

Horizontal Distribution and Characterization of *Rhizoctonia* spp. in Tall Fescue Turf

S. B. Martin, C. L. Campbell, and L. T. Lucas

Graduate research assistant, assistant professor, and professor, respectively, Department of Plant Pathology, North Carolina State University, Raleigh 27650. Present address of senior author: New York State Agricultural Experiment Station, Geneva 14456.

Portion of a thesis submitted by senior author for Ph.D. degree at North Carolina State University.

The authors thank M. R. Newnam for technical assistance.

Journal Paper 8460 of the North Carolina Agricultural Research Service, Raleigh.

Accepted for publication 9 February 1983.

ABSTRACT

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.

A 12-yr-old stand of tall fescue (*Festuca arundinacea*) turf with a history of brown patch (induced by *Rhizoctonia solani*) was divided into 225 contiguous quadrats (0.37 m² each) and the soil sampled for propagules of *Rhizoctonia* in June 1980 and 1981 by direct assay of soil organic debris. Propagule number frequency distributions were described by the negative binomial frequency distribution in both years, indicating a horizontal

clumping of propagules. Fifty-three isolates in 1980 and 54 isolates in 1981 were recovered and identified as *Rhizoctonia solani*, *R. zeae*, or binucleate *Rhizoctonia*-like fungi. *R. solani* was less frequently recovered (9% of the total in 1980 and 1981) than *R. zeae* (45.3% in 1980 and 48.2% in 1981) or binucleate *Rhizoctonia*-like fungus (39.6% in 1980 and 42.6% in 1981).

Rhizoctonia solani Kühn induces brown patch, a foliar blight of tall fescue (*Festuca arundinacea* Schreb.) and other turfgrasses (9). This disease often causes severe damage to cool-season turfgrasses in the warm, humid areas of the United States, and frequently is severe during the summer months on tall fescue used throughout central North Carolina.

Fungi that closely resemble *R. solani* cause disease on turfgrasses and other crops (5,29). These fungi exhibit mycelial characteristics similar to those of *R. solani*, but they have predominantly binucleate hyphal cells, whereas cells of *R. solani* are multinucleate (24,25). *Rhizoctonia cerealis* van der Hoeven (1) is a binucleate species that causes "yellow patch" on turfgrasses (2), as well as sharp eyespot and root rot of wheat (26,30), but a perfect state has not been induced. *R. cerealis* is a pathogen on tall fescue under greenhouse and growth-chamber conditions (5). Certain other binucleate *Rhizoctonia*-like fungi (RLF) have been induced to form a *Ceratobasidium* perfect state (3,4).

Little is known about the relative abundance and distribution of *Rhizoctonia* spp. in turf soils. Techniques utilizing frequency distributions have been applied to the study of population dispersion or distribution of many organisms, including insects (31), nematodes (13), bacterial lesions (32,37), and soilborne fungi (14). Lesion distribution of hypocotyl rot of snapbean (*Phaseolus vulgaris* L.), induced by *R. solani*, was characterized through frequency-distribution analysis, but the soil habitat was not sampled for direct assay of propagule level and distribution (7). These and other studies have demonstrated the value of characterizing organism dispersion in ecological and epidemiological investigations. The purpose of this study was to determine and to characterize the horizontal, or planar, distribution of propagules of *Rhizoctonia* spp. in organic debris of tall fescue soil, to identify the *Rhizoctonia* species that contribute to the overall population of *Rhizoctonia* propagules sampled, and to determine the relative proportion of each species or type.

MATERIALS AND METHODS

Site selection and sampling. An 83.6-m² area in a 12-yr-old stand of tall fescue (cv. 'Kentucky 31') maintained as home lawn turf with a history of brown patch was divided into 225 contiguous quadrats

(0.37 m² each). The soil was a Cecil clay loam. Five soil cores (June 1980) and a single core (June 1981) were removed from each quadrat to a depth of approximately 5 cm with a standard soil-sampling tube (2-cm bore diameter). Sample size was reduced to a single core per quadrat in 1981 because of difficulties in handling larger samples. Soil cores from each quadrat were placed in polyethylene bags, labelled with a quadrat number, and stored for 7 days at approximately 25 C before elutriation. Percent leaf area affected by typical *Rhizoctonia* lesions (24) within each quadrat was estimated visually with a scale of 1 to 5, in which 1 = no disease, 2 = slight, 3 = medium, 4 = severe, and 5 = very severe. Disease intensity was low at this time in both years.

Elutriation. Samples were weighed before separation of organic debris for assay of *Rhizoctonia* spp. Samples were processed through the method of Clark et al (8), using a semiautomatic elutriator (6). Air- and water-flow rates were approximately 50 cm³/sec and 80 ml/sec, respectively. Soil samples were broken up manually preceding elutriation, and elutriation time was 8 min to ensure proper separation of organic debris in various stages of decomposition from mineral components of soil.

Variation between elutriator chambers was tested by randomly selecting 20 quadrat samples and subdividing each of these into four equal subsamples per quadrat on a weight basis. Each of the four subsamples per quadrat was elutriated simultaneously and propagule counts made as before to identify possible bias in elutriation chambers. No consistent bias was found after analysis of these data.

Debris containing fescue leaves, stems, roots, and more decomposed debris was collected on 60-mesh sieves (240- μ m openings), then washed through a 10-mesh sieve (1,700- μ m opening) nested over another 60-mesh sieve. This allowed separation of live grass leaves, stems, and roots, which were discarded. Preliminary assay of these living substrates indicated propagules of *Rhizoctonia* were not present in numbers comparable to those in the more decomposed debris portions. Use of 60-mesh sieves allowed recovery of propagules of *Rhizoctonia* of a size capable of infection (15,38). Organic debris (240-1,700 μ m) was washed with tap water from 60-mesh sieves onto coarse filter paper (9.0-cm diameter) in Buchner funnels (7.5-cm i.d.) attached to a vacuum pump with sufficient suction to remove excess water. Debris was then gently scraped from the filter papers into 100 \times 15-mm plastic petri dishes. Small portions of debris were placed in each petri dish so that individual debris particles could be visualized after addition of approximately 20 ml of cooled (50 C)

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "advertisement" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

1.5% water agar. Water agar was used as a nonselective medium to avoid possible bias in sampling of unknown *Rhizoctonia* species and because other media did not appreciably enhance recovery in other experiments (8).

Plates were incubated 24–48 hr at approximately 25 C before counting and recovery of colonies of *Rhizoctonia*. Because of the large number of plates in 1980, some debris plates were stored at 3 C for up to 2 days before the incubation period began to prevent overgrowth of *Rhizoctonia* by other organisms. No apparent differences in colony number were due to the cold storage.

Characterization of *Rhizoctonia* spp. Fifty-three isolates in 1980 and 54 isolates in 1981 were recovered by hyphal-tip transfer from debris plates onto acidified potato-dextrose agar (APDA) or plain PDA plates. Nuclear condition and the presence of dolipore septa of isolates was determined by staining young colonies (4–6 cm diameter) with 0.05% trypan blue in lactophenol (29). Gross morphological characteristics such as hyphal branching habit (the character considered for counting colonies of *Rhizoctonia* in debris plates), colony color, and presence or absence of sclerotia, were considered when identifying *Rhizoctonia* spp. (24).

Different morphological types of *R. solani* (three isolates), binucleate RLF (five isolates), and *R. zae* Voorhees (five isolates) recovered from plates were paired with five anastomosis group (AG) tester isolates of *R. solani* (21,23) and binucleate *Rhizoctonia* spp. Ceratobasidium anastomosis group (CAG) tester isolates 1, 2, 3, 4, and 5 (4). Unknown isolates and AG and CAG tester isolates were grown on PDA approximately 48 hr, then 7-mm-diameter mycelial plugs were cut from margins of actively growing colonies and placed 4–6 cm apart on sterile glass slides coated with a thin layer of 1.5% water agar. Unknown isolates were paired with AG or CAG tester isolates and incubated in sterile, moist chambers in the dark at 28 C for 2–5 days. The hyphal contact area was stained with 0.05% trypan blue in lactophenol and examined microscopically at $\times 400$ for presence of anastomosis (23).

Construction and analysis of frequency distributions. Total propagules per quadrat, propagules per gram of dry soil per quadrat, and foliar blight severity per quadrat were used to construct frequency tables. Data from 1980 were adjusted (by dividing by 5) for comparison with 1981 data in which single cores per quadrat were taken. Frequency data were tested for goodness-of-fit to several discrete frequency distributions, including the negative binomial (11), Neyman type A (20), and Poisson by chi-square analysis, using a computer FORTRAN routine developed by Gates and Ethridge (12).

RESULTS

Isolate identification and characterization. *R. solani*, *R. zae*, and a high proportion of binucleate RLF were isolated from the sampled area in both years. *Rhizoctonia* species assayed were found occasionally as free sclerotia, but more commonly in infested debris as sclerotia or thick-walled hyphae.

R. zae was the most frequently isolated species, and binucleate RLF were isolated more frequently than *R. solani* (Table 1). *R. zae* isolates conformed to the description given by Voorhees (36) and temperature growth response of selected *R. zae* isolates on PDA indicated growth optima in vitro at approximately 32 C, in agreement with other workers (19,28,35). Hyphal cells of *R. zae* isolates were multinucleate, although septal visualization was difficult because the mycelium appeared grainy. Isolates of *R. zae* did not anastomose with *R. solani* AG tester isolates or with binucleate RLF CAG tester isolates.

Isolates of binucleate RLF were fairly uniform in appearance and had a tan or light brown pigmentation in 2-wk-old PDA cultures grown in light at 20–25 C. Dark brown sclerotia were formed in older cultures. These binucleate isolates were visually distinguishable from isolates of *R. cerealis* recovered from diseased bentgrass (*Agrostis palustris* Huds.) in North Carolina during cool, wet weather (S. B. Martin and L. T. Lucas, unpublished), and none of the isolates tested anastomosed with CAG 1 (2). Thus, the binucleate RLF in this study were probably not *R. cerealis*. Some of these isolates were pathogenic but only slightly virulent on tall

fescue in greenhouse tests (S. B. Martin, unpublished).

R. solani was the least frequently isolated species from debris, even though it was frequently isolated from lesions on diseased foliage of tall fescue affected with typical brown patch symptoms at this site and other areas in North Carolina. Of three morphologically dissimilar *R. solani* isolates tested, two isolates were AG 1, and the other did not fuse with any of the AG tester isolates.

Propagule distribution. Total propagule density ranged from 0 to 26 propagules per quadrat sample in 1980 and from 0 to 22 propagules per quadrat sample in 1981. Frequency class 22 (Fig. 1A) represents a combined class and includes samples with propagule numbers greater than or equal to 22. The variance (s^2) exceeded the mean (\bar{x}) in all observed frequency distributions tested including total propagule number per quadrat and those observed frequencies from data converted to propagules per gram of dry soil in both 1980 and 1981. The variance to mean ratio (s^2/\bar{x}) greatly exceeded unity in all these frequency distributions, and data were not described by a Poisson distribution, which assumes that the variance is equal to the mean (Table 2). The observed frequency data are positively skewed, although differences in skewness are apparent between 1980 and 1981 (Fig. 1).

Observed frequencies of total propagules per quadrat in both 1980 and 1981 were best described by the negative binomial distribution, with $k = 4.87$ and 1.10 for the 1980 and 1981 data, respectively. The k value is an index of dispersion where clumping or aggregation increases as the value of k decreases (11,31,33). When propagule numbers were adjusted to propagules per gram of dry soil for both years, none of the tested statistical distributions described the data well (Table 2). These frequency data show divergence in the higher frequency classes when observed and expected values are compared (Fig. 1B and D). This may be because the soil weight had relatively little to do with the amount of organic debris present in a sample, since this debris was confined almost entirely to the surface of the samples.

Distribution of foliar disease. Foliar disease distributions were dissimilar for 1980 and 1981 (Table 3). In 1980, most of the theoretical distributions, with the exception of the Poisson and Poisson with zeros, were not fitted because the mean exceeded the variance. The Poisson and Poisson with zeros did not adequately describe the observed frequency data. In 1981, the variance exceeded the mean, and the observed frequency distribution was best described by the negative binomial and Neyman type A distributions (Table 3).

There was no significant correlation between propagule level (total per sample) within a quadrat to degree of foliar blight in that quadrat in either 1980 or 1981.

DISCUSSION

Rhizoctonia spp. propagules were not randomly distributed horizontally in tall fescue organic debris. Observed frequency distributions for total propagules per quadrat sample were better described by the negative binomial or Neyman A. This indicated a horizontal clumping of propagules in the organic debris in soil. Sampling was performed for only 2 yr and was not performed sequentially within years; thus, the distributions described could

TABLE 1. Frequency of isolation of *Rhizoctonia* species recovered from tall fescue organic debris in June 1980 and 1981

Source	Percent isolation ^a	
	1980	1981
<i>Rhizoctonia zae</i>	45.3	48.2
Binucleate Rhizoctonialike fungi	39.6	42.6
<i>Rhizoctonia solani</i>	9.4	9.2
Unknown ^b	5.7	0

^aFifty-three isolates recovered in 1980 and 54 in 1981.

^bUnknown isolates were morphologically similar to binucleate Rhizoctonialike fungi but possessed mostly three nuclei per cell.

not be claimed to be truly "contagious" (33), although spatial heterogeneity was indicated. Implications of nonrandom spatial population distributions to sampling precision and accuracy and to statistical analyses have been made by several authors (13,14,31,32).

The difference in k values between 1980 and 1981 for soil propagule distributions may have been due to differences in sample size between years (even though correction for this was attempted), a change in the apparent location of "clumps" due to pathogen movement over the disease season, and subsequent survival or mortality over winter, or differential rates of survival among individual sites of sampled area. The general conclusion of clumped

or nonrandom distribution of propagules, however, was upheld for both years.

With a closely aggregated perennial crop such as tall fescue turf, with pathogens that spread by rapid mycelial growth during periods favorable for disease, and with considerable mowing during disease development, the propagules might be expected to be randomly dispersed. Similar arguments have been proposed for distribution of *Fusarium oxysporum* f. *ubense* in soils (34). This was not the case for propagule distributions of *Rhizoctonia* spp. over the time frame studied. The fact that there were several species of *Rhizoctonia* sampled and that the relative levels of each contributing species were consistent between the years sampled

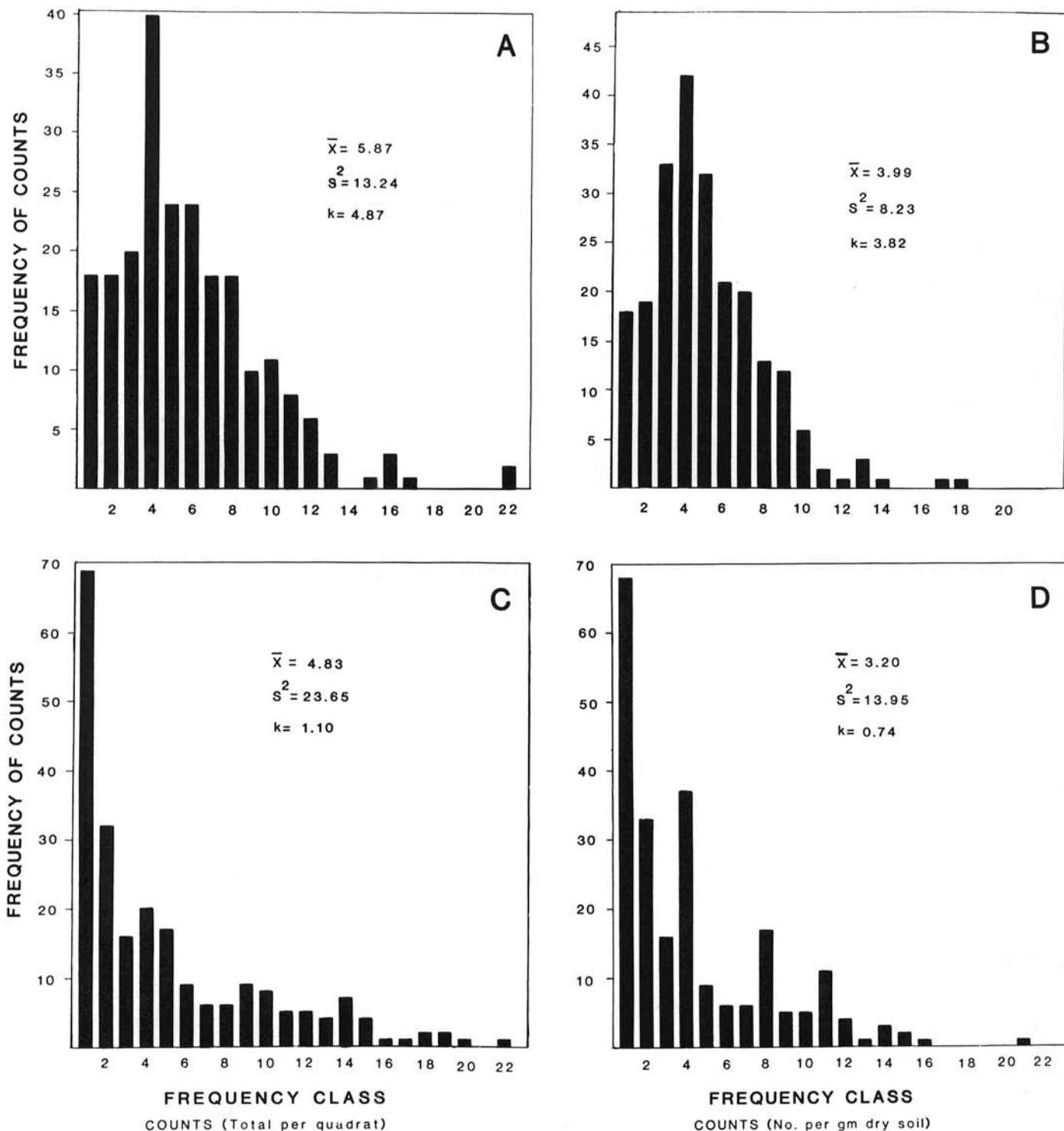


Fig. 1. Observed frequency distributions of *Rhizoctonia* propagule counts in 1980 (A = total, B = corrected to number per gram of dry soil) and 1981 (C = total, D = corrected number per gram of dry soil).

TABLE 2. Goodness-of-fit of theoretical frequency distribution to observed frequency data of *Rhizoctonia* propagules per quadrat sample in organic debris from tall fescue (*Festuca arundinacea*) turf

Year	Theoretical distribution ^a		Probability of exceeding χ^2 value	k^b
	Propagule no.	Distribution		
1980	Total	Poisson	0.000	...
		Negative binomial	0.539	4.87
		Neyman type A	0.268	
	Corrected ^c	Poisson	0.0	
		Negative binomial	0.080	3.82
1981	Total	Poisson	0.0	
		Negative binomial	0.229	1.102
		Neyman type A	0.0	
	Corrected	Poisson	0.0	
		Negative binomial	0.007	0.742
		Neyman type A	0.0	

^aOther theoretical distribution functions such as Thomas Double Poisson, Poisson-Binomial, and Poisson with zeros were tested but did not give a significant fit.

^bDispersion parameter of negative binomial distribution.

^cPropagule numbers corrected for number per gram of dry weight soil.

indicated the probable role of site microenvironment in propagule distribution. Many environmental factors—both biotic and abiotic—could influence inoculum density, including temperature, moisture, edaphic factors (13,17,18,22), and microbial antagonists, to mention a few. If such factors were not uniform over a field, differential inoculum levels could result.

R. zeae was found most frequently in this study and has been reported as pathogenic, but only mildly virulent, as a foliar pathogen on several grasses (19), although grass species were not specified. Our investigations (S. B. Martin, unpublished) have suggested that *R. zeae* can, under certain conditions, severely blight tall fescue, but, under normal temperatures for brown patch development, most isolates of *R. solani* from diseased tall fescue were more virulent than *R. zeae* isolates. These same data also indicated a very low virulence of binucleate RLF from soil debris on tall fescue.

Overwintering of *R. solani* in infected but asymptomatic plants has been suggested to be more important than previously thought (10,16). Studies on survival of *R. solani* and associated parasitic and saprophytic habits over time indicate that inoculum levels of the pathogen in field soil depends on time of sampling (22,27). These studies have been with annual field crops, but a similar situation may exist in *R. solani* populations in turf. Papavizas et al (22) and Roberts and Herr (27) reported higher inoculum levels of *R. solani* in the fall, with lower levels in the spring. This phenomenon was attributed to decomposition of substrates during the spring, resulting in lack of nutrient availability for *R. solani* survival. Inoculum of *R. solani* might build up during the parasitic phase on turf in summer, and subsequent soil populations should reflect this. Concomitant with an inoculum buildup during a favorable disease season and spread by mowing and by active parasitism and saprophytism, apparent inoculum (propagule) distribution and the relative proportions of *Rhizoctonia* species may also change. The propagule levels could not be correlated with foliar disease levels, and the lack of correlation could have been due to the heterogeneity of species and their relative virulence. Exact counts of specific propagule levels by species in each quadrat might better relate to subsequent foliar disease foci (27). This situation is complicated because of the several species of *Rhizoctonia* in turf soils; these species all grow on agar media used for enumeration of *R. solani*, and trapping methods do not distinguish *R. solani* from other *Rhizoctonia* spp. that may be present (S. B. Martin, unpublished). Therefore, relation of soil inoculum densities of *Rhizoctonia* spp. as a group to foliar disease (induced primarily by *R. solani*) is difficult. Environmental parameters and inoculum potential are also equally important and relate to differential disease development.

TABLE 3. Goodness-of-fit of theoretical frequency distribution to observed frequency data of severity^a of foliar blight on tall fescue in each quadrat

Year	s^{2b}	\bar{x}^c	Theoretical distribution	Probability of exceeding χ^2	
				χ^2	k
1980 ^d	0.699	0.799	Poisson	0.007	...
			Poisson with zeros	0.0027	...
1981	0.5645	0.4776	Poisson	0.1198	...
			Poisson with zeros	0.2856	...
			Negative binomial	0.5082	2.38
			Neyman type A	0.6036	...

^aDisease severity rated per quadrat with a 1 to 5 scale, with 1 = no disease, 2 = slight, 3 = medium, 4 = severe, and 5 = very severe.

^b s^2 = the sum of the squared deviations of individual ratings per quadrat from the mean divided by the total minus 1.

^c \bar{x} = arithmetic average, or mean of ratings per quadrat.

^dOnly the Poisson and Poisson with zeros was fitted in 1980 because the $\bar{x} > s^2$.

These data indicated that populations of overwintered propagules of *Rhizoctonia* in tall fescue organic debris are diverse, consisting of at least three species, and are not randomly distributed horizontally, and that the soil propagule density of *R. solani* is quite low. These data imply that fungi that closely resemble *R. solani* may be quite common in some soils and, therefore, the nuclear condition of RLF should be routinely determined to aid in identification.

LITERATURE CITED

- Boerma, G. H., and van der Hoeven, A. A. 1977. Checklist for scientific names of common parasitic fungi. Ser. 26: Fungi on field crops: Cereals and grasses. Neth. J. Plant Pathol. 83:165-204.
- Burpee, L. L. 1980. *Rhizoctonia cerealis* causes yellow patch of turfgrasses. Plant Dis. 64:1114-1116.
- Burpee, L. L., Sanders, P. L., and Cole, H., Jr. 1978. A staining technique for nuclei of *Rhizoctonia solani* and related fungi. Mycologia 70:1281-1283.
- Burpee, L. L., Sanders, P. L., Cole, H., Jr., and Sherwood, R. T. 1980. Anastomosis groups among isolates of *Ceratobasidium cornigerum* and related fungi. Mycologia 72:689-701.
- Burpee, L. L., Sanders, P. L., Cole, H., Jr., and Sherwood, R. T. 1980. Pathogenicity of *Ceratobasidium cornigerum* and related fungi representing five anastomosis groups. Phytopathology 70:843-846.
- Byrd, D. W., Barker, K. R., Ferris, H., Nusbaum, C. J., Griffin, W. E., Small, R. H., and Stone, C. A. 1976. Two semiautomatic elutriators for extracting nematodes and certain fungi from the soil. J. Nematol. 8:206-213.
- Campbell, C. L., and Pennypacker, S. P. 1980. Distribution of hypocotyl rot caused in snapbean by *Rhizoctonia solani*. Phytopathology 70:521-525.
- Clark, C. A., Sasser, J. N., and Barker, K. R. 1978. Elutriation procedures for quantitative assay of soils for *Rhizoctonia solani*. Phytopathology 68:1234-1236.
- Couch, H. B. 1973. Diseases of Turfgrasses. 2nd ed. Robert E. Krieger Publishing Co., Huntington, NY. 348 pp.
- Daniels, J. 1963. Saprophytic and parasitic activities of some isolates of *Corticium solani*. Trans. Br. Mycol. Soc. 46:485-502.
- Elliott, J. M. 1977. Some Methods for the Statistical Analysis of Benthic Invertebrates. 2nd ed. Sci. Publ. 25, Freshwater Biological Assoc., Ambleside, Cumbria, England. 156 pp.
- Gates, L. E., and Ethridge, F. G. 1972. A generalized set of discrete frequency distributions with FORTRAN program. Math. Geol. 4:1-24.
- Goodell, P., and Ferris, H. 1980. Plant parasitic nematode distribution in an alfalfa field. J. Nematol. 12:136-141.
- Hau, F. C., Campbell, C. L., and Beute, M. K. 1982. Inoculum distribution and sampling methods for *Cylindrocladium crotalariae* in a peanut field. Plant Dis. 66:568-571.
- Henis, Y., and Ben-Yephet, Y. 1970. Effect of propagule size of *Rhizoctonia solani* on saprophytic growth, infectivity, and virulence on bean seedlings. Phytopathology 60:1351-1356.
- Herr, L. J. 1976. In field survival of *Rhizoctonia solani* in soil and in diseased sugarbeets. Can. J. Microbiol. 22:983-988.
- Herr, L. J., and Roberts, D. L. 1980. Characterization of *Rhizoctonia*

- populations obtained from sugarbeet fields with differing soil textures. *Phytopathology* 70:476-480.
18. Lewis, J. A. 1979. Influence of soil texture on survival and saprophytic activity of *Rhizoctonia solani* in soils. *Can. J. Microbiol.* 25:1310-1314.
 19. Luttrell, E. S. 1954. Diseases of pearl millet in Georgia. *Plant Dis. Rep.* 38:507-514.
 20. Neyman, J. 1939. On a new class of 'contagious' distributions, applicable in entomology and bacteriology. *Ann. Appl. Stat.* 10:35-57.
 21. Ogoshi, A. 1976. Studies on the grouping of *Rhizoctonia solani* Kühn with hyphal anastomosis and on the perfect stages of groups. (Japanese with English summary.) *Bull. Natl. Inst. Agric. Sci., Ser. C. Plant Pathol. Entomol.* 30:1-63.
 22. Papavizas, G. C., Adams, P. B., Lumsden, R. D., Lewis, J. A., Dow, R. L., Ayers, W. A., and Kantzes, J. G. 1975. Ecology and epidemiology of *Rhizoctonia solani* in field soil. *Phytopathology* 65:871-877.
 23. Parmeter, J. R., Jr., Sherwood, R. T., and Platt, W. D. 1969. Anastomosis grouping among isolates of *Thanatephorus cucumeris*. *Phytopathology* 59:1270-1278.
 24. Parmeter, J. R., Jr., and Whitney, H. S. 1970. Taxonomy and nomenclature of the imperfect state. Pages 7-19 in: *Rhizoctonia solani: Biology and Pathology*. J. R. Parmeter, ed. University of California Press, Berkeley.
 25. Parmeter, J. R., Jr., Whitney, H. S., and Platt, W. D. 1967. Affinities of some *Rhizoctonia* species that resemble mycelium of *Thanatephorus cucumeris*. *Phytopathology* 57:218-273.
 26. Reinecke, P., and Fehrman, H. 1979. Infection experiments with *Rhizoctonia cerealis* van der Hoeven on cereals. *J. Plant Dis. Prot.* 86:241-246.
 27. Roberts, D. L., and Herr, L. J. 1979. Soil populations of *Rhizoctonia solani* from areas of healthy and diseased beets within four sugarbeet fields differing in soil texture. *Can. J. Microbiol.* 25:902-910.
 28. Ryker, T. C., and Gooch, F. S. 1938. *Rhizoctonia*-sheath spot of rice. *Phytopathology* 28:233-246.
 29. Sanders, P. L., Burpee, L. L., and Cole, H., Jr. 1978. Preliminary studies on binucleate turfgrass pathogens that resemble *Rhizoctonia solani*. *Phytopathology* 68:145-149.
 30. Scott, D. B., Visser, C. P. N., and Ruzenacht, E. M. C. 1979. Crater disease of summer wheat in African drylands. *Plant Dis. Rep.* 63:836-840.
 31. Southwood, T. F. 1978. *Ecological Methods with Particular Reference to the Study of Insect Populations*. Chapman and Hall, London. 391 pp.
 32. Strandberg, J. 1973. Spatial distribution of cabbage black rot and estimation of diseased plant populations. *Phytopathology* 63:998-1003.
 33. Thompson, H. R. 1954. A note on contagious distributions. *Biometrika* 41:268-271.
 34. Trujillo, E. E., and Snyder, W. C. 1963. Uneven distribution of *Fusarium oxysporum* f. *ubense* in Honduras soils. *Phytopathology* 53:167-170.
 35. Ullstrup, A. J. 1963. A note on the geographic distribution of *Rhizoctonia zae*. *Mycologia* 55:682-683.
 36. Voorhees, R. K. 1934. Sclerotial rot of corn caused by *Rhizoctonia zae*. *Phytopathology* 24:1290-1303.
 37. Waggoner, P. E., and Rich, S. 1981. Lesion distribution, multiple infection, and the logistic increase of plant disease. *Proc. Natl. Acad. Sci., U.S.A.* 78:3293-3295.
 38. Weinhold, A. R. 1977. Population of *Rhizoctonia solani* in agricultural soils determined by a screening procedure. *Phytopathology* 67:566-569.