Characterization of *Waitea circinata* (*Rhizoctonia*) Isolated from Agricultural Soils in Alaska

R. H. LEINER and D. E. CARLING, University of Alaska Fairbanks, Agricultural and Forestry Experiment Station, 533 East Fireweed, Palmer, AK 99645

ABSTRACT

Leiner, R. H., and Carling, D. E. 1994. Characterization of *Waitea circinata* (*Rhizoctonia*) isolated from agricultural soils in Alaska. Plant Dis. 78:385-388.

A *Rhizoctonia* similar in morphology to *R. oryzae* and *R. zeae* was frequently isolated from agricultural soils in south central Alaska during 1983–1990. On potato-dextrose agar, cultures developed white to pale orange mycelium. Sclerotia formed in the agar rather than on the agar surface, were irregular in shape (similar to those of *R. oryzae*), and dark orange to brown when mature (similar to those of *R. zeae*). Hyphal diameter averaged 6.1 μm and the number of nuclei per cell averaged 5.4. Radial growth increased from 1.3 mm per 24 hr at 11 C to a maximum of 12.8 mm per 24 hr at 30 C. Most isolates infected barley seedlings. Calculated as percentage of the noninoculated seedling height, virulence of Alaskan isolates was 49% at 15 C and 48% at 25 C. Among 87 isolates tested on 2% V8 juice agar or water agar, 7% produced a teleomorph that was identified as *Waitea circinata* var. *circinata*.

The teleomorph of *Rhizoctonia oryzae* Ryker & Gooch (19) and *R. zeae* Voorhees (21) has been described as *Waitea circinata* Warcup & Talbot (11, 18,22) based on characteristics of isolates collected from Australian soil in 1962. *W. circinata* was later isolated from pine seedlings with symptoms of damping-off and root rot in Ontario, Canada, (1,2) and from diseased clover roots in Australia (23,24). Gunnell (11) described three varieties of *W. circinata* based on differences in colony morphology of the vegetative state: *W. c. circinata*, which forms orange to brown, globose sclerotia up to 2 mm in diameter; *W. c. oryzae*, which forms orange to salmon, irregularly shaped sclerotia; and *W. c. zeae*, which forms orange to brown, regularly shaped sclerotia up to 1 mm in diameter. Gunnell (11) designated the original isolates of *W. circinata* described by Warcup and Talbot (22) as *W. c. circinata*, but it is noteworthy that an anamorphic name has not yet been assigned to this group. However, *W. c. oryzae* and *W. c. zeae* represent the anamorphs *R. oryzae* and *R. zeae*, respectively (11).

R. oryzae has been isolated from rice (12,19), and *R. zeae*, from corn (20,21) and turfgrasses (5,14–16), often in association with symptoms similar to those caused on the respective crops by various anastomosis groups of *R. solani* Kühn (19). Recently, Ogoshi et al (17) found that *R. oryzae* and *R. solani* AG-8 were associated with root rot on wheat and barley in the Pacific Northwest. Burton et al (6) reported *R. solani* AG-8 and two other isolates of *Rhizoctonia*, presumed to represent a variant form of *R. oryzae*, associated with barley stunt disease in the United Kingdom.

In Palmer, Alaska, studies of *Rhizoctonia* have been conducted since 1983 (7–9). These studies have been focused on *R. solani* AG-3, the primary causal agent of Rhizoctonia disease of potato (7,8), but other *Rhizoctonia* species were collected, including a group of isolates that resembled *R. oryzae* and *R. zeae*. These latter isolates produced orange to brown, irregularly shaped sclerotia that formed in the agar medium when grown on potato-dextrose agar (PDA). These isolates are referred to herein as *Rhizoctonia* (W-AK). The objective of this study was to characterize *Rhizoctonia* (W-AK) in terms of colony morphology, hyphal diameter, number of nuclei per cell, teleomorph, growth rate, and pathogenicity (13).

MATERIALS AND METHODS

Isolation. Isolates of *Rhizoctonia* (W-AK) were collected from agricultural soils at 18 sites in the Matanuska Valley of south central Alaska, from 1983 to 1990. Two sites were commercial farm fields and the other 16 sites were plots located at the Palmer Research Center (8). Soil samples from 12 of these plots were collected periodically during the summers of 1986–1990 as part of studies on *R. solani* soil populations (8,13). Soils were silt loam with a history of agricultural production that included such crops as potatoes, vegetables, grains, and forage grasses. In 1984, one isolate was collected from a sample of fine sandy soil taken from a grass field near Pilgrim Hot Springs on the Seward Peninsula. In all sampling years except 1984, a direct method was used to isolate *Rhizoctonia* from soil pellets placed on a selective medium (8). Beet seed baiting (9), an indirect method of isolation, was used in 1984.

Colony morphology. In 1989, 328 isolates were grown on PDA at 20–23 C and examined for number, size, and color of sclerotia. A subgroup of 24 representative isolates (Table 1) was selected for more detailed study. These 24 isolates were grown on PDA in the dark at 20–23 C and evaluated over 10 days for color of mycelium and size, shape, and color of sclerotia.

To determine the hyphal diameter and number of nuclei per cell, 12 isolates were grown on cellophane overlay (10) on petri dishes containing water agar for

Table 1. Designation and origin of isolates of *Rhizoctonia* (W-AK) and representative isolates of other *Rhizoctonia* species used in these studies

Group	Isolate number	Origin	Collectors
Rhizoctonia (W-AK)	W630,W601,W604,W613, W614,W615,W616,W629, W636,W648,W650,W652, W006,W023,W037,W057, W082,W139,W170,W199, W214,W256,W267,W276	Alaska, USA	R. H. Leiner & D. E. Carling
R. oryzae	161,231	Washington, USA	E. N. Bassett
	541	Japan	A. Ogoshi
R. zeae	504,521,590	Japan	A. Ogoshi
R. solani AG-2-1	F56L[y]	Alaska, USA	D. E. Carling & R. H. Leiner
AG-3	L32,M8	Alaska, USA	D. E. Carling & R. H. Leiner
AG-8	811	Australia	S. M. Neate
AG-8	C1,H1	Washington, USA	E. N. Bassett
AG-9	S21[z]	Alaska, USA	D. E. Carling & R. H. Leiner

[y] ATCC 62805.
[z] ATCC 62804.

Accepted for publication 30 December 1993.

© 1994 The American Phytopathological Society

48–72 hr under low levels of continuous light at 20–23 C (13). Mycelium was stained with 3% KOH and safranin O and examined at 400× using bright field microscopy (3). Hyphal diameter was determined for each isolate by measuring 10 cells at right angles to the longitudinal cell wall. Nuclei were counted in 10 cells, selected by their location in the stain gradient where nuclei and septa could be distinctly observed.

Teleomorph. Eighty-seven isolates of *Rhizoctonia* (W-AK) were grown for 6 wk in petri dishes containing 15–20 ml of either 2% water agar or 2% V8 juice agar (10) under low levels of continuous light at 20–23 C. Dimensions of basidia, sterigmata, and basidiospores were measured at 400× using bright field microscopy.

Growth rate. Three replications of 20 isolates were arranged in randomized complete blocks at five temperatures: 11, 14, 22, 27, and 30 C. Included were 11 isolates of *Rhizoctonia* (W-AK) (W006, W037, W139, W214, W276, W601, W613, W616, W629, W630, and W652), three isolates of *R. oryzae* (161, 231, and 541), two isolates of *R. zeae* (504 and 590), and one isolate from each of four anastomosis groups of *R. solani* (F56L from AG-2-1, L32 from AG-3, C1 from AG-8, and S21 from AG-9) (Table 1). Agar disks, 5 mm in diameter, were cut from the edge of colonies growing on PDA and placed in the center of petri dishes containing PDA. The radius of each colony was determined daily until the colony reached the edge of the petri dish. The last radial measurement before the hyphal growth reached the edge of the petri dish was used to calculate radial growth rate in millimeters per 24 hr.

Since the optimum temperature for growth of *Rhizoctonia* (W-AK) was not reached in the initial range of temperatures, the growth rate of 15 isolates was determined at a higher set of temperatures: 25, 27, 29, 32 and 34 C. Radial measurements were made after 48 hr and used to calculate growth rate.

Pathogenicity. Pathogenicity was determined on barley (*Hordeum vulgare* L.) seedlings at 15, 22, and 25 C. Thirty-three isolates were tested at 15 and 22 C, but because growth chamber space was limited, only 19 were included at 25 C. Included as inoculation treatments were 21 isolates of *Rhizoctonia* (W-AK) and representative isolates of *R. oryzae, R. zeae*, and *R. solani* (Table 1). At each temperature, each inoculation treatment was replicated five times in a randomized complete block design. The pathogenicity test was repeated at 15 C, with minor procedural modifications between the first and the second runs (13). Soilless potting mix (75 ml) was placed in 4 × 20.5-cm cone-shaped containers and saturated with tap water. Three agar disks (7 mm in diameter) were cut from the margin of *Rhizoctonia* colonies growing on PDA and placed on the potting mix. In control treatments, disks of sterile PDA were used. The disks were covered with 0.5 g of precooked rolled oats and moist potting mix and incubated for 7 days. Seeds of barley Weal were pregerminated in a moist chamber at 22 C for 4 days prior to planting, and one seed was placed on the potting mix in each container. Plants received 18 hr of fluorescent light per day.

Plant height was determined after some seedlings exceeded 20 cm. Plants grown at 25, 22, and 15 C were harvested at 10, 12, and 14 days after planting, respectively, because higher temperature resulted in a faster rate of plant development. After height was measured, plants were removed from the potting mix. The root systems were separated from the potting mix, rinsed gently in water, and rated on a scale of 0–4, where 0 = no visible damage, healthy roots; 1 = traces of superficial root discoloration; 2 = moderate amount of root discoloration; 3 = abundant root discoloration, some root tips missing, roots broken at discolored tips, and occasional lesions on hypocotyl sheath; and 4 = reduced root length due to breakage at discolored, rotted tips.

At each temperature, plant heights were analyzed with GLM analysis (SAS Release 6.04, SAS Institute, Cary, NC) and compared among taxonomic groups using least significant difference means separation at the 5% level.

RESULTS

Isolation. Over a period of 8 yr, 428 isolates of *Rhizoctonia* (W-AK) were collected from soil samples.

Colony morphology. The mycelium of *Rhizoctonia* (W-AK) colonies was floccose to appressed and changed color from white to shades of orange with increasing age. Sclerotia were light orange during the formative stages but darkened to shades of orange and brown as cultures aged. Irregular in shape, sclerotia formed in agar rather than on the agar surface and ranged in size from less than 1 mm to larger aggregated masses of sclerotial tissue more than 3 mm long. Diameter of the hyphae ranged from 3.9 to 10.0 μm, with a mean of 6.1 μm (± 1.3 SD). Cells contained from two to 12 nuclei, with a mean of 5.4 (± 1.7 SD).

Teleomorph. Six isolates of *Rhizoctonia* (W-AK), representing 7% of the 87 isolates tested, formed hymenia in tight clusters on the surface of V8 juice agar or water agar. Repetition in basidiospores was not observed. Dimensions of basidia, sterigmata, and basidiospores were measured from *Rhizoctonia* (W-AK) isolates W613, W616, W199, and W267 and *R. oryzae* 231. Basidia of *Rhizoctonia* (W-AK) had four sterigmata 2–5 μm long (3.7 μm average of 25 observations). Basidia ranged in length from 8 to 13 μm (10.9 μm average of 11 observations) and in width from 6 to 9 μm (7.7 μm average of 21 observations). Basidiospores ranged in length from 6 to 10 μm and in width from 4 to 5 μm (8.5 × 4.1 μm average of 11 observations).

Growth rate. Growth rates of *Rhizoctonia* (W-AK), *R. oryzae*, and *R. zeae* increased as temperature increased from 11 to 30 C, in contrast to the growth rate of *R. solani*, which increased with temperature to 27 C, then decreased at 30 C (Fig. 1). Growth rate of *Rhizoctonia* (W-AK) decreased above 30 C (Fig. 2). Growth rates of *R. oryzae* isolates 161 and 231 from Washington decreased above 30 C, while that of *R. oryzae* isolate 541 from Japan increased to 34 C (Fig. 3). Growth rate of *R. zeae* increased to 32 C, then decreased at 34 C (Fig. 2).

Pathogenicity. The results of the pathogenicity tests on barley seedlings grown in a growth chamber at 15 C were similar, and only the results from the second test are presented (Table 2). Root ratings were negatively correlated with the heights of barley plants inoculated with isolates of all species and subspecific groups of *Rhizoctonia*, as indicated by

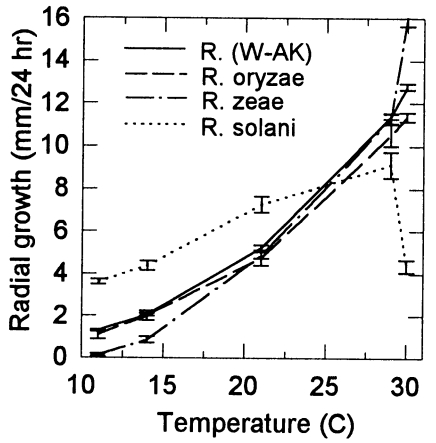

Fig. 1. Growth rate of *Rhizoctonia* (W-AK), *R. oryzae, R. zeae*, and *R. solani* at 11–30 C.

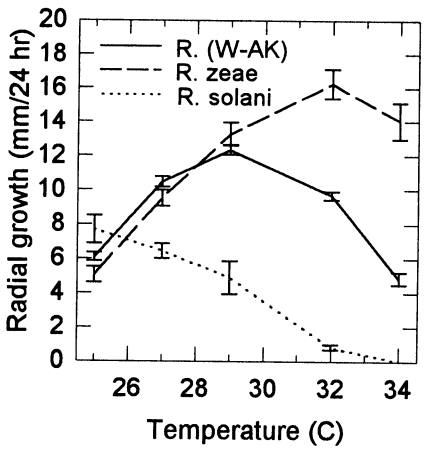

Fig. 2. Growth rate of *Rhizoctonia* (W-AK), *R. zeae*, and *R. solani* at 25–34 C.

a Pearson correlation coefficient (r) of −0.93 or greater for the means.

At 15 C, height of plants inoculated with *Rhizoctonia* (W-AK), *R. oryzae*, or *R. solani* AG-8 were not significantly different from each other but were significantly less than the control at the 5% level (Table 2). All other treatments did not differ significantly from the control. Height of plants inoculated with *Rhizoctonia* (W-AK) was not significantly different from that of plants inoculated with *R. oryzae* at 15 and 22 C but was significantly greater at 25 C. Height of plants inoculated with *Rhizoctonia* (W-AK) was significantly less than that of plants inoculated with *R. zeae* at 15 C, not significantly different at 22 C, and significantly greater at 25 C.

Height of plants inoculated with *Rhizoctonia* (W-AK) changed little at different temperatures, whereas virulence of other groups of *Rhizoctonia* was affected by temperature. Height of plants inoculated with *R. oryzae* or *R. zeae* decreased as temperature increased (Table 2). Height of plants inoculated with *R. solani* AG-8 increased with increasing temperature and was significantly less than that of the control at 15 C only. Height of plants inoculated with *R. solani* AG-2, AG-3, or AG-9 increased as temperature increased but was not significantly different from that of the control at any temperature.

Individual isolates of *Rhizoctonia* (W-AK) showed a range of virulence. Inoculation treatments with some isolates of *Rhizoctonia* (W-AK) were not significantly different from those of the control. Height of plants inoculated with isolates W630 and W276 was less than 40% of the height of the control plants (Table 3).

DISCUSSION

Rhizoctonia (W-AK) (*W. circinata*) was frequently isolated from cultivated soils in Alaska's Matanuska Valley. *W. circinata* has been collected in temperate areas (1,2,22–24), whereas *R. oryzae* (*W. c. oryzae*) and *R. zeae* (*W. c. zeae*) generally have been associated with hot, humid climates (11,12). Although varieties of *Waitea* are reported from warm, temperate, or subtropical areas (11,12), this report and others (2,6,17) indicate that biotypes adapted to cool temperatures exist. *Rhizoctonia* (W-AK) was isolated regularly from plots that were sampled repeatedly during the growing season over several years, and populations of *Rhizoctonia* (W-AK) ranged from 0 to 40 propagules per 100 g of soil (13). Although populations of *Rhizoctonia* (W-AK) were lower than those of *R. solani* AG-3 in the same plots, no relationship between crop and the population of *Rhizoctonia* (W-AK) and either crop or population of *R. solani* AG-3 was apparent (*unpublished*).

Rhizoctonia (W-AK) damaged sheaths and roots of barley seedlings in pathogenicity tests conducted in the growth chamber. Damage to sheaths consisted of lesions similar to the "eyespot" lesions reported by Ryker and Gooch (19) and Burton et al (6). Damage to roots was similar to that caused by *R. solani* AG-8. Virulence of isolates of *Rhizoctonia* (W-AK) ranged from avirulent to highly virulent, indicating that some isolates can infect and damage barley seedlings when conditions for disease development are favorable.

Although virulence of some *Rhizoctonia* groups can change in response to temperature (7,17), in these studies virulence of *Rhizoctonia* (W-AK) remained similar at 15, 22, and 25 C. *R. oryzae* was more virulent than *Rhizoctonia* (W-AK) at 25 C but similar at 15 and 22 C, whereas *R. zeae* was less virulent than *Rhizoctonia* (W-AK) at 15 C but more virulent at 25 C. In pathogenicity studies on wheat and barley, Ogoshi et al (17) found that *R. oryzae* was mildly virulent to avirulent at 10 C and moderately virulent at 20 C. Conversely, *R. solani* AG-8 was highly virulent at 10 C but mildly virulent at 20 C. Burton et al (6) reported that at

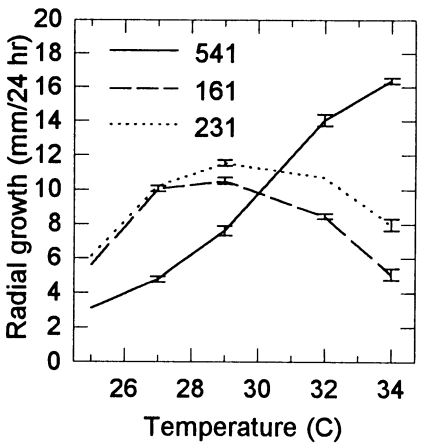

Fig. 3. Growth rate of three isolates of *R. oryzae* at 25–34 C.

Table 2. Pathogenicity of *Rhizoctonia* (W-AK) and other *Rhizoctonia* species on barley seedlings at three temperatures

Temperature Group	No. of isolates	Plant height[y] (cm)	Root rating[z]
15 C			
Control	...	21.7 a	0.2 ± 0.9
R. solani AG-9	1	20.2 a	0.8 ± 0.8
R. solani AG-2-1	1	19.3 a	0.8 ± 0.8
R. zeae	3	18.3 ab	1.9 ± 0.5
R. solani AG-3	1	18.0 ab	0.6 ± 0.5
R. solani AG-8	3	14.2 bc	2.3 ± 1.3
R. oryzae	2	10.8 c	2.9 ± 0.6
Rhizoctonia (W-AK)	21	10.7 c	2.9 ± 0.9
22 C			
Control	...	28.7 a	0.6 ± 0.9
R. solani AG-9	1	26.9 a	1.2 ± 0.8
R. solani AG-2-1	1	26.4 a	0.0 ± 0.0
R. solani AG-3	1	25.0 a	1.2 ± 0.4
R. solani AG-8	3	20.8 ab	1.7 ± 1.3
R. zeae	3	14.8 bc	2.4 ± 0.6
Rhizoctonia (W-AK)	21	10.8 c	3.0 ± 1.0
R. oryzae	3	7.9 c	3.4 ± 0.6
25 C			
R. solani AG-9	1	32.3 a	0.2 ± 0.4
R. solani AG-2-1	1	29.0 ab	0.3 ± 0.5
R. solani AG-3	1	26.2 ab	0.6 ± 0.9
Control	...	26.1 ab	0.0 ± 0.0
R. solani AG-8	2	24.2 b	1.4 ± 0.5
Rhizoctonia (W-AK)	9	12.6 c	2.5 ± 0.9
R. zeae	3	3.4 d	3.4 ± 0.8
R. oryzae	2	2.5 d	3.8 ± 0.4

[y] At each temperature, numbers followed by the same letter are not significantly different at the 5% level.

[z] Mean rating followed by standard deviation, on a scale of 0–4, with 0 = no damage and 4 = roots severely rotted.

Table 3. Virulence of isolates of *Rhizoctonia* (W-AK) on barley seedlings[x]

Isolate	Plant height (cm)	Root rating[y]
Control	21.7	0.2 ± 0.4
W601	17.4	0.0 ± 0.0
W604	16.0	2.2 ± 0.4
W650	15.8	2.2 ± 0.4
W629	12.8	2.8 ± 0.4
W139	11.3	3.2 ± 0.8
W037	9.8	3.4 ± 0.5
W615	8.3	3.2 ± 0.4
W630	7.5	3.2 ± 0.4
W276	6.4	3.4 ± 0.4
LSD[z]	5.4	

[x] Data for each isolate are the mean of five observations at 15 C.

[y] Mean rating followed by standard deviation, on a scale of 0–4, with 0 = no damage and 4 = roots severely rotted.

[z] Least significant difference at 5% level, calculated by GLM analysis.

12 C, the presumptive *R. oryzae* had no effect on barley seedlings, whereas at 18 and 26 C, inoculation reduced emergence and growth of barley seedlings. It is not clear why the virulence of *Rhizoctonia* (W-AK) is not affected by temperature.

Growth rates of isolates of *Rhizoctonia* (W-AK) were very similar to those of *R. oryzae* from Washington, with optimum temperature for growth at approximately 29 C. Ogoshi et al (17) reported a difference in temperature optima between isolates of *R. oryzae* collected from rice and those collected from wheat and barley. The observation in this study, of differences in temperature optima among isolates of *R. oryzae*, agrees with observations by Ogoshi et al (17) of different temperature optima within this species.

Root diseases of barley caused by *Rhizoctonia* spp. have not been reported in Alaska, although barley has been cultivated in various parts of the state for more than 30 yr (4). Results from pathogenicity tests suggest that *Rhizoctonia* (W-AK) may cause moderate damage to barley seedlings under environmental conditions favorable for disease development. In the field trials conducted at the Palmer Research Center in 1990, no yield reductions were observed following inoculation with *Rhizoctonia* (W-AK) (13). However, that growing season was unusually warm and dry, which may have adversely affected fungal growth and disease development, and may not be representative of the potential of *Rhizoctonia* (W-AK) to damage barley in the field. Further field studies are required to establish the potential of *Rhizoctonia* (W-AK) to damage barley in Alaska.

On the basis of observations of the perfect state, *Rhizoctonia* (W-AK) is clearly *W. circinata*. Also, based on our observations of the vegetative state—specifically, sclerotial shape, size, and color at maturity—its taxonomic identity can be further defined as *W. c. circinata*, according to the descriptions of Gunnell (11). *W. c. circinata* can be consistently differentiated from *W. c. zeae* and *W. c. oryzae* by these vegetative differences. Anastomosis reactions have been used by some researchers (18,20) to distinguish *R. oryzae* from *R. zeae*, but other researchers (6,11; R. H. Leiner, *unpublished*) have found anastomosis reactions to be inconclusive because of the very low frequency of reaction between confronted isolates.

The nomenclature of *Rhizoctonia* (W-AK) (*W. c. circinata*) is complicated by different names for the anamorph and teleomorph. Since the teleomorph is known, *Rhizoctonia* (W-AK) can be designated as *W. c. circinata*. Although assignment of an anamorphic name is not necessary, it may be useful, since the teleomorph is rarely observed. Two anamorphic designations are possible: 1) a variety of a new collective species and 2) separate species name such as those for *R. oryzae* and *R. zeae*. In the first case, the three anamorphs of *W. circinata* would be given a single anamorphic species name, probably *R. circinata*, and assigned variety names to correspond to the three varieties of *W. circinata* described by Gunnell (11). Thus, *Rhizoctonia* (W-AK) would be designated as *R. circinata* var. *circinata* and the groups now known as *R. oryzae* and *R. zeae* would be designated as *R. circinata* var. *oryzae* and *R. circinata* var. *zeae*, respectively. This taxonomic system would easily allow for expansion if more groups of *W. circinata* are found, as has been the case with *R. solani*. In the second case, the anamorph of *W. c. circinata* could be given a species name, as was done for *R. oryzae* and *R. zeae*. It is questionable, however, whether differences in sclerotial size, shape, and color alone justify the creation of separate anamorphic species when the teleomorphs are varieties within a single species. At this time, we prefer designation of a single collective anamorphic species with three subspecies. Future research, including molecular studies, may permit a more definitive taxonomic separation of these groups.

LITERATURE CITED

1. Agnihotri, V. P. 1971. Effects of certain fungitoxicants on the viability and pathogenicity of sclerotia of *Waitea circinata*. Phytopathol. Z. 70:71-80.
2. Agnihotri, V. P., and Vaartaja, O. 1969. Stimulation of *Waitea circinata* by root exudates of *Pinus cembroides*. Can. J. Microbiol. 15:1319-1323.
3. Bandoni, R. J. 1979. Safranin O as a rapid nuclear stain for fungi. Mycologia 71:873-874.
4. Brown, D. A., Comeau, M., and Burgess, M. 1993. Alaska Agriculture Statistics 1993. Alaska Agricultural Statistics Service, Palmer.
5. Burpee, L., and Martin, B. 1992. Biology of *Rhizoctonia* species associated with turfgrasses. Plant Dis. 76:112-117.
6. Burton, R. J., Coley-Smith, J. R., Waring, P. W., and Gladders, P. 1988. *Rhizoctonia oryzae* and *R. solani* associated with barley stunt disease in the United Kingdom. Trans. Br. Mycol. Soc. 91:409-417.
7. Carling, D. E., and Leiner, R. H. 1990. Effect of temperature on virulence of *Rhizoctonia solani* and other *Rhizoctonia* on potato. Phytopathology 80:930-934.
8. Carling, D. E., and Leiner, R. H. 1990. Virulence of isolates of *Rhizoctonia solani* AG-3 collected from potato plant organs and soil. Plant Dis. 74:901-903.
9. Carling, D. E., Leiner, R. H., and Kebler, K. M. 1986. Characterization of *Rhizoctonia solani* and binucleate *Rhizoctonia*-like fungi collected from Alaskan soils with varied crop histories. Can. J. Plant Pathol. 8:305-310.
10. Carling, D. E., Leiner, R. H., and Kebler, K. M. 1987. Characterization of a new anastomosis group (AG-9) of *Rhizoctonia solani*. Phytopathology 77:1609-1612.
11. Gunnell, P. S. 1986. Characterization of the teleomorphs of *Rhizoctonia oryzae-sativae, Rhizoctonia oryzae*, and *Rhizoctonia zeae*, and the effect of cultural practices on aggregate sheath spot of rice, caused by *R. oryzae-sativae*. Ph.D. thesis. University of California, Davis.
12. Hashioka, Y., and Makino, M. 1969. Rhizoctonia group causing the rice sheath spots in the temperate and tropical regions, with special reference to *Pellicularia sasakii* and *Rhizoctonia oryzae*. Res. Bull. Fac. Agric. Gifu Univ. 28:51-63.
13. Leiner, R. H. 1991. Characterization of a *Rhizoctonia (Waitea circinata)* isolated from Alaskan agricultural soils. M.S. thesis. University of Alaska Fairbanks.
14. Martin, S. B., Campbell, C. L., and Lucas, L. T. 1983. Horizontal distribution and characterization of *Rhizoctonia* spp. in tall fescue turf. Phytopathology 73:1064-1068.
15. Martin, S. B., Jr., and Lucas, L. T. 1983. Pathogenicity of *Rhizoctonia zeae* on tall fescue and other turfgrasses. Plant Dis. 67:676-678.
16. Martin, S. B., and Lucas, L. T. 1984. Characterization and pathogenicity of *Rhizoctonia* spp. and binucleate *Rhizoctonia*-like fungi from turfgrasses in North Carolina. Phytopathology 74:170-175.
17. Ogoshi, A., Cook, R. J., and Bassett, E. N. 1990. *Rhizoctonia* species and anastomosis groups causing root rot of wheat and barley in the Pacific Northwest. Phytopathology 80:784-788.
18. Oniki, M., Ogoshi, A., Araki, T., Sakai, R., and Tanaka, S. 1985. The perfect state of *Rhizoctonia oryzae* and *R. zeae* and the anastomosis groups of *Waitea circinata*. Trans. Mycol. Soc. Jpn. 26:189-198.
19. Ryker, T. C., and Gooch, F. S. 1938. Rhizoctonia sheath spot of rice. Phytopathology 28:233-246.
20. Sumner, D. R., and Bell, D. K. 1982. Root diseases induced in corn by *Rhizoctonia solani* and *Rhizoctonia zeae*. Phytopathology 72:86-91.
21. Voorhees, R. K. 1934. Sclerotial rot of corn caused by *Rhizoctonia zeae* N. sp. Phytopathology 24:1290-1303.
22. Warcup, J. H., and Talbot, P. H. B. 1962. Ecology and identity of mycelia isolated from soil. Trans. Br. Mycol. Soc. 45:495-518.
23. Wong, D. H., Barbetti, M. J., and Sivasithamparam, K. 1985. Pathogenicity of *Rhizoctonia* spp. associated with root rots of subterranean clover. Trans. Br. Mycol. Soc. 85:156-158.
24. Wong, D. H., and Sivasithamparam, K. 1985. *Rhizoctonia* spp. associated with root rots of subterranean clover in Western Australia. Trans. Br. Mycol. Soc. 85:21-27.