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Rice Sheath Blight: A Major Rice Disease

Rice, the primary staple food in many countries, is subject to diseases that often place major biological constraints on production. Of these, rice sheath blight is second only to, and often rivals, rice blast in importance. Rice sheath blight occurs throughout temperate and tropical production areas and is most prominent where rice is grown under intense production systems. First reported in Japan in 1910, the disease became established in many oriental countries and, as a result, is often referred to as "oriental leaf and sheath blight" (5). It is also known as "brown-bordered leaf and sheath spot" (11).

The Pathogen

The causal agent has been reported in the literature to be *Corticium sasakii* (Shirai) Matsumoto, *C. vagum* Berk. & Curt., *Sclerotium irregulare* I. Miyake, *Hypochnus sasakii* Shirai, *Pellicularia sasakii* (Shirai) S. Ito, and *Rhizoctonia solani* Kühn. Researchers now generally accept *R. solani*, perfect stage *Thanatephorus cucumeris* (Frank) Donk, in the AG 1 anastomosis series as the pathogen (1,5,9).

Although the pathogen is soilborne, rice sheath blight develops into a major production-limiting disease in an alarmingly short time. In fact, the disease has become the most important rice disease in the southern rice-producing areas of the United States over the last 10 years. Yield losses as large as 50% occur in susceptible cultivars when all the leaf sheaths and leaf blades are infected.

Symptoms, Disease Development

Lesions can sometimes be found on young plants under favorable conditions, but initial symptoms are usually lesions on sheaths of lower leaves when plants are in the late tillering or early internode elongation stage of growth (Fig. 1). These lesions appear 0.5–3 cm below the leaf collar as circular, oblong, or ellipsoid, green-gray, water-soaked spots about 1 cm long. They enlarge to approximately 1 cm in width and 2–3 cm in length. As a lesion develops, the center becomes bleached with an irregular purple-brown border. Under favorable microclimatic conditions of low sunlight, humidity near 95%, and high temperature (28–32 C), infection spreads rapidly by means of runner hyphae to upper plant parts, including leaf blades, and to adjacent plants. Lesions on the upper portion of the plant coalesce to encompass entire leaf sheaths and stems (Fig. 2). Subsequent opening of the plant canopy through leaf death allows increased sunlight penetration and decreased humidity. Lesions then dry, becoming white, tan, or gray with brown borders (Fig. 3). Sclerotia, initially white but turning brown at maturity, are produced superficially on or near the infected tissue after about 6 days. Sclerotia are loosely attached and easily dislodged from the plant at maturity (Fig. 4).

Disease development is most rapid in the early heading and grain filling growth stages. Plants heavily infected at these stages produce poorly filled grain, particularly in the lower portion of the panicle. Additional losses result from increased lodging or reduced ratoon production due to death of the culm (Fig. 5).

New cultivars and changing cultural practices often combine many of the factors favoring disease development and contribute greatly to the rapid increase in sheath blight incidence and severity. Because of high yielding ability, new cultivars are rapidly and widely accepted by producers. In recent years in the southern United States, new long-grain cultivars are generally more susceptible to the pathogen (Fig. 6) and require higher fertility levels, particularly nitrogen, to achieve high yields. In addition, these cultivars are grown in denser stands and tend to be more compact (dwarfed), creating a favorable microclimate for disease development earlier in the growing season.

Epidemiology

Basidiospores of *T. cucumeris*, produced in hymenia on host plants, can initiate infection but are considered to be unimportant in the epidemiology of rice sheath blight (1,4,5). Soilborne sclerotia, and to a lesser degree mycelium in plant debris, are the means of pathogen survival between crops and are the primary inoculum (3,12). Sclerotia are nonbuoyant when first mature but become buoyant after approximately 30 days when exterior cells become void of cellular content. Sclerotia floating in the paddy tend to accumulate around the rice plant at the water-plant interface, so initial infections occur near the waterline. Sclerotia and sclerotia fragments are capable of initiating hyphal growth several times.

Sclerotia survive long periods in temperate rice production areas and tend to accumulate in the soil. Sclerotia populations in undisturbed Arkansas rice fields after a crop with a high incidence of sheath blight vary from high to low as depth increases (6). Densities in the 0–0.6-cm surface zone varied from 216 to 701 sclerotia per liter of soil, with a viability range from 42.3 to 51.4%. Sclerotia in this zone represent annual production on the diseased crop and serve to replenish the soil populations. The permanent soil population in 0.6–7.6-cm depths ranged from 27 to 87 sclerotia per liter, with a viability from 14.2 to 30.3%. Buried sclerotia are viable after 2 years.

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Control Options

Host resistance. Resistance, the most desirable control measure, has been investigated by researchers in several countries. Thousands of entries have been evaluated under disease pressures obtained by various inoculation techniques in greenhouse or field tests. International sheath blight nurseries providing simultaneous entry evaluation in several countries are conducted by researchers at the International Rice Research Institute, Los Baños, Philippines. Results from these programs are similar in that a source of immunity or of high-level resistance has not been found. Several moderately resistant cultivars have been identified based on the degree of upward disease development on the plant. Tests with related wild rices have failed to provide sources more resistant than those found in cultivated species.

Little research on the inheritance of resistance factors has been conducted because of the lack of suitable donor parents. Evaluation of F_2 populations from crosses of the moderately resistant and susceptible cultivars suggests "resistance" may be dominant over susceptibility with a 3:1 segregation ratio (8). Thick wax deposits on leaf sheaths are known to inhibit infection. Wax thickness appears to be correlated with resistance and segregates at the same ratio.

Preliminary investigations in Japan suggest Indica types of rice are more tolerant than Japonica types. As a result of hybridization between these rices in cultivar development programs, however, this distinction appears to be genetically unimportant. Among cultivars grown in the southern United States, the higher level of resistance is found in the short- and medium-grain types, which are more like the Japonica rices. Long-grain cultivars similar to the Indica rices possess little sheath blight resistance, particularly those with a short maturity time. Yield loss differences between very susceptible and moderately resistant cultivars can be substantial. In inoculated field tests, losses in the moderately resistant medium-grain cultivar Mars varied between 7 and 15%, while losses in the less resistant long-grain cultivar Starbonnet were 15–25%. Losses in the highly susceptible long-grain cultivar Lebonnet were 25–50%.

Cultivar performance is greatly influenced by physiological, morphological, and ecological factors. Young plants are more resistant than old plants, with greatest susceptibility at panicle emergence. High levels of nitrogenous fertilizers also increase susceptibility (2). Short cultivars with broad leaves and high tillering abilities produce a closed canopy and, in turn, a favorable microclimate for disease development much earlier than tall cultivars with fewer tillers. Early-maturing cultivars appear more susceptible than ones that mature later under environmental conditions less favorable for sheath blight development. Differences are small when planting dates are staggered so cultivars head at the same time.

Fungicides. Researchers have extensively tested fungicides in Japan, where foliar spraying has been practiced commercially for several years (5). Organic arsine compounds and organic tins are the most effective for inhibiting infection, lesion enlargement, and

Fig. 1. Lesion on rice leaf sheath during early internode elongation growth stage.

Fig. 3. Dried lesions with bleached centers and brown borders after plant canopy opens.

Fig. 5. Drastic yield reduction and severe lodging caused by rice sheath blight.

Fig. 2. Lesions girdling upper leaf sheath of rice plant at early heading growth stage.

Fig. 4. Mature *Rhizoctonia solani* sclerotia loosely attached to rice plant.

Fig. 6. Natural infection in a highly susceptible rice cultivar.

Table 1. Mean yield response to foliar fungicides in the rice cultivars Lebonnet and Starbonnet inoculated with *Rhizoctonia solani*

		Lebonnet			Starbonnet		
			Response			Response	
Treatment[a]	Rate/A/ appl.[b]	Yield[c] (lb/A)	lb/A[d]	%[e]	Yield (lb/A)	lb/A	%
Uninoculated untreated	···	6,724	1,897	100	5,901	1,003	100
Inoculated untreated	···	4,827	···	···	4,898	···	···
Duter 47.5W	2 lb	6,263	1,436	75	5,663	765	76
Duter 47.5W	1 lb	6,436	1,609	84	5,821	923	92
Benlate 50W	2 lb	6,113	1,286	67	5,965	1,067	106
Benlate 50W	1 lb	5,723	896	47	5,283	385	38
Mertect 340F	12 oz	5,436	609	32	4,994	96	9

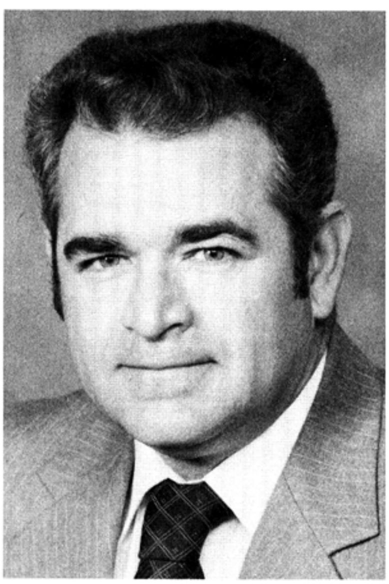
[a] All plots except the uninoculated untreated check were inoculated with *R. solani* immediately after internode elongation began.
[b] Formulated material per acre per application in 10GPA water. The first application was made during early internode elongation and the second, 10–14 days later.
[c] Mean yield per cultivar from three tests having substantial, statistically significant sheath blight losses defined as the difference between inoculated and uninoculated untreated check yields.
[d] Response difference between the treatment yield and the inoculated untreated check yield.
[e] Percent sheath blight loss prevented by treatment.

mycelial growth. The arsine compounds are often phytotoxic, particularly if plants are under stress, but can be made safer by the addition of iron. Less effective antibiotic preparations, such as polyoxin and validamycin, have also been used commercially in Japan.

Fungicides have not provided the high level of control desired in the United States. Results from foliar fungicide applications are often erratic, particularly in tests with a large number of candidate fungicides. However, individual tests (10) can be selected as examples of effective fungicide performance or, better yet, data can be averaged over locations and years. Averaged data from tests considered to provide a valid estimate of sheath blight damage measured as the yield difference between untreated inoculated and untreated uninoculated checks are presented in Table 1 (7). Duter (fentin hydroxide), the most efficacious fungicide tested to date, prevented approximately 84% of sheath blight losses in the cultivar Lebonnet and 92% of losses in the cultivar Starbonnet when applied twice at the 1 lb/A rate. Due to possible phytotoxicity or to experimental error, the 2 lb/A rate prevented only 75 and 76% of yield losses in Lebonnet and Starbonnet, respectively. Although response percentages are numerically close in both cultivars, the magnitude of the yield response is much greater in the more susceptible Lebonnet. This is an important consideration in practical decisions concerning commercial application.

At present, two fungicide applications are normally suggested in sheath blight treatment, and their timing appears to be important. The first application is made shortly after symptoms are observed (usually early internode elongation) and a second, 10–14 days later (before heading). Only Benlate (benomyl) and Mertect (thiabendazole) are currently registered for commercial use on rice in the United States. Because of potential residue problems, fentin hydroxide use to date has been limited to a single early application as granted for 1981 and 1982 to Arkansas, Mississippi, and Texas by the EPA under Section 18 of the amended FIFRA. Losses sustained after fungicide application are often substantial and symptom expression is striking, particularly with a single application or at the lower application rates.

Inoculum manipulation. Classic approaches to inoculum manipulation and/or destruction are either not very effective or not feasible. Burning stubble usually is not thorough enough to consume sclerotia or render them nonviable. Long rotations with other crops are no longer economically feasible. Rotation is also ineffective because the pathogen has a wide host range and inoculum is maintained on many weeds and alternate crops occupying



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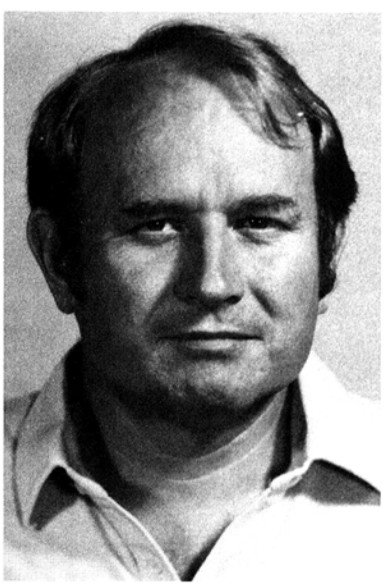

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the field in years when rice is not grown (5). An excellent example of this, and no doubt a major contributing factor in the dramatically increased rice sheath blight incidence, is the utilization of soybean (*Glycine max*) as a rotation crop with rice in the southern United States. The standard rotation is 1 year of rice and 2 years of soybean, but quite frequently during the past 10 years this rotation has been reduced to only 1 year for each crop or abandoned for continuous rice. Aerial blight of soybean, incited by the same pathogen (9), is increasing in incidence and severity. Prolific sclerotia production on soybean also serves to maintain the high levels of inoculum in the soil. To complicate matters further, irrigation of soybean, which also promotes aerial blight development, is becoming a widespread practice.

Other strategies to limit sclerotia production or longevity are currently under investigation. Production of sclerotia can be reduced by growing cultivars resistant to sheath blight. The use of effective foliar fungicides to directly reduce yield losses also has an added benefit of substantially reducing sclerotia production. Theoretically, the primary inoculum could be greatly reduced through the use of resistant cultivars in conjunction with a fungicide that provides effective disease control in rice and its rotation crops.

Expanding Control Options

The impact of rice sheath blight as a major rice disease worldwide appears to be increasing. At present, control programs to change this trend consist of integrating the somewhat limited control options of host resistance, foliar fungicides, rotation schemes, and cultural manipulations. Current research efforts are directed toward expansion of these options. Evaluation of the rice germ plasm pool continues, as do efforts to improve cultivar performance by combining known levels of resistance and by altering plant growth habits favorable for disease development. The search for more efficacious fungicides in conjunction with better methods of application or timing is being continued. Rotation and cultural programs designed to limit primary inoculum and reduce disease severity are being improved or developed.

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