Density of Sclerotia of *Rhizoctonia solani* and Incidence of Sheath Blight in Rice Fields in Mississippi

J. P. DAMICONE, Mississippi Cooperative Extension Service, P.O. Box 68, Stoneville 38776, and M. V. PATEL and W. F. MOORE, Department of Plant Pathology and Weed Science, Mississippi State University, Mississippi State 39762

ABSTRACT

Damicone, J. P., Patel, M. V., and Moore, W. F. 1993. Density of sclerotia of *Rhizoctonia solani* and incidence of sheath blight in rice fields in Mississippi. Plant Dis. 77:257-260.

Sixty-five fields in various rotation sequences of Lemont rice with soybean were surveyed over a 2-yr period. Density of sclerotia of *Rhizoctonia solani* was determined prior to planting, and incidence of sheath blight was assessed at midseason. Sclerotia were detected in 80% of fields sampled. Sheath blight was present in 79.5% of the 39 fields cropped to rice during the study. Disease incidence in 33% of the fields exceeded the current threshold for fungicide treatment of 15% incidence of disease foci. Density and viability of sclerotia and disease incidence increased linearly ($P < 0.05$) with number of years cropped to rice in the 3 yr prior to sampling. Relationships for years cropped to soybean were converse with those of rice. No viable sclerotia and few disease foci were detected in fields following three years of soybean culture. Rotation with soybean in an area where occurrence of soybean aerial blight is rare did not increase inoculum of *R. solani* or the incidence of sheath blight in rice. Densities of total sclerotia were positively correlated with incidence (%) of diseased tillers ($r = 0.54$–0.63) and incidence (%) of disease foci ($r = 0.64$–0.67). However, variability interfered with the development of models to accurately predict sheath blight incidence. When density of viable sclerotia was used, there was an increase in the degree of correlation with disease incidence in only 1 yr.

Sheath blight disease of rice, caused by *Rhizoctonia solani* (Kühn) AG-1 IA, has become the most important disease of rice (*Oryza sativa* L.) in the southern United States over the last 10 yr (7,11). Several factors have been implicated with regard to the increasing importance of this disease. Semidwarf rice cultivars that are susceptible to sheath blight have been released and widely planted (11,12). High rates of nitrogen fertilizer are applied to these cultivars to achieve maximum yields. The high fertility and dense plant canopy resulting from this production system favors early and severe sheath blight development (11,18). Crop rotations that include soybeans are also suspected to increase levels of sheath blight (1,7,8,10–12) because *R. solani* AG-1 IA is also the causal agent of soybean aerial blight (7,17,20).

In flooded (lowland) rice culture, primary inoculum is thought to consist primarily of buoyant sclerotia, which germinate and infect tillers at the waterline (1,5,6,10). Lesions first appear on lower leaf sheaths from the late tillering to internode elongation stages of rice development. The disease spreads within the rice canopy from primary tiller infections by means of hyphae that grow superficially on sheaths, leaves, and panicles and then infect by means of infection cushions (13). This secondary spread by hyphae occurs rapidly when relative humidity is near 95% and temperature is 28–32 C (5,9). Secondary spread in Mississippi typically results in blighted plants within circular disease foci approximately 1 m in diameter. In severely infested fields, numerous disease foci may coalesce, causing large blighted areas. When weather favors disease development, foliage and panicles are completely blighted, and tillers lodge within disease foci. Loss in grain yield may reach 42%, and additional economic losses may be incurred by up to a 20% reduction in milling quality (12).

Effective strategies for management of sheath blight are limited. Development of resistant cultivars has been slow, because resistance is linked to undesirable traits such as tall plant stature, late maturity, and poor milling quality (15). Rotation with a nonhost crop, such as pasture (coastal bermuda) in Texas, resulted in lower inoculum density and disease incidence compared with soybean (1). However, pasture is not an economically viable crop in the Mississippi Delta, and the effects of current rotation practices in this region are unknown. Benomyl, propiconazole, and iprodione are fungicides registered for control of sheath blight, and reliance on these fungicides has increased (4,8). Thresholds used to determine the need for fungicide treatment are based on incidence of primary infections (6,8). A threshold of 5% diseased tillers at the panicle differentiation stage of rice development is used in Texas and a 15% incidence of disease foci is used in Mississippi. Because scouting flooded rice fields is time-consuming, laborious, and expensive, it is not widely utilized by growers.

Procedures for extraction and quantification of sclerotia of *R. solani* AG-1 IA from soil have been developed (1–3,10). Belmar et al (1) proposed the use of soil assay for prediction of primary disease incidence based on a linear relationship between inoculum density and disease incidence in Texas.

This study was undertaken to assess

Present address of first author: Department of Plant Pathology, Oklahoma State University, Stillwater 74078-9947.

Accepted for publication 3 November 1992.

the extent of sheath blight infestation in commercial rice fields in Mississippi and to determine the impact of crop rotation practices on inoculum density and disease incidence. Additional objectives were to quantify inoculum density and disease incidence relationships and to assess the utility of soil assay as an alternative to in-season field scouting.

MATERIALS AND METHODS

Sixty-five fields in 10 delta counties in Mississippi were surveyed over 2 yr. Fields were in typical rotation sequences of rice (R) and soybean (S). Twenty-nine of the fields were cropped to rice in alternate years (R-S-R), 26 were cropped to rice once every third year (S-S-R), and 10 were cropped to rice once in 4 yr (S-S-S). Fewer S-S-S fields were sampled, because this rotation was infrequently encountered. Soil types ranged from clay to silt loam with the majority being clay. Soil samples were taken in a systematic manner along a W-shaped pattern across fields in the spring just prior to planting and construction of levees (1). One 425-cm^3 soil sample (7.5 × 7.5 × 7.5 cm) per hectare was taken in 1988, and samples were assayed separately (1). In 1989, one 15-cm^3 soil sample (2-cm diameter × 7.5-cm deep) was taken per 0.2 ha, and samples from a field were bulked. Samples were air-dried for 14 days on a greenhouse bench, weighed, crushed by hand, and then soaked overnight in distilled water prior to extraction (1,10). A 425-cm^3 subsample was processed after thoroughly mixing soil from 1989 bulked samples.

Sclerotia were extracted with a semiautomatic elutriator (2,10). Samples were eluted through 1.7-mm and 0.6-mm mesh sieves. The residue with sclerotia retained on the smaller mesh sieve was suspended in water, filtered through a brown paper towel, and air-dried on a lab bench. Sclerotia and dense debris were separated from the often large amount of lightweight debris by brushing the entire sample against a slanted board until all heavy debris fell into a tray below the board. Sclerotia of *R. solani* AG-1 (sasakii form) were identified among the remaining dense debris under a dissecting microscope on the basis of color, size, and morphology (7,16,18). Sclerotia were then removed from the residue and counted.

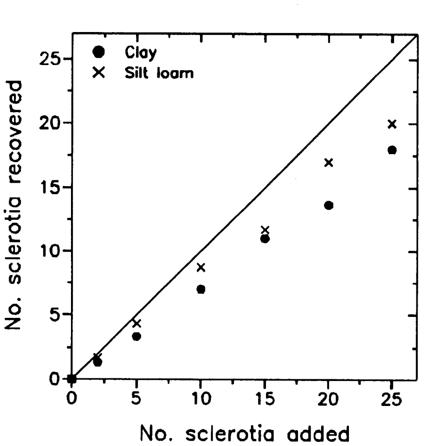

Fig. 1. Efficiency of elutriation procedure for extraction of sclerotia of *Rhizoctonia solani* AG-1 IA from soil standards. Data points represent mean values of three samples, and the diagonal line represents a 1:1 extraction ratio.

Efficiency of the extraction procedure was assessed using standards prepared with Commerce silt loam and Sharkey clay soil collected from fields previously cropped to cotton and soybeans, respectively. Sclerotia were collected in a field from mature, infected rice plants and mixed with soil at 0, 2, 5, 10, 15, 20, and 25 sclerotia per 425 cm^3. Three replicate samples of each soil type and inoculum density were prepared. Sclerotial extraction and quantification were then performed as described above.

The viability of all sclerotia was assayed, and the pathogenicity of several isolates of *R. solani* was determined. Sclerotia were surface-disinfected in an aqueous mixture of 0.26% NaOCl and 10% EtOH for 5 min, rinsed in sterile distilled water, and blotted dry. Sclerotia were plated on potato-carrot agar acidified to pH 4.5 (19), and plates were incubated on a lab bench at 22–24 C for 7 days. Sclerotia were considered viable if resulting colonies of *R. solani* produced sasakii-type sclerotia (7,16) when transferred to potato-carrot agar plates and incubated as described above for 14 days. Pathogenicity of 25 arbitrarily selected isolates was determined by placing a plug of agar with mycelium from 7-day-old cultures onto detached flag leaves from greenhouse-grown rice plants of the cultivar Lemont. Inoculated and uninoculated detached leaves were incubated in moist chambers for 7 days on the lab bench and then rated for appearance of sheath blight symptoms.

As a follow-up to soil sampling, the incidence of sheath blight was determined in 25 fields in 1988 and 14 fields in 1989 cropped to rice (cv. Lemont). Sheath blight was assessed along a W-shaped pattern similar to that used for soil sampling. The number of diseased and total tillers was counted in one 0.8-m length of row per 0.4 ha, systematically selected along the transect, using a T-shaped tool made with polyvinyl chloride pipe (2.5-cm diameter) to open the canopy. Assessments were made between the first internode (green ring) and 2.5-cm panicle (early boot) stages of rice development in 1988 and at first internode in 1989. Percent incidence of diseased tillers and disease foci were calculated for each field.

Mean values of sclerotial density, viability, and sheath blight incidence were calculated for each field. Simple statistics were used to assess distributions of sclerotia within fields in 1988 and incidence of diseased tillers both years. Analysis of variance was performed on field means following rank transformation (ties = mean) to stabilize variances. Main effects were year and cropping sequence. Linear contrasts were used to assess the influence of rice (or conversely soybean) cropping frequency on inoculum density and disease incidence. Correlation coefficients were calculated for relationships between disease incidence and inoculum density.

RESULTS

The procedure for extraction of *R. solani* AG-1 IA from soil was efficient in recovery of 70% (clay) to 83% (silt loam) of sclerotia from standard soil samples (Fig. 1). Sclerotia were recovered from 52 of the 65 fields sampled (80%). Mean density of total sclerotia in infested fields ranged from in 0.1 to 15.2 per 500 cm^3 of soil. Sclerotial density of all samples from fields surveyed was within the range of the prepared standards. Density of total sclerotia was significantly lower in 1988 than in 1989 (Table 1). In 1988, when samples within fields were assayed separately, variance to mean ratios (V/M) for fields where sclerotia were detected ($n = 26$) ranged from 0.2 to 9.8 with a mean of 3.1. Variance to mean ratio was positively correlated with mean sclerotial density ($r = 0.54$, $P < 0.01$). The effect of crop rotation on density of total sclerotia was also significant ($P < 0.01$). A positive linear relationship was significant for density and number of years cropped to rice (0, 1, or 2) in the 3 yr prior to sampling (Table 1). Conversely, this relationship was negative for density of total sclerotia and years cropped to soybean (1, 2, or 3). The interaction of year and crop rotation was not significant for density of total sclerotia ($P = 0.96$).

Mean viability of sclerotia in fields ranged from none to 100% and did not significantly differ between years (Table 1). The effect of crop rotation on viability was significant ($P < 0.01$). This effect was a positive linear relationship for viability with number of years cropped to rice (Table 1) or, conversely, a negative linear relationship with years cropped to soybean. Viable sclerotia were not detected in fields following 3 yr of cropping to soybeans. All of the 25 isolates of *R. solani* obtained from arbitrarily selected sclerotia caused sheath blight symptoms on detached rice leaves.

Sheath blight was found in 31 of the 39 fields (79.5%) planted to rice following soil sampling. Incidence of diseased tillers was 5% or greater in 13% of fields, whereas 33% of fields had a 15% or greater incidence of disease foci. In fields where sheath blight was detected, incidence of diseased tillers and disease foci ranged from 0.04 to 15.1% and 2.7 to 83%, respectively. Values of V/M for diseased tillers in infested fields ranged from 1.6 to 55.8 with a mean of 13.1. Mean diseased tillers and V/M were positively correlated ($r = 0.61$, $P < 0.01$). The effect of year was not significant on incidence of either diseased tillers or disease foci (Table 1). The effect of crop rotation on both measures of disease incidence was significant ($P < 0.01$). Disease incidence (foci or tillers) increased linearly with years cropped to rice (Table 1) or decreased linearly with years cropped to soybean. Low levels of sheath blight were found in fields following 3 yr of cropping to soybeans. The greatest incidence of sheath blight found in S-S-S fields was 0.6% diseased tillers and 3.8% disease foci. The interaction of year and crop rotation was not significant for diseased tillers ($P = 0.62$) or disease foci ($P = 0.42$).

Density of total sclerotia was positively correlated with incidence of diseased tillers and foci in 1988 and 1989 (Table 2). The degree of correlation was greater for disease foci than for diseased tillers in both years (Table 2). A high degree of variability was evident when density of total sclerotia was plotted against incidence of disease foci (Fig. 2). Linear regressions of incidence disease foci or tillers (y) on total sclerotia (x) were significant, but R^2 values were low, and significant lack of fit was evident. The degree of correlation between sheath blight incidence and density of viable sclerotia was greater than for total sclerotia in 1988 but not in 1989.

DISCUSSION

Cropping practices can have a major influence on establishment and increase of persistent soilborne diseases such as sheath blight of rice. Sheath blight was a minor disease in Mississippi prior to the introduction of the semidwarf rice cultivar Lemont in 1984 (G. L. Sciumbato, *personal communication*). The taller variety Starbonnet was grown on 75% of the state acreage prior to that time. This study established that sclerotia of *R. solani* AG-1 IA and sheath blight are now present in all 10 counties surveyed and in the majority of fields

Table 1. Influence of crop rotation and sampling year on density and viability of sclerotia of *Rhizoctonia solani* and incidence of sheath blight in fields planted with the rice cultivar Lemont[a]

Index	1988		1989			$P > F$	
Rotation[b]	Fields (no.)	Mean	Fields (no.)	Mean	2-Yr mean	Linear[c]	Year[d]
Sclerotia/500 cm³ of soil[e] (no.)							
R-S-R	14	3.82	15	7.33	5.64	...	...
S-S-R	12	0.95	14	2.56	1.82	...	...
S-S-S	9	0.24	1	0.33	0.25	...	...
Mean	...	1.86	...	4.72	...	...	...
$P > F$	...	...	...	...	...	0.001	0.001
Percent viable sclerotia[f]							
R-S-R	13	35.9	14	41.9	39.0	...	...
S-S-R	7	13.7	11	21.2	18.3	...	...
S-S-S	3	0	1	0	0	...	...
Mean	...	25.6	...	31.5	...	...	...
$P > F$	...	...	...	...	...	0.004	0.457
Percent diseased tillers[g]							
R-S-R	7	7.41	5	0.97	4.72	...	...
S-S-R	9	3.08	8	0.56	1.90	...	...
S-S-S	9	0.18	1	0.09	0.17	...	...
Mean	...	3.12	...	0.67	...	...	...
$P > F$	...	...	...	...	...	0.021	0.315
Percent disease foci[h]							
R-S-R	7	42.6	5	14.5	30.9	...	...
S-S-R	9	19.1	8	8.7	14.2	...	...
S-S-S	9	1.5	1	3.4	1.7	...	...
Mean	...	18.6	...	10.4	...	...	...
$P > F$	...	...	...	...	...	0.005	0.721

[a] Analysis of variance was performed on rank transformed means; actual mean values are presented.

[b] For the 3 yr prior to sampling, rice (R) was rotated with soybeans (S) in alternate years (R-S-R), 1 yr in three (S-S-R), or 1 yr in four (S-S-S for the previous 3 yr).

[c] Linear contrast of variable with years of the 3-yr rotation in rice (2, 1, or 0) or conversely in soybeans (1, 2, or 3).

[d] Contrast of variable with sampling year (1988 and 1989).

[e] Soil samples were taken prior to planting. Separate 425-cm³ samples were assayed per field in 1988 (1/ha), and one 425-cm³ sample from bulked 15-cm³ subsamples (1/0.2 ha) was assayed per field in 1989.

[f] Determined after 7 days on potato-carrot agar at 22-24 C.

[g] Diseased tillers within 0.8-m row samples taken along a W-shaped transect.

[h] Percentage of 0.8-m row samples with sheath blight along a W-shaped transect.

Table 2. Correlation coefficients for relationships among soil density of total and viable sclerotia of *Rhizoctonia solani* and incidence of sheath blight in fields planted with the rice cultivar Lemont

Index	Total sclerotia density[a]		Viable sclerotia[b]	
Year	Fields (no.)	No./500 cm³	Fields (no.)	No./500 cm³
Diseased tillers[c] (%)				
1988	26	0.63**[d]	22	0.87**
1989	14	0.54*	14	0.45
Disease foci[e] (%)				
1988	26	0.67**	22	0.92**
1989	14	0.64*	14	0.50

[a] Soil samples were taken prior to planting. Separate 425-cm³ samples were assayed per field in 1988 (1/ha), and one 425-cm³ sample from bulked 15 cm³ subsamples (1/0.2 ha) was assayed per field in 1989.

[b] Determined after 7 days on potato-carrot agar at 22-24 C.

[c] Diseased tillers within 0.8-m row samples taken along a W-shaped transect.

[d] Coefficients significant at ** = $P < 0.01$ and * = $P < 0.05$.

[e] Percentage of 0.8-m row samples with sheath blight along a W-shaped transect.

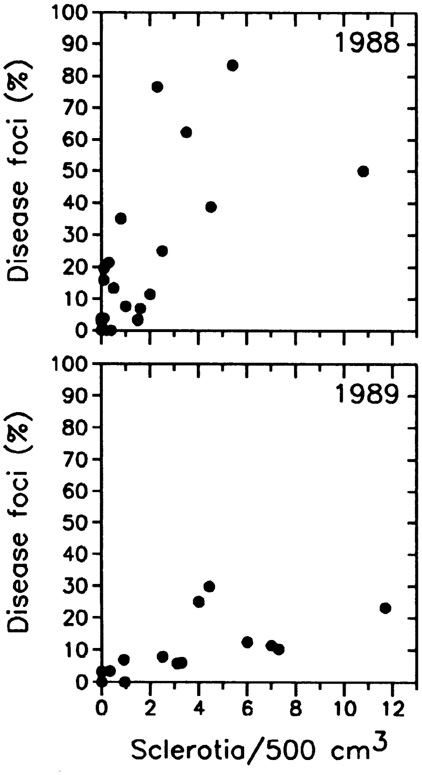

Fig. 2. Relationship of preplanting sclerotial density of *Rhizoctonia solani* to sheath blight incidence in the rice cultivar Lemont. Data points represent mean values of individual fields.

sampled. One third of fields had levels of disease equal to or exceeding the threshold for fungicide usage currently used in Mississippi.

Planting of soybeans as a rotation crop is thought to increase the incidence of sheath blight, because soybeans are susceptible to *R. solani* AG-1 IA, the causal agent of aerial blight (1,7,8, 10–12). Aerial blight is a widespread disease of soybean in the Gulf Coast production areas of south Mississippi, where no rice is grown but summer rains are frequent. In the Delta region of northwestern Mississippi, aerial blight of soybeans is rare. Although follow-up surveys of sampled fields planted to soybeans were not made in this study, 19 soybean fields in Bolivar County with histories of sheath blight problems in rice crops were surveyed in 1988. Aerial blight was not found in these fields during the pod fill stages of soybean development (*unpublished*). Declines in density and viability of sclerotia and sheath blight incidence occurred following 2 yr of soybean, and low levels of nonviable sclerotia were detected after 3 yr of soybean. However, only 10 S-S-S fields were sampled, and a sufficient number of sclerotia for viability testing was recovered from four. A larger sample size for the S-S-S rotation may be needed to confirm this result. The data presented indicate that in areas where occurrence of soybean aerial blight is infrequent, rotation of rice with soybean is beneficial. Frequent cropping and intensive management of susceptible rice cultivars are more likely to cause sheath blight buildup.

An objective of this study was to adapt preplanting soil assays of initial inoculum as a practical tool for predicting sheath blight incidence and the need for fungicide treatment. Despite a significant relationship between preplanting density of sclerotia and incidence of sheath blight in this study, a precise and accurate estimate of disease incidence based on inoculum density was not possible. In 1988, estimates of sclerotial density were based on samples taken within fields and assayed separately. Relationships between inoculum density and disease incidence were stronger with this method than in 1989 when samples were bulked within fields. This adjustment was made in an attempt to make soil assays practical by reducing soil volume. Estimates of viable inoculum density from nonbulked samples resulted in the highest correlation with disease incidence.

Factors other than sclerotial density may have affected sheath blight development and contributed to the variability between inoculum density and disease incidence observed in this study. Forms of inoculum other than sclerotia may serve to initiate disease foci. Mycelium in plant debris and sclerotial fragments have been reported to serve as primary inoculum (11). Mycelium in debris was not quantified, and only sound sclerotia were counted and assayed for viability in this study. Hyphae radiating from infections near the waterline onto the water surface (7) were frequently encountered in this study. It is possible that hyphae become dislodged from these infections with water movement and move some distance to initiate new infection foci.

Differences between fields in management practices may also account for variability in disease development. Nitrogen fertilization has a strong impact on sheath blight by creating a dense canopy and a favorable environment for infection (11). High levels of nitrogen also result in less epicuticular wax deposition on rice leaves and sheaths, increased infection cushion formation by *R. solani*, and greater susceptibility to sheath blight (14). Lodging resistance in Lemont allows growers to exceed recommended nitrogen levels while attempting to achieve high yields.

Flushing fields one or more times before establishment of a permanent flood is a routine management practice for production of Lemont in Mississippi, where nearly all rice is drill-seeded. Flushing is recommended because of the low seedling vigor inherent in this cultivar. Water is applied across fields from the high to low end until the low end is saturated. Debris and sclerotia are frequently observed to collect at the low ends of fields and incidence of sheath blight is often highest there. The clumped distribution of rice sheath blight and soybean aerial blight has been well quantified (1,21). Values of V/M for sclerotial density and incidence of sheath blight in this study were usually greater than one, indicating their distributions were clumped. The mean V/M for the 19 fields cropped to rice in 1988 where sclerotia were detected was four times greater for incidence of diseased tillers than for sclerotial density. This increase in the clumping of disease compared to inoculum supports the occurrence of sclerotial redistribution following soil sampling. More intensive sampling than that done in this study may be required for a more accurate estimate of disease incidence and/or inoculum density.

Management of sheath blight has been directed toward the integration of cultural practices with chemical control. Crop rotation options are restricted by land availability, economic returns on rotational crops, and ability to grow rotational crops on the clay soils cropped to rice in the Mississippi Delta. Although other crops such as pasture may be superior to soybeans for reducing sheath blight inoculum (1), rotation with soybeans in areas where aerial blight is rare is effective. Based on this study, use of a threshold approach to management of sheath blight with fungicides in Mississippi will continue to rely on in-season assessment of disease incidence. Using presence or absence of sclerotia and disease as response criteria for sampling, preplanting soil assays correctly predicted disease occurrence in 85% of fields. Therefore, these procedures may have practical use for making cropping decisions following rotation away from rice for several years.

LITERATURE CITED

1. Belmar, S. B., Jones, R. K., and Starr, J. L. 1987. Influence of crop rotation on inoculum density of *Rhizoctonia solani* and sheath blight incidence in rice. Phytopathology 77:1138-1143.
2. Byrd, D. W., Barker, K. R., Ferris, H., Nusbaum, C. J., Griffin, W. E., Small, R. H., and Stone, C. A. 1976. Two semi-automatic elutriators for extracting nematodes and certain fungi from soil. J. Nematol. 8:206-212.
3. 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.
4. Damicone, J. P., and Sciumbato, G. L. 1990. Efficacy of foliar fungicides for control of sheath blight of rice. Fungic. Nematicide Tests 45:170.
5. Hashiba, T. 1984. Forecasting model and estimation of yield loss by rice sheath blight disease. JARQ 18:92-98.
6. Hori, M. 1969. On forecasting the damage due to sheath blight of rice plants and the critical point for judging the necessity of chemical control of the disease. Rev. Plant Prot. Res. 2:70-73.
7. Jones, R. K., and Belmar, S. B. 1989. Characterization and pathogenicity of *Rhizoctonia* spp. isolated from rice, soybean, and other crops grown in rotation with rice in Texas. Plant Dis. 73:1004-1010.
8. Jones, R. K., Belmar, S. B., and Jeger, M. J. 1987. Evaluation of benomyl and propiconazole for controlling sheath blight of rice caused by Rhizoctonia solani. Plant Dis. 71:222-225.
9. Kozaka, T. 1975. Sheath blight in rice plants and its control. Rev. Plant Prot. Res. 8:69-80.
10. Lee, F. N. 1980. Number, viability, and buoyancy of *Rhizoctonia solani* sclerotia in Arkansas rice fields. Plant Dis. 64:298-300.
11. Lee, F. N., and M. C. Rush. 1983. Rice sheath blight: A major rice disease. Plant Dis. 67:829-832.
12. Marchetti, M. A. 1983. Potential impact of sheath blight on yield and milling quality of short-statured rice lines in the southern United States. Plant Dis. 67:162-165.
13. Marshall, D. S., and Rush, M. C. 1980. Infection cushion formation on rice sheaths by *Rhizoctonia solani*. Phytopathology 70:947-950.
14. Massaquoi, R. C., and Rush, M. C. 1988. Relationship of quantity of epicuticular wax to resistance of rice to sheath blight. Proc. Rice Tech. Working Grp. 22:69.
15. Min, A., Sciumbato, G. L., Kanter, D. G., and Jackson, B. R., and Damicone, J. P. 1990. Identification of rice sheath blight resistance. Biol. Cult. Tests 5:66.
16. Naiki, T., and Ui, T. 1978. Ecological and morphological characteristics of sclerotia of *Rhizoctonia solani* Kuhn in sugar beet field soil. Soil Biol. Biochem. 9:377-381.
17. O'Neill, N. R., Rush, M. C., Horn, N. L., and Carver, R. B. 1977. Aerial blight of soybeans caused by *Rhizoctonia solani*. Plant Dis. Rep. 61:713-717.
18. Ou, S. H. 1985. Rice Diseases. 2nd ed. Commonwealth Mycological Institute, Kew, England.
19. Tuite, J. 1969. Plant Pathological Methods. Burgess, Minneapolis, MN.
20. Yang, X. B., Berggren, G. T., and Snow, J. P. 1990. Types of Rhizoctonia foliar blight on soybean in Louisiana. Plant Dis. 74:501-504.
21. Yang, X. B., Snow, J. P., and Berggren, G. T. 1990. Analysis of epidemics of Rhizoctonia aerial blight of soybean in Louisiana. Phytopathology 80:386-392.