Rhizoctonia Species and Anastomosis Groups Causing Root Rot of Wheat and Barley in the Pacific Northwest

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ABSTRACT

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Of 104 isolates of *Rhizoctonia solani* from roots or rhizosphere soil of wheat or barley plants representing 45 fields in Idaho, Oregon, and Washington, 42% (representing 14 of the 45 fields) were AG-8. The rest were AG-3 (four), AG-4 (34), AG-5 (one), AG-9 (one), and a possible newly recognized AG-10 (20). AG-8 made up 67% of the isolates of *R. solani* from plants, whereas AG-3, AG-4, AG-9, and AG-10 made up 85% of those from soil. *R. oryzae* (anastomosis group WAG-O) was recovered from 17 fields; 58% of the isolates were from roots and 42% were from soil. The binucleate isolates were AG-CI (five), AG-D (five), AG-E (18), AG-H (four), and AG-K (eight). At 10 C, isolates of AG-8 were highly pathogenic and those of *R. oryzae* were nonpathogenic or mildly pathogenic to wheat and barley. At 20 C, isolates of *R. oryzae* were moderately pathogenic, whereas those of *R. solani* AG-8 were mildly pathogenic to wheat and barley. Isolates of *R. solani* AG-4 and AG-5 and *R. oryzae* from Arkansas (AR) and Japan (Jpn) (both from rice) were nonpathogenic or mildly pathogenic at both 10 and 20 C. The optimal water potential for colony growth of *R. solani* AG-4 and AG-8, *R. oryzae* from rice (AR and Jpn), and *R. oryzae* from wheat or barley from the Pacific Northwest (PNW) was −0.2 to −0.6 MPa at temperatures between 15 and 35 C. Conversely, the optimal temperature for growth was about 25 C for *R. solani* AG-4 and AG-8, 28–30 C for *R. oryzae* from wheat or barley (PNW), and 32–35 C for *R. oryzae* from rice (AR and Jpn). Apparently, *R. solani* AG-8 and *R. oryzae* both are involved in Rhizoctonia root rot of wheat and barley in the Pacific Northwest. Although *R. oryzae* requires a higher temperature than *R. solani* AG-8 to cause root rot of wheat and barley, these strains, compared with those of the same anastomosis group from rice, may represent a "low temperature" ecotype of this species.

Additional keywords: soilborne pathogen, root disease, bare-patch.

Rhizoctonia root rot of wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) was first diagnosed in the Pacific Northwest of the United States in 1984 (22). The disease occurred as patches of stunted plants in fields of spring barley and spring wheat in Washington and winter wheat in Idaho and Oregon. Roots of diseased plants either were girdled (circumscribed) or rotted off (severed) by infections that began as sunken brown lesions. These root symptoms, and the occurrence of the disease as patches of stunted plants, match the symptoms of bare-patch or purple-patch of cereals described in Australia (4,12,14) and possibly barley stunt disorder in Scotland (5) and crater disease of wheat in South Africa (3,15).

All isolates of *Rhizoctonia* cultured from the roots or lower stems of diseased wheat and barley plants obtained from the patches in 1984 were multinucleate, and the young vegetative hyphae exhibited morphological characteristics typical of *R. solani* Kühn (22). The isolates were highly pathogenic to wheat, causing plant stunting and severed roots (spear tips), but none anastomosed with strains of *R. solani* AG-1, AG-2-1, AG-2-2, AG-3, AG-4, or AG-5. Neate and Warcup (7) erected AG-8 for the strains responsible for root rot (bare-patch) of wheat and barley in Australia.

Although Rhizoctonia root rot of wheat and barley is a newly diagnosed problem for the Pacific Northwest, sharp eyespot caused by *R. cerealis* has long occurred on wheat in this area, and Sprague (17) isolated *R. oryzae* Ryker from barley from near Lewiston, ID. In addition, strains of *R. solani* cause root rot of peas and potatoes grown in rotation with wheat and barley in the Pacific Northwest; possibly these same strains are pathogenic on the roots of wheat and barley. The purpose of this study was to determine which species and/or anastomosis group(s) is responsible for Rhizoctonia root rot and associated stunting of wheat and barley plants at soil temperatures likely to occur in the Pacific Northwest.

MATERIALS AND METHODS

Sampling of plants and soils. Wheat or barley plants and soils were sampled from 45 fields in northern Idaho, northeastern Oregon, and eastern Washington from May to July (late spring to early summer) 1986. These fields were in typical rotations (wheat/fallow; wheat/peas; or wheat/barley/peas) for the region. None was obviously affected by Rhizoctonia root rot, nor were they selected because of suspected Rhizoctonia root rot, unless stated otherwise. Plants were in the stem-extension stage in May and headed in June. Approximately 25 plants were dug at random from an area about 100 m in diameter and at least 50 m in from the edge of the field. Plants were dug to at least a 10-cm depth and transported with soil in plastic bags to the laboratory. Soil was shaken from the roots and transferred to 20-cm-diameter clay pots for subsequent baiting experiments (see below). Roots then were washed in a jet stream of tap water, severed from the tiller bases (in the case of tiller roots) or subcrown internodes (in the case of seminal roots), and washed again (overnight) beneath running tap water.

Isolation and identification of *Rhizoctonia*. Roots were blotted dry on new paper toweling, and segments with cankerous lesions or spear tips were placed on acidified water agar (2% water agar amended with 3 ml of 10% lactic acid per liter of medium). Hyphal tips of *Rhizoctonia*-like fungi were transferred to homemade potato-dextrose agar (PDA) prepared with the boiled water extract from 200 g of unpealed potatoes, 20 g of glucose, and 20 g of agar. Soils (collected with the plants) from the respective fields and transferred to pots on a greenhouse bench (20 ± 2

C) were watered to approximately −0.03 MPa matric potential ("field capacity"), and 4-cm-long internodal segments of mature, dried oat straw were inserted vertically, 10 per pot, and left there for 3 days. Straws then were removed, washed, blotted, and placed on acidified water agar. Isolates of *Rhizoctonia* were transferred to PDA.

Isolates were identified on the basis of appearance of mature colonies on PDA in petri plates, whether binucleate or multinucleate (20), requirement for thiamine when grown on Czapex agar medium with or without thiamine hydrochloride at 10 μg/ml (9), hyphal anastomosis with known tester isolates, and characters of the teleomorph (when available). To test for hyphal anastomosis, an isolate of unknown anastomosis group was cocultured on water agar with tester isolates of known anastomosis groups (8). Inspection for hyphal fusion was made under a compound microscope at ×60 or ×150. The teleomorph was produced by the soil method of Stretton et al (18).

Tests for pathogenicity. Up to three isolates of each species and selected anastomosis groups of *Rhizoctonia* were tested for pathogenicity to wheat and barley at 10 and 20 C. The isolates and their original hosts were: three of AG-4 from winter wheat, alfalfa, and spring barley, respectively; two of AG-5 from winter wheat, representing an earlier collection (22), and one from spring barley collected in the course of our study; two of AG-8 from spring barley and one from winter wheat; and one of *R. oryzae* from spring barley and two from winter wheat.

Pathogenicity tests in soil were conducted by a modification of the method of McDonald and Rovira (4). Inoculum in colonized millet seeds was produced by transferring PDA cubes with mycelium to 1-L flasks of autoclaved (60 min, twice) seed that had been adjusted to 75% (w/w) water content. After 3 wk, the colonized seeds were spread out and dried at room temperature, then blended at 0.1% (1 g/kg of soil) with pasteurized (80 C moist heat for 30 min) natural Thatuna silt loam obtained from the Washington State University Plant Pathology Farm. These infested soils, representing the respective isolates, were placed in tapered plastic tubes (4 cm diameter × 20.5 cm long) with drain holes (Ray Leach Cone-tainer Co., Canby, OR). Seven tubes (replicates) were prepared for each isolate × host × soil temperature in a completely randomized design. The seven replicate tubes of the respective isolates were completely randomized within each of the eight possible combinations of the two hosts, two soils, and two temperatures and were analyzed as eight separate experiments.

To fill the tubes, cotton plugs were placed in the bottoms, vermiculite was added to fill the bottom 7.5 cm of each tube (for improved drainage and aeration), and then 40 g of infested soil was placed on the vermiculite, filling each tube to within about 5.5 cm of the top. The soil was watered to near saturation and left to drain and incubate in the dark at 10 or 20 C for 2 wk, and then three seeds of either wheat (cultivar Stephens) or barley (cultivar Gustoe) were placed on the drained soil and covered with a 2-cm-thick layer of the same soil not infested with *Rhizoctonia*. The tubes were again watered to near saturation, returned to the growth chambers at 10 or 20 C, and left to drain while the plants emerged, with light provided on a 12-hr day/night cycle. Controls were prepared in the same way with noncolonized, autoclaved millet seeds at the same rate. The tests were repeated.

Pathogenicity tests with *R. oryzae* also were conducted at 10 and 20 C in vermiculite, to further evaluate the isolates from wheat, barley, and rice in a rooting medium assumed to be even more conducive to root rot than pasteurized soil. The isolates tested included one each from winter wheat, spring barley (both from the Pacific Northwest [PNW]), and one each from rice from Arkansas (AR) and Japan (Jpn). Five (2.5 cm × 15 cm) plastic tapered tubes (Ray Leach Cone-tainers) were filled to 8-cm depth with autoclaved vermiculite for each of three replicates of isolate × host × temperature. The five tubes, representing each replicate of each treatment, were kept together as a unit, with replicates of the respective isolates arranged in a completely randomized design within each of the four combinations of host and temperature.

Two 7-mm-diameter disks of a PDA culture of the appropriate isolate together with 0.5 g of quick oats (Quaker) were added to each tube, covered with another 1-cm-thick layer of vermiculite, and watered to saturation. All tubes with infested vermiculite were incubated for 3 days at 16 C, and then half of the tubes representing each respective isolate were incubated at 10 C and the other half at 20 C for 4 more days. Two seeds of either winter wheat (cultivar Stephens) or spring barley (cultivar Gustoe) were placed on the infested vermiculite, covered with a 1-cm-thick layer of uninfested vermiculite, saturated with a water solution of standard mineral nutrients, and the tubes then returned to 10 and 20 C, respectively. Controls included sterile agar and oats with no pathogen.

Plants were removed from the tubes and evaluated for size and root disease after 21 or 35 days at 20 or 10 C, respectively, in soil, and after 17 or 28 days at 20 or 10 C, respectively, in vermiculite. Shoot length was measured for each plant as the distance from the remnant seed piece to the tip of the longest leaf. Roots were washed and rated on a scale of 0 to 3, where 0 = root system extensive and white, 1 = one or two of the seminal roots with one or more lesions each (mildly pathogenic), 2 = three or all seminal roots with one or more lesions, some with several lesions (moderately pathogenic), and 3 = root system severely rotted and brown (severely pathogenic). All data were analyzed by general linear model (version 5, SAS Institute, Inc., Cary, NC), and values for isolates tested in the two hosts in the two soils at the two temperatures were compared either by a least significant difference or Duncan's multiple range test at $P = 0.05$.

Determination of optimal temperature and water potential for colony growth in vitro. Several experiments were conducted to determine the optimal temperature and substrate water potential (osmotic potential of agar medium) for colony growth of isolates of *R. solani* AG-8 and *R. oryae*, the two taxa pathogenic to wheat and barley. An isolate of *R. solani* AG-2-1 from sugar beet from Japan, an isolate of *R. oryzae* from rice from Arkansas, and an isolate of *R. oryzae* from Japan were included in these experiments as representatives of these species from hosts other than wheat or barley. In a typical experiment, one isolate each of *R. solani* AG-2-1, AG-8 from wheat or barley, *R. oryzae* from wheat or barley from the Pacific Northwest, and *R. oryzae* from rice from Arkansas or Japan were grown on homemade PDA adusted to different osmotic potentials with KCl (16) and incubated at different temperatures. Incubation temperatures ranged from 5 to 40 C, and water potentials ranged from −0.2 (homemade PDA with no KCl) to −2.0 MPa. A 6-mm-diameter plug from the margin of a fresh PDA culture of each isolate was transferred to each of two (duplicate) petri plates of medium for each temperature and water potential. Colony diameters were measured for all plates when the fastest growing colonies (treatments) reached the edge of the plate (41–48 hr after start of the experiment). Colony diameters were divided by the hours of incubation and multiplied by 24 to reduce all data to millimeters colony growth per 24 hr.

RESULTS

***R. solani* from plants and soils.** One hundred and four isolates of *R. solani* were recovered from plants or soils of 45 fields of

TABLE 1. Number of isolates of *Rhizoctonia oryzae* from wheat and barley plants or baited from soils collected with the plants

Plant	No. fields sampled[a]	No. isolates	
		Roots	Soil
Spring barley	11 (6)	33	18
Spring wheat	9 (1)	0	7
Winter wheat	19 (8)	11	7
Winter barley	6 (2)	3	2
Total	45 (17)	47	34

[a]Numbers in parentheses indicate fields positive for *R. oryzae*.

wheat or barley sampled in Idaho, Oregon, and Washington. Nearly half (44/104) of these isolates, representing 14 fields, were identified as AG-8. Of these 44 isolates, 38 (86%) were from roots of wheat or barley and six (14%) were baited from soil with oat straws. Twenty of the 104 isolates of *R. solani* were tentatively placed in AG-10 (fused with each other but not with isolates of AG-1 to AG-9 or AG-BI, to be described in a later publication) and, of these, 19 were baited from soil and only one was isolated from a plant. Of the other 40 isolates of *R. solani*, 34 were AG-4 (17 from roots and 17 from soil), four were AG-3 from soil, one was AG-5 from spring barley, and one was AG-9 from soil.

***R. oryzae* from plants and soils.** Eighty-one multinucleate *Rhizoctonia*-like fungi (not *R. solani*) were isolated from 17 fields of wheat and barley (Table 1). These were identified as *R. oryzae* (WAG-O) (10) based on anastomosis with representative isolates of *R. oryzae*.

Identification of telemorphs of multinucleate *Rhizoctonia* spp. Sixteen isolates of AG-8, one of AG-9, six of AG-10, and three of *R. oryzae* were cultured for induction of the teleomorph. Eleven isolates of AG-8, one of AG-9, and six of AG-10 formed their teleomorph, each of which matched *Thanatephorus cucumeris* (Frank) Donk (19). One isolate of *R. oryzae* formed its teleomorph, which matched *Waitea circinata* Warcup & Talbot (21).

Binucleate *Rhizoctonia* from plants and soils. Forty-one isolates of binucleate *Rhizoctonia* were isolated and identified as AG-CI (five), AG-D (five), AG-E (18), AG-H (four), AG-K (eight), and an unidentified AG-X (one). Twenty-four of these isolates were from roots and 17 were from soils.

Pathogenicity of *R. solani* and *R. oryzae*. There was no statistical difference in performance of different isolates of a given species and anastomosis group of *Rhizoctonia*, and, therefore, values for isolates within groups were combined for purposes of presenting the results herein. *R. solani* AG-8 caused more disease on wheat and barley at 10 C than at 20 C, and *R. oryzae* caused more disease on these plants at 20 C than at 10 C (Table 2). This pattern held for both natural and pasteurized Thatuna silt loam. Isolation from infected roots confirmed the presence of the respective species of *Rhizoctonia* under test. None of the isolates of *R. solani* AG-4 and AG-5 caused root symptoms or stunting of wheat or barley at 10 or 20 C in either pasteurized or natural soil. Tests with *R. solani* AG-8 and the PNW isolates of *R. oryzae* (from wheat or barley) were repeated and results were the same: *R. solani* AG-8 caused severe disease at 10 C and mild or moderate disease at 20 C, in contrast to *R. oryzae*, which caused mild or no disease at 10 C and moderate to severe disease at 20 C.

Pathogenicity tests also were conducted in vermiculite with two isolates of *R. oryzae* from wheat and barley (PNW-2 and PNW-3, respectively) and two isolates of the same anastomosis group (WAG-O) from rice (AR and Jpn). On barley, the PNW isolates caused significantly more disease than the AR and Jpn isolates at both 10 and 20 C; the latter caused only mild disease or no disease on barley at 10 C but caused stunting of wheat and especially barley at 20 C (Table 3). Under these conditions, that is, in vermiculite, PNW-2 caused the most disease of the four isolates on wheat and barley at either 10 or 20 C.

Optimal temperatures and water potentials for colony growth on agar. Figure 1 presents the results of a typical experiment with one isolate each of *R. solani* AG2-1 and AG-8 and *R. oryzae* from wheat, barley, rice from Arkansas, and rice from Japan. The values from this experiment for the two isolates of *R. oryzae* from wheat and barley, respectively, were combined, as were those for the two isolates from rice from Arkansas and Japan, respectively. All isolates grew maximally at substrate water potentials in the range of −0.20 (homemade PDA) to −0.64 MPa (PDA amended with 0.1 molal KCl/L) and progressively less as the substrate water potential was lowered to −1.1 MPa and "drier" with KCl. This pattern held for all temperatures. Isolates of *R. solani* AG2-1 and AG-8 grew maximally in the range of 20–25 C, and they grew better at 15 C than at 35 C. Isolates of *R. oryzae* from barley or wheat grew maximally at 25–30 C, and they grew better at 35 C than at 15 C. The AR and Jpn isolates of *R. oryzae* from rice grew maximally at 30–35 C.

One isolate from wheat, two from barley, and two from rice (AR and Jpn) were grown on PDA with no KCl at temperatures up to 40 C to further evaluate the optimal temperature for isolates of *R. oryzae*. The optimal temperature was 28–32 C for the isolates from wheat or barley and 32–36 C for the AR and Jpn isolates from rice (Fig. 2). This experiment was conducted three times, and the optimal temperature for colony growth on PDA always was about 4 C higher for the AR and Jpn isolates from rice than for the PNW isolates from wheat or barley.

TABLE 2. Pathogenicity of isolates of *Rhizoctonia solani* AG-4, AG-5, and AG-8, and Pacific Northwest isolates of *R. oryzae* to wheat and barley at 10 and 20 C in pasteurized and natural Thatuna silt loam

	Pasteurized soil				Natural soil			
	Wheat		Barley		Wheat		Barley	
Isolate	Ht[a] (cm)	DR[a,b] (0–3)	Ht[a] (cm)	DR[a,b] (0–3)	Ht[a] (cm)	DR[a,b] (0–3)	Ht[a] (cm)	DR[a,b] (0–3)
10 C								
R. solani								
AG-4	124	0.3	106	0.2	130	0.4	103	0.3
AG-5	121	0.4	98	0.2	126	0.6	106	0.3
AG-8	86	2.7	56	2.9	123	1.5	83	2.1
R. oryzae	120	0.4	98	0.3	118	0.5	103	0.6
Control	127	0.1	106	0.1	118	0.4	106	0.3
LSD	29.2	0.3	16.0	0.3	16.4	0.7	18.8	1.0
20 C								
R. solani								
AG-4	194	0.4	177	0.9	195	0.5	135	0.6
AG-5	189	0.4	144	0.5	180	0.3	125	0.4
AG-8	166	1.3	120	1.7	179	0.7	131	1.0
R. oryzae	166	1.8	61	2.9	161	1.0	111	1.1
Control	179	0.3	167	0.5	203	0.4	142	0.4
LSD	49.5	1.1	80.3	0.6	8.2	0.3	33.5	0.5

[a]Each value is the average of three isolates for each species or anastomosis group (AG) (only two for AG-5). Each isolate, in turn, was tested in seven replicate containers per host × temperature × soil, providing potentially 21 readings per value. Plant heights (Ht) and disease ratings were based only on emerged seedlings; not all seeds produced seedlings. Each host × soil × temperature was treated as a separate experiment for purposes of statistical analysis. The general linear model (version 5, SAS Institute, Inc., Cary NC) was used for analysis, with least significant difference (LSD) calculated at $P = 0.05$.

[b]DR = disease rating with 0 = no symptoms and 3 = reduced, brown root system.

DISCUSSION

R. solani AG-8 and *R. oryzae* both potentially are responsible for Rhizoctonia root rot and associated stunting of wheat and barley in the Pacific Northwest. These two taxa made up 36% (38/104) and 45% (47/104), respectively, of the multinucleate *Rhizoctonia* spp. isolated from roots of wheat and barley. *R. solani* AG-8 was isolated from roots at twice the frequency of AG-4, the second most frequently isolated taxon of *R. solani* from roots. *R. oryzae* was isolated from wheat and barley roots more frequently than any other taxon of *Rhizoctonia*. *R. solani* AG-8 and *R. oryzae* both caused stunting and root rot on wheat and barley. *R. solani* AG-4 caused a slight discoloration of roots of barley at 20 C in pasteurized soil; otherwise, AG-4 and AG-5 were nonpathogenic to these plants. *R. solani* AG-8 produced a more characteristic spear tipping than *R. oryzae*; otherwise, the symptoms produced by these two taxa on roots were similar and matched those described (22) for this disease of wheat and barley.

The fields sampled in this study were chosen at random and not because of obvious symptoms of damage to the crop due to Rhizoctonia root rot. This procedure might explain the relatively low percentage of plants (fewer than 10%) that yielded either *R. solani* AG-8 or *R. oryzae* upon plating roots or baiting from soil collected with the roots. On the other hand, the recovery of *R. solani* AG-8 from nearly half the fields and *R. oryzae* from about one-third of the fields indicates to us that both pathogens are widely distributed in wheat and barley fields in the Inland Pacific Northwest. Had our sampling of plants and soils from any given field been more exhausitve, both pathogens might have been recovered from virtually every field.

R. oryzae causes rice sheath spot (11), characterized as reddish brown elliptical spots 1–10 cm long on leaf sheaths just above the water line. *R. oryzae* has been isolated from leaf sheaths and roots of other gramineous hosts, including oats (*Avena sativa*), barley, wheat, downy brome (*Bromus tectorum*), barnyard grass (*Echinachloa crusgalli*), and other grasses (6,12,16). Burton et al (1) reported the association of *R. oryzae* along with *R. solani* with barley stunt disease in the United Kingdom, but, to our knowledge, this is the first report that *R. oryzae* is associated with Rhizoctonia root rot of wheat.

R. solani AG-8 caused more damage than *R. oryzae* on wheat and barley at 10 C, and the reverse was true at 20 C. We have shown that *R. solani* AG-8 had an in vitro temperature optimum for growth 5 C lower than that of *R. oryzae*. Soil temperatures for winter grains in the Inland Pacific Northwest average 10–15 during stand establishment and drop rapidly as the crop develops before onset of winter. In contrast, soil temperatures for spring grains average 5–10 C during stand establishment and increase

TABLE 3. Pathogenicity of isolates of *Rhizoctonia oryzae* to wheat and barley at 10 and 20 C in vermiculite

	Plant height (cm) and disease rating (DR)[y] per plant species[z]			
	Wheat		Barley	
Isolate[x]	Height	DR	Height	DR
10 C				
PNW 2	11.4 c	2.1 c	4.8 e	2.9 d
PNW 3	14.5 ab	1.1 b	9.1 d	2.5 c
AR	14.4 ab	0.6 a	13.3 c	0.5 a
Jpn	14.4 ab	0.6 a	13.8 bc	0.5 a
Control	15.7 a	0	15.1 a	0
20 C				
PNW 2	11.9 d	2.3 c	4.5 e	3.0 e
PNW 3	15.5 c	1.8 b	6.5 d	2.8 de
AR	14.0 cd	1.2 a	9.5 c	1.9 c
Jpn	16.3 bc	0.9 a	8.0 d	2.5 d
Control	21.5 a	0	19.4	0

[x]PNW 2 and 3 were from the Pacific Northwest from barley and wheat, respectively. AR and Jpn isolates were from rice from Arkansas and Japan, respectively.

[y]DR: 0 = no symptoms, and 3 = reduced, brown root system.

[z]Each value is the mean for potentially 30 seedlings grown for 21 days at 20 C and 35 days at 10 C, in individual containers, three replicates of five containers per replicate of isolate × host × temperature, two seeds per container. Not all seedlings emerged and, thus, a variable number of determinations existed for each value. Analysis, therefore, was by general linear model (version 5, SAS Institute, Inc., Cary, NC). Means within columns and temperature regime followed by the same letter are not different according to Duncan's multiple range test. The controls for DR rated zero and were not included in the analysis.

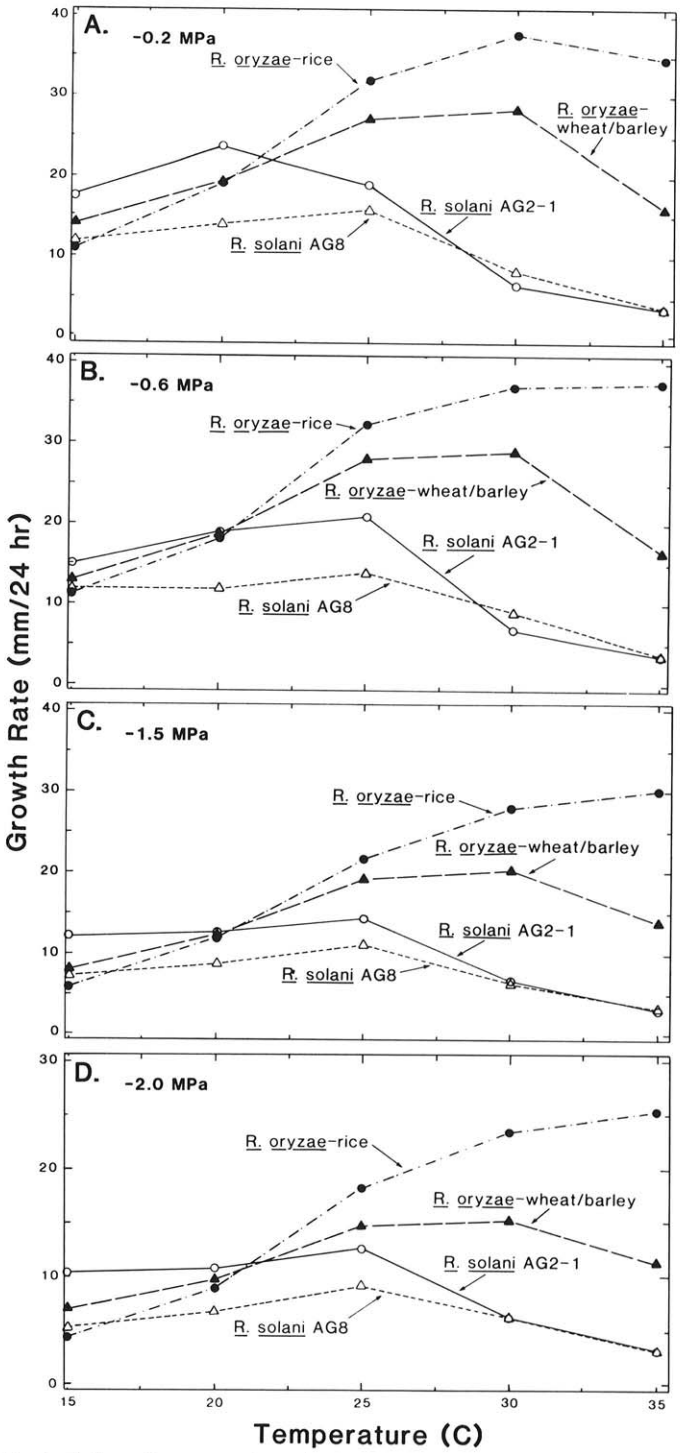

Fig. 1. Colony diameters of one isolate each of *Rhizoctonia solani* AG-2-1 and AG-8 and two isolates each of *R. oryzae* from rice and *R. oryzae* from wheat and barley, respectively, grown on potato-dextrose agar at different temperatures and osmotic potentials adjusted with KCl. Values for the two isolates of *R. oryzae* from rice and those from wheat and barley were similar and, therefore, were combined.

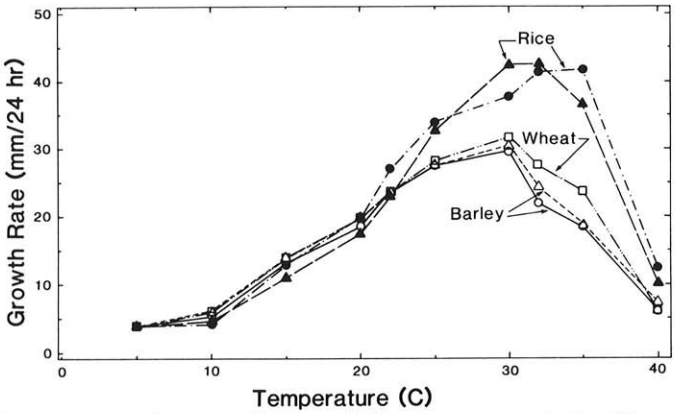

Fig. 2. Colony diameters of isolates of *Rhizoctonia oryzae* isolated from rice (two isolates), wheat (one isolate), and barley (two isolates) and grown on potato-dextrose agar at different temperatures.

to 20–25 C (daily average) as the crop develops. Our samples were collected when the crops were in the jointing to heading stages and, therefore, already exposed to temperatures favorable to both species of *Rhizoctonia*. This may explain why our numbers give no clear indication of a higher frequency of one species of *Rhizoctonia* over the other on either winter or spring grains.

Although favored by the higher range of temperatures than *R. solani* AG-8, the PNW isolates of *R. oryzae* from wheat and barley apparently are adapted to lower temperatures than are the AR and Jpn isolates of *R. oryzae* from rice. Optimal temperatures for growth in vitro by the rice isolates ranged from 32 to 35 C, higher by about 4 C than the optimal temperatures for growth of the PNW isolates from wheat and barley. All isolates were of the same anastomosis group, namely, WAG-O (10), and one PNW isolate of *R. oryzae* formed its teleomorph identified as *W. circinata*. The possibility exists that the PNW isolates from wheat and barley represent a low-temperature "ecotype" of *R. oryzae* (*W. circinata*).

AG-9 was first reported from Alaska by Carling et al (2). In addition to this newly described AG, we found another AG of *R. solani*, tentatively called AG-10. The isolates of this AG fused with each other but not with other recognized anastomosis groups, and they have the teleomorph of *T. cucumeris*. A detailed description of AG-10 will be given in another paper.

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