isolates reduced emergence, but isolates of AG4 and AG5 caused significant postemergence root rot. Although some isolates of AG2-2, AG4, and AG5 reduced emergence and caused root discoloration on seedlings of corn, cotton, and sorghum, none were highly virulent on these crops. Both isolates of binucleate *Rhizoctonia* sp. were either avirulent or caused only slight root discoloration. Since AG4, the predominant AG of *R. solani* on wheat, was highly virulent to sugar beet seedlings, wheat preceding sugar beets in rotation is not advised.

Rhizoctonia solani Kühn (teleomorph: *Thanatephorus cucumeris* (A.B. Frank) Donk) is an important pathogen of sugar beet (*Beta vulgaris* L.) and wheat (*Triticum aestivum* L.) in the Texas Panhandle. On beets, *R. solani* causes both damping-off of seedlings and crown rot of mature beets (16,21). Seedling disease is mainly a problem on beets that are either planted late or replanted. When beets are planted early (March or early April), damping-off caused by *R. solani* is seldom a problem. Later in the season, as soil temperatures increase, crown rot becomes prevalent, first appearing in June and becoming most severe in July through August.

On hard red winter wheat, Rhizoctonia root rot has only recently been identified as a problem in the Texas Panhandle (10). The disease is usually observed on wheat planted early (August or early September), when soil temperatures are high. It is characterized by reduced stands and nonvigorous growth of individual plants. Typically, infected plants lose lower leaves; lower leaf sheaths become dark brown and necrotic; and roots exhibit discrete, dark brown water-soaked lesions or may be pruned off. Severely infected plants often die, leaving gaps of varying lengths in rows.

Although *Rhizoctonia* spp. have long been recognized as pathogens of wheat, there is considerable discrepancy in reports of species and anastomosis groups (AG) responsible for disease. In the Pacific Northwest, *Rhizoctonia oryzae* Ryker & Gooch (teleomorph: *Waitea circinata* Warcup & Talbot) and *R. solani* AG8 have both been associated with diseased wheat: *R. oryzae* with a root rot and *R. solani* AG8 with bare patch, respectively (17,19).

Lipps and Herr (9) reported sharp eyespot of wheat in Ohio was caused by *Rhizoctonia cerealis* Van der Hoeven (teleomorph: *Ceratobasidium cereale* D. Murray & L.L. Burpee), a binucleate species. However, a disease with similar symptoms in Arkansas reportedly was caused by *R. solani* AG4 (18). These isolates of AG4 did not infect roots, but killed seedlings in greenhouse studies. *R. cerealis,* which also killed seedlings, did not typically cause root damage (18).

Accepted for publication 22 November 1993.

Because of uncertainty about species and anastomosis groups of *Rhizoctonia* spp. that cause disease on wheat, and since sugar beets are grown in rotation with wheat, a survey was conducted to determine the predominant populations of *Rhizoctonia* spp. on these two crops in the Texas Panhandle. Pathogenicity of selected isolates to crops grown in rotation with wheat and sugar beets were also conducted.

MATERIALS AND METHODS

Isolation and AG typing. Infected hard red winter wheat and sugar beet samples were collected in the fall of 1990 from 10 counties in the Texas Panhandle. Plants exhibiting disease symptoms were harvested from more than 100 randomly selected fields and taken to the laboratory for processing. Isolations from wheat were predominantly made from lower leaf sheaths and crown tissue. Few cultures were obtained from roots despite repeated attempts. Isolations were also made from diseased seedlings obtained from previous greenhouse studies in which soils were being screened for various seedling pathogens. On beets, isolations were made from lower root or crown tissue. Diseased tissue was thoroughly washed under tap water and placed on potato-dextrose agar (PDA). A total of 98 cultures resembling *Rhizoctonia* spp. were subcultured onto PDA. Once isolates were freed of fungal and bacterial contaminants, they were stored on sterilized barley (20). All isolates were then paired with known tester isolates of *R. solani* using standardized techniques for AG determination (2). Briefly, cellophane rectangles were dipped in soft PDA (13 g/L) prior to placement on water agar. Mycelial disks from cultures growing on PDA were paired and incubated at 25 C until hyphae met (usually 48–72 hr). The area of cellophane where hyphae overlapped was removed from the petri dish, placed on a glass slide, stained with 0.05% trypan blue, covered with a coverslip, and examined microscopically (400×) for hyphal anastomosis.

Following AG determination, 10 isolates (two or three from each of the predominant AG groups) were randomly selected for pathogenicity tests. These included three isolates of AG4, two of AG2-2, three of AG5, and two binucleate *Rhizoctonia*. Three of the isolates were from wheat, four from mature sugar beet, and three from sugar beet seedlings.

Temperature range and pathogenicity determinations. The effect of temperature on in vitro radial growth was determined by transferring mycelial plugs (0.8 cm in diameter) from the edge of 5-day-old actively growing colonies to PDA. Cultures were incubated in the dark at 10, 15, 20, 25, 30, or 35 C, and colony diameter was measured after 24 and 48 hr. There were three replications of each isolate at each temperature, and the study was repeated once.

Pathogenicity was determined using mature sugar beet, seedlings of sugar beet, wheat, corn, cotton, and sorghum. Colonized barley kernels were used as inoculum. Mature sugar beets were harvested from disease-free fields, transplanted into 7.5-L pots in a greenhouse, and inoculated 3 wk later by placing three colonized barley kernels just below the soil surface in contact with roots. Roots were harvested 8–12 wk after inoculation and rated for disease using a 0–4 scale, with 0 = no disease symptoms and 4 = dead plants. There were three replications of each isolate and the noninoculated control.

For seedling tests, plants were grown in 10 × 10 cm pots containing a nonsterile soil mix of topsoil, sand, and peat (1:1:1 w/w/w) in incubators maintained at 25 C with a 12-hr photoperiod. Ten seeds were planted in each pot and infested with five colonized barley kernels, and emergence counts were taken after approximately 7 days. Plants were harvested and rated for disease using the 0–4 rating described previously. Sugar beet seedlings were not given a disease index value, but, alternatively, two stand counts were taken approximately 7 days apart to determine postemergence damping-off. There were eight replications of sugar beet seedling and each fungal isolate, and four replications for the other crops. These tests were repeated once.

Statistical analyses. Tests for homogeneity of variance were conducted on experiments that were repeated. All data were analyzed by ANOVA, and treatment means were separated by Duncan's multiple range test. When test variances were homogeneous and there were no differences among tests or test × isolate interactions as indicated by ANOVA, data from repeated tests were merged for ease of presentation.

RESULTS

Anastomosis grouping. Most isolates of *R. solani* (49%) were AG4, 43% were AG2-2, 5% were AG5, and 2% were binucleate *Rhizoctonia* (Table 1). Most AG4 isolates (89%) were from wheat, while 95% of AG2-2 isolates were from sugar beet. Eighty-nine percent of all isolations from mature sugar beet were AG2-2. Six percent of the isolations from mature sugar beet were AG4 and one was binucleate *Rhizoctonia*-like. Of the seven cultures of *Rhizoctonia* from sugar beet seedling, two were AG4 and three were AG5. Only two isolates recovered in this study were binucleate *Rhizoctonia,* one from mature sugar beet and one from a sugar beet seedling.

Temperature effects on mycelial growth. Tests for homogeneity of variance indicated significant differences between repeated tests, and ANOVA indicated significant test × isolate interactions existed. Consequently, results of repeated tests are shown separately (Tables 2 and 3). In both tests, all isolates generally

Table 1. Identity of 98 isolates of *Rhizoctonia* spp. collected from wheat and sugar beets in Texas in 1990

Crop	Isolates (no.)	Anastomosis groups of *R. solani*[z]			Binucleate *Rhizoctonia*
		AG4	AG2-2	AG5	
Beet	46	3	41	1	1
Wheat	45	43	1	1	0
Beet seedling	7	2	1	3	1

[z] Determined by pairing each isolate against known tester isolates.

Table 2. Growth of isolates of *Rhizoctonia* species at six temperatures[x] (test 1)

Temp. (C)	Anastomosis groups of *R. solani*								Binucleate *Rhizoctonia* spp.	
	AG4			AG2-2		AG5				
	W[y]	B	BS	W	B	W	B	BS	B	BS
10	18.6 fD[z]	22.3 eB	17.3 eD	15.6 fE	15.6 eE	20.6 eC	15.3 eE	27.3 eA	17.6 eD	19.0 eD
15	29.6 eC	27.6 dD	24.3 dE	21.3 eF	21.0 dF	31.0 dB	30.3 dBC	32.3 dA	24.6 dE	25.3 dE
20	71.6 cA	55.3 bD	69.6 bAB	40.6 cG	45.6 cF	64.6 bC	64.3 bC	68.3 bB	49.6 bE	51.6 bE
25	82.6 bA	60.3 aE	72.3 abC	47.0 bH	52.3 aG	70.6 aCD	69.6 aD	77.3 aB	55.3 aF	59.6 aE
30	85.0 aA	44.3 cGH	74.6 aB	54.6 aD	50.0 bF	59.6 cC	50.0 cF	52.0 cE	45.0 cG	43.0 cH
35	37.3 dA	9.6 fF	33.0 cB	25.3 dC	20.0 dD	12.0 fE	11.3 fE	9.0 fF	11.6 fE	20.0 eD

[x] Colony diameter (mm) after 48 hr of growth on potato-dextrose agar.
[y] Host from which isolate was recovered: B = mature beet, BS = beet seedling, and W = wheat seedling.
[z] Means in a column followed by the same lowercase letter or in a row followed by the same uppercase letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

Table 3. Growth of isolates of *Rhizoctonia* species at six temperatures[x] (test 2)

Temp. (C)	Anastomosis groups of *R. solani*								Binucleate *Rhizoctonia* spp.	
	AG4			AG2-2		AG5				
	W[y]	B	BS	W	B	W	B	BS	B	BS
10	22.6 dD[z]	20.6 fE	17.0 fG	18.3 fF	19.0 dF	25.3 eB	26.0 eB	30.6 eA	24.0 dC	20.6 eE
15	37.6 cC	29.0 eF	29.0 eF	29.3 eF	27.6 cF	38.6 cBC	40.0 dB	46.3 dA	35.3 cD	31.6 dE
20	68.6 bA	50.0 cC	49.6 cC	44.0 cD	39.0 bE	64.3 cB	64.0 cB	69.0 cA	49.3 bC	50.6 cC
25	82.0 aA	63.0 bD	70.0 bC	53.6 bEF	50.6 aF	77.0 aB	75.3 aB	80.3 aA	55.6 aE	62.0 bD
30	82.0 aA	66.0 aE	76.6 aB	59.3 aF	53.6 aH	73.6 bC	68.3 bD	73.0 bC	56.0 aG	64.6 aE
35	38.3 cA	37.0 dAB	38.3 dA	35.3 dB	19.6 dD	16.3 fE	15.0 fE	15.3 fE	13.0 eF	21.6 eC

[x]Colony diameter (mm) after 48 hr of growth on potato-dextrose agar.
[y]Host from which isolate was recovered: B = mature beet, BS = beet seedling, and W = wheat seedling.
[z]Means in a column followed by the same lowercase letter or in a row followed by the same uppercase letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

Table 4. Emergence of sugar beet seedlings from soil infested with isolates of *Rhizoctonia* spp.

Isolate[x]	Test 1[y]		Test 2	
	7 Day[z]	11 Day	7 Day	14 Day
None	9.3 a	9.1 ab	9.2 a	9.0 a
BS-binucleate	9.1 a	9.1 ab	8.7 a	9.2 a
B-binucleate	9.7 a	9.7 a	8.5 a	9.1 a
BS-AG5	9.7 a	9.0 ab	8.9 a	8.5 a
B-AG5	9.1 a	8.1 b	8.2 a	7.7 a
W-AG5	9.1 a	8.5 ab	9.2 a	9.1 a
B-AG2-2	5.2 b	1.9 de	6.7 b	4.9 b
W-AG2-2	8.5 a	5.5 c	6.2 b	3.9 bc
BS-AG4	5.5 b	2.1 d	1.7 c	1.6 d
B-AG4	5.2 b	1.6 de	6.0 b	2.6 cd
W-AG4	3.2 c	0.7 e	2.9 c	2.1 d

[x]Letters preceding AG designation indicate host from which isolate originated: B = mature sugar beet, BS = sugar beet seedling, and W = wheat.
[y]Stand counts were taken twice in each test. In test 1, the first count was 7 days after planting and the second 11 days after planting. In the second test, the first count was 7 days after planting and the second 14 days after planting.
[z]Values represent the mean number of seedlings emerged from eight replications, with ten seeds planted per pot. Values in each column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

grew best between 20 and 30 C. In the first test, isolates grew best at 20–25 C, and in the second test at 25–30 C. Radial growth at temperatures less than 20 C or greater than 30 C was always dramatically reduced.

Isolates within a particular AG usually grew at similar rates, but the small differences were often statistically significant. An exception to this was the AG4 isolate from mature sugar beet in test 1 (Table 2), which grew relatively well at cool temperatures, but at high temperatures its growth rate was far less than that of the other two AG4 isolates from beet and wheat seedlings. In the second test, these differences were less pronounced but still apparent at 25–30 C.

Although differences within an AG generally were small, differences among AGs frequently were great, especially among certain isolates. In both tests, the AG4 isolate from wheat was significantly more vigorous at 20–35 C than were most other isolates; but at 10–15 C, it was only intermediate in growth. Conversely, the AG5 isolate from beet seedling grew much better at 10 or 15 C than did the other isolates. Generally, AG4 and AG5 isolates were more vigorous at all temperatures than were AG2-2 and binucleate *Rhizoctonia* isolates.

Pathogenicity determinations. In pathogenicity tests on mature beets, only the isolates of AG2-2 and AG4 from mature beet caused infection, with the AG2-2 isolate being the more virulent (disease index value of 4). The isolates of AG2-2 from wheat and of AG4 from beet were much less virulent, with disease index values of 1.7 and 1.3, respectively.

Because repeated pathogenicity tests with sugar beet seedlings were significantly different, data for both tests are shown (Table 4). Only isolates of AG2-2 and AG4 significantly affected emergence. In both tests, the AG4 isolate from wheat caused mostly preemergence damping-off, while the other isolates of AG4 and AG2-2 caused more postemergence damping-off. None of the other isolates affected either preemergence or postemergence damping-off.

None of the isolates greatly reduced the emergence of corn, cotton, sorghum, or wheat (Table 5), although some stands were significantly less than the noninfested control. Varying degrees of infection, as indicated by the disease index (DI), were observed with most isolates (Table 5). In general, symptoms consisted of necrotic or discolored local lesions but no extensive root deterioration. Random isolations from symptomatic roots and stems from all host–isolate combinations typically yielded cultures of *Rhizoctonia* spp. Plants in noninfested soils were generally free of root lesions and disease symptoms.

DISCUSSION

Ninety-five percent of all *R. solani* isolates from wheat collected in the Texas Panhandle were AG4. Sterne and Jones (18) also found *R. solani* AG4 to be the primary AG of *R. solani* infecting wheat in Arkansas, but they isolated mainly from sharp eyespot lesions on wheat stems. In this study, isolations were made from crown and leaf sheath tissues from young wheat seedlings (≤4 on Feeke's scale). Sharp eyespot lesions are frequently seen on older wheat in the Texas Panhandle. However, it is not known if the isolates of *R. solani* AG4 we obtained would cause the same disease described by Sterne and Jones, although they indicated that their isolates from sharp eyespot lesions also were virulent to wheat seedlings (18).

The other two isolates of AG4 used in this study differed in their effect on wheat. The isolate from beet seedling was virulent, but the one from beet was not. Variation in virulence among isolates of *R. solani* within an AG is not uncommon (1,4,22). Therefore, the lack of virulence of the beet AG4 isolate to wheat was not surprising. Similar differences among isolates were also observed with AG5 on corn and cotton; binucleate *Rhizoctonia*-like isolates on corn, cotton, and sorghum; AG2-2 on corn; and AG4 on sorghum.

Although AG4 was by far the predominant pathogen on wheat, an AG2-2 and an AG5 were also recovered from diseased seedlings. These could have been growing saprophytically on dead tissue, since it is known that cortical tissues on wheat and other crops slough off and provide a rich food source for soil microorganisms (3,5,8,14,15). However, in virulence tests, not only the AG5 isolated from wheat but also the two

Table 5. Effects of several isolates of *Rhizoctonia* species on four crops grown in rotation with sugar beet

Isolate[x]	Corn		Cotton		Sorghum		Wheat	
	Emerged[y]	DI[z]	Emerged	DI	Emerged	DI	Emerged	DI
None	10.0 a	0.0 f	7.5 a	0.0 e	9.0 ab	0.2 e	9.2 ab	0.0 f
BS-binucleate	9.1 ab	0.8 e	7.5 a	0.4 e	8.9 ab	1.1 d	9.2 ab	0.4 e
B-binucleate	8.9 ab	1.3 d	8.0 a	1.4 d	9.6 a	1.7 c	8.7 ab	0.2 ef
BS-AG5	9.2 ab	1.5 d	6.7 a	2.2 c	9.1 ab	2.1 b	9.6 a	2.0 c
B-AG5	8.9 ab	2.3 b	7.5 a	2.4 bc	8.7 abc	2.3 ab	8.7 ab	2.1 c
W-AG5	9.4 ab	2.2 bc	6.9 a	2.8 ab	8.6 bc	2.2 ab	9.2 ab	2.3 bc
B-AG2-2	7.6 c	3.0 a	4.5 b	2.9 ab	9.3 ab	2.0 bc	8.0 b	1.3 d
W-AG2-2	8.6 bc	2.5 b	7.2 a	2.4 bc	8.7 abc	2.3 ab	8.7 ab	1.0 d
BS-AG4	8.9 ab	1.9 c	4.9 b	3.2 a	7.9 c	2.2 ab	8.6 ab	2.7 a
B-AG4	8.6 bc	1.9 c	4.7 b	2.7 ab	8.9 ab	1.6 c	8.1 b	0.5 e
W-AG4	9.2 ab	2.2 bc	6.6 a	2.4 bc	8.6 bc	2.5 a	8.7 ab	2.6 ab

[x]Letters preceding AG designation indicate host from which isolate originated: B = mature sugar beet, BS = sugar beet seedling, and W = wheat.

[y]Values represent the mean of two stand counts taken in each repeated test. Because results from repeated tests were not different, data were merged for ease of presentation. Means followed by the same letter in a column are not significantly different ($P = 0.05$) as determined by Duncan's multiple range test.

[z]Disease index (DI) was based on a 0–4 scale, with 0 = no disease symptoms and 4 = dead plant.

other isolates of AG5 caused significant damage to wheat seedlings, while isolates of AG2-2 caused minimal damage.

It was interesting that neither of the binucleate *Rhizoctonia* spp. in this study were pathogenic. Similar results have been reported by others (7,20). In a study by Windels and Nabben (20) using 361 isolates from sugar beets, approximately 10% were found to be binucleates. These were nonpathogenic to either mature sugar beets or seedlings. However, others have found binucleate *Rhizoctonia* to be highly virulent. *R. cerealis* has been reported to cause sharp eyespot on wheat (9) and also reduced sugar beet stand establishment (11). The two binucleate isolates in this study and those tested by Windels and Nabben (20) were not identified to species.

As reported in other studies, the main AG isolated from mature sugar beets was AG2-2 (6,7,12,13). The two isolates of AG2-2 used in pathogenicity studies were virulent both on mature beets and on beet seedling, although they were not as consistently virulent on sugar beet seedlings as were the isolates of AG4. In contrast to another report (20), the isolates of AG5 used were nonpathogenic on sugar beet seedlings, which was unexpected in view of the frequency with which AG5 was isolated from diseased beet seedlings.

In the Texas Panhandle, wheat usually precedes sugar beets in rotation. Therefore, from a disease management standpoint, it is significant that the predominant AG on wheat was AG4, which is also highly virulent on sugar beet seedlings. Since AG4 is so common on wheat, it is somewhat surprising that damping-off of sugar beet seedlings is not more common. However, this can be partially explained by the temperature optimum for linear growth of AG4. Sugar beets are typically planted in cool soils ranging around 15 C or lower. As indicated by the results in Table 2, AG4 grows much more vigorously at warmer temperatures (25–30 C). Therefore, sugar beet seedlings may often escape infection by *R. solani* because temperatures are below the optimum for fungal growth. The fact that AG4 is more vigorous at higher temperatures also helps explain why root rot of wheat is more severe in August plantings than when wheat is planted in late September or October when soil temperatures are much cooler. The results of this study should be beneficial to Texas growers making decisions about planting time and sequence of rotation crops.

LITERATURE CITED

1. Bolkan, H. A., and Ribeire, W. R. C. 1985. Anastomosis groups and pathogenicity of *Rhizoctonia solani* isolates from Brazil. Plant Dis. 69:599-601.
2. Carling, D. E., and Sumner, D. R. 1992. *Rhizoctonia.* Pages 157-165 in: Methods for Research on Soilborne Phytopathogenic Fungi. L. L. Singleton, J. D. Mihail, and C. M. Rush, eds. American Phytopathological Society, St. Paul, MN.
3. Deacon, J. W., and Lewis, S. J. 1982. Natural senescence of the root cortex of spring wheat in relation to susceptibility of common root rot (*Cochliobulus sativus*) and growth of a free-living nitrogen-fixing bacterium. Plant Soil 66:13-20.
4. Grisham, M. P., and Anderson, N. A. 1983. Pathogenicity and host specificity of *Rhizoctonia solani* isolated from carrots. Phytopathology 73:1564-1569.
5. Henry, C. M., and Deacon, J. W. 1981. Natural (non-pathogenic) death of the cortex of wheat and barley seminal roots, as evidenced by nuclear staining with acridine orange. Plant Soil 60:255-274.
6. Herr, L. J. 1987. Populations of *Rhizoctonia solani* in soil under crops in rotation with sugar beet. Ann. Appl. Biol. 110:17-24.
7. Herr, L. J., and Roberts, D. L. 1980. Characterization of *Rhizoctonia* populations obtained from sugarbeet fields with differing soil textures. Phytopathology 70:476-480.
8. Kirk, J. J., and Deacon, J. W. 1986. Early senescence of the root cortex of agricultural grasses, and of wheat following root amputation or infection by the take-all fungus. New Phytol. 104:63-75.
9. Lipps, P. E., and Herr, L. J. 1982. Etiology of *Rhizoctonia cerealis* in sharp eyespot of wheat. Phytopathology 72:1574-1577.
10. Mathieson, J. T., and Rush, C. M. 1991. Influence of temperature and five fungicides on Rhizoctonia root rot of hard red winter wheat. Plant Dis. 75:983-986.
11. O'Sullivan, E., and Kavanagh, J. A. 1990. Damping-off of sugar beet caused by *Rhizoctonia cerealis.* Plant Pathol. 39:202-205.
12. Ruppel, E. G. 1972. Correlation of cultural characters and source of isolates with pathogenicity of *Rhizoctonia solani* from sugar beet. Phytopathology 62:202-205.
13. Ruppel, E. G. 1985. Susceptibility of rotation crops to a root rot isolate of *Rhizoctonia solani* from sugar beet and survival of the pathogen in crop residues. Plant Dis. 69:871-873.
14. Rush, C. M., Gerik, T. J., and Lyda, S. D. 1984. Interactions between *Phymatotrichum omnivorum* and *Sorghum bicolor.* Plant Dis. 68:500-501.
15. Rush, C. M., Lyda, S. D., and Gerik, T. J. 1984. The relationship between time of cortical senescence and foliar symptom development of Phymatotrichum root rot of cotton. Phytopathology 74:1464-1466.
16. Rush, C. M., and Winter, S. R. 1990. Influence of previous crops on Rhizoctonia root and crown rot of sugar beet. Plant Dis. 74:421-425.
17. Smiley, R. W., Wilkins, D. E., and Klepper, E. L. 1990. Impact of fungicide seed treatments on Rhizoctonia root rot, take-all, eyespot, and growth of winter wheat. Plant Dis. 74:782-787.
18. Sterne, R. E., and Jones, J. P. 1978. Sharp eyespot of wheat in Arkansas caused by *Rhizoctonia solani.* Plant Dis. Rep. 62:56-60.
19. Weller, D. M., Cook, R. J., MacNish, G., Bassett, E. N., Powelson, R. L., and Petersen, R. R. 1986. Rhizoctonia of small grains favored by reduced tillage in the Pacific Northwest. Plant Dis. 70:70-73.
20. Windels, C. E., and Nabben, D. J. 1989. Characterization and pathogenicity of anastomosis groups of *Rhizoctonia solani* isolated from *Beta vulgaris.* Phytopathology 79:83-88.
21. Winter, S. R. 1984. Soil incorporated sulfur for Rhizoctonia root rot control in sugar beet. J. Am. Soc. Sugar Beet Technol. 22:278-284.
22. Yitbarek, S. M., Verma, P. R., and Morrall, R. A. A. 1987. Anastomosis groups, pathogenicity, and specificity of *Rhizoctonia solani* isolates from seedling and adult rapeseed/canola plants and soils in Saskatchewan. Can. J. Plant Pathol. 9:6-13.