First Report of Dry Top Rot of Sugarcane in Florida: Symptomatology, Cultivar Reactions, and Effect on Stalk Water Flow Rate

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ABSTRACT

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Dry top rot, caused in sugarcane by *Ligniera vasculorum* (Matz) Cook, was detected at the USDA-ARS Sugarcane Field Station, Canal Point, Florida, on 13 November 1991 in CP 88-Series clones. This is the first report of the disease in Florida; previous reports of the disease were in the 1920s and 1930s in Puerto Rico. It also has been reported in Barbados, Cuba, and Venezuela. Overall symptoms include initial drying of the spindle leaf tips, subsequent drying of the upper leaves, reduced growth of the top internodes of the stalk, gradual shrinking and drying of stalks, and finally stalk death. Masses of orange-brown spores, 17–25 μm diameter, were present in the xylem cells of the vascular bundles of the basal internodes. Water flow in symptomatic stalks was restricted. The disease incidence of cultivars was variable.

Plants of sugarcane (interspecific hybrids of *Saccharum* spp.) were observed with symptoms of an unknown disease on 13 November 1991 in increase plots in the variety development program at the USDA-Sugarcane Field Station, Canal Point, Florida. Affected plants appeared to be suffering from drought, although there was and had been adequate soil moisture. The symptoms included withering spindle leaves, drying of leaf tips, and retarded stalk growth compared to unaffected plants within the same plot and in adjacent plots. The upper internodes of severely affected plants were withered and abnormally shortened, and the stalks tapered toward the apex. Subsequently, the most severely affected plants died. The symptoms appeared to be similar to those described for dry top rot of sugarcane, caused by *Ligniera vasculorum* (Matz) Cook. This obligate parasite is a species of the Plasmodiophoromycetes that produces no host hypertrophy. Dry top rot was first reported in Puerto Rico in 1920 and caused serious losses in the 1920s (1). The literature on the disease is limited (1–4, 6,7), with no recent reports of the disease.

Our objectives were to identify the disease and describe symptoms, verify pathogen identity, determine the disease reactions of promising cultivars in the selection program, and compare water flow in infected and healthy plants, since the withering of the leaves suggested impaired water uptake.

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MATERIALS AND METHODS

Microscopic examination. The vascular bundles of symptomatic stalks were examined microscopically for the presence of spores characteristic of the causal agent (2,3,6,7) in freehand sections from internodal stalk tissue located 2.5–25.0 cm above the soil line.

The association of spores within xylem cells at the base of the stalks showing characteristic wilting and necrosis of spindle leaves was determined for cultivars CP 88-1196 and CP 88-1614 using 20 symptomatic and 20 asymptomatic stalks per cultivar. The presence of spores also was determined in symptomatic stalks of cultivars CP 87-1226 and CP 88-1508 and in asymptomatic stalks of the two cultivars collected from a field in Belle Glade, Florida, and a field 15 km south of Canal Point where the disease has not been observed.

Disease ratings. Disease reaction ratings were taken for 57 cultivars in single increase plots four rows wide (6.1 × 10.7 m) that contained approximately 50 stools (the plant that develops from a single vegetative cutting, including the initial shoot and subsequent tillers). We used a 0–3 scale, where 0 = no symptoms; 1 = symptoms in only one stool; 2 = symptoms on one to four stools per plot, with at least one stalk (tiller) per stool affected; and 3 = symptoms on five or more stools per plot affected, with several stalks of each stool dead or the entire stool dead. Disease severity ratings were repeated 10 mo later on regrowth (ratoon) that developed after cutting the initial plants at the soil line.

Water transport. The rate of water flow was determined through 4-cm-long nodal sections cut approximately 25.0 cm above the soil line of mature, infected and noninfected stalks of cultivars CP 88-1196 and CP 88-1614. We followed the methods described for sugarcane infected with ratoon stunting disease (5), with six replications. Briefly, the basipetal end of each nodal section was immediately attached to a column of water (90.0 × 2.5 cm) using a rubber tube coupling. The rate of water flow ($ml/cm^2/15$ min) was measured by collecting water that flowed through the nodal section. The disease state of the nodal samples was verified microscopically by the presence or absence of spores in the xylem elements. The evaluations were repeated on stalks that grew after the cutting of the initial plant crop. Least significant difference for the rate of water flow of infected and healthy stalks was determined.

RESULTS

Symptomatology. Initial dry top rot symptoms are withering of spindle leaves and drying of leaf tips (Fig. 1A). The internodes near the growing point are shortened, shrunken, and flaccid compared to those of healthy stalks. Later

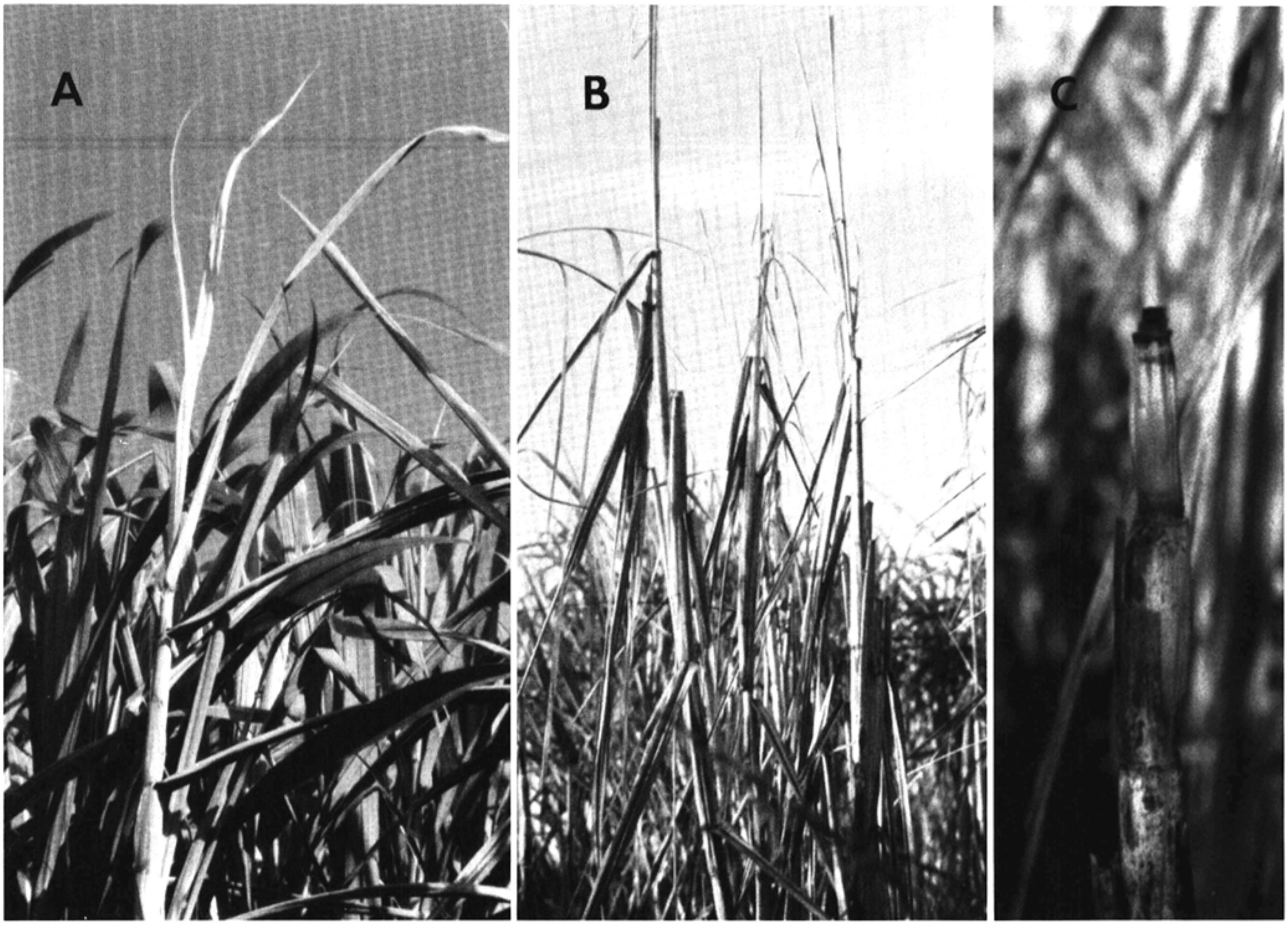

Fig. 1. Symptoms of dry top rot caused in sugarcane by *Ligniera vasculorum.* **(A)** Early drying of spindle leaves. **(B)** Later drying of leaves with stalk death. **(C)** Dead stalk that is withered and shrunken.

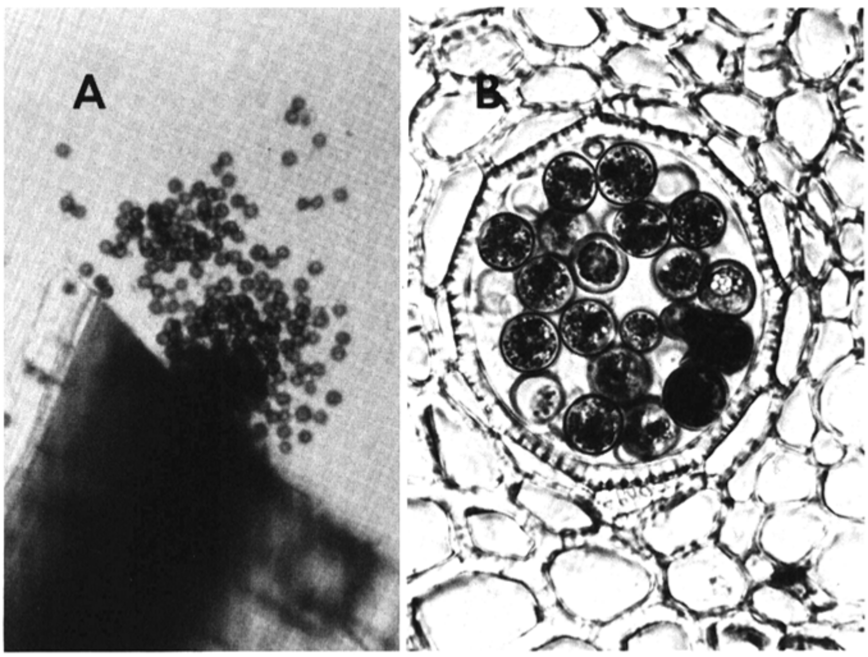

Fig. 2. Spores of *Ligniera vasculorum* in xylem tissue of sugarcane, **(A)** flowing from a vascular bundle mounted in water (×100), and **(B)** mounted in lactic acid with cotton blue (×400).

stages of the disease include complete drying and necrosis of spindle and upper leaves, death of the shoot apex and stalk, and possibly death of the entire stool (Fig. 1B). The spindle leaves become detached from stalks that die, exposing the withered internodes (Fig. 1C).

Longitudinal and cross sections of the basal internodes of symptomatic stalks revealed orange-pink vascular bundles. Orange-brown, spherical spores, measuring 17–25 μm in diameter with 1.5 μm walls, were found in the xylem sampled from these discolored vascular bundles (Figs. 2A and B). The xylem vessels appeared packed with these spores, and spore masses flowed from excised vascular bundles when placed in a drop of water (Fig. 2A). In some xylem vessels, usually above the region where the spores were found, a gray granular substance similar to the plasmodium described for the pathogen (2,6,7) was observed. No mycelium was observed in either the xylem vessels or the surrounding parenchyma tissues.

Association of symptoms and fungal spores. Orange-brown spores similar to those described for dry top rot (2,6,7) were associated with the symptomatic stalks. Spores were found in all 20 symptomatic stalks of cultivars CP 88-1196 and CP 88-1614. Spores were observed in three of 20 and two of 20 asymptomatic stalks of these respective cultivars taken from the same plots. The characteristic spores were consistently found in symptomatic stalks of cultivars CP 88-1508 (14 of 15 stalks) and CP 87-1226 (15 of 17 stalks). Spores were also observed in vascular bundles in 5- to 6-mo-old plants that developed from planting dry top rot–infected seedcane, and in the 4-mo regrowth of infected plants that were cut at ground level in February 1992. No spores were present in symptomless sugarcane sampled from other locations.

Disease ratings. Dry top rot appeared to be evenly distributed throughout the field where the plants were rated; cultivars with the most infected plants were adjacent to plots having no infected plants. The severity ratings for 22 of the 57 cultivars were higher in 1992 than in 1991; whereas eight decreased and the remainder were the same for both years (Table 1). Cultivar susceptibility to dry top rot appeared to be influenced by its parentage. All of the cultivars that were progeny of CP 81-1238 had dry top rot symptoms during at least one of the 2 yr that they were rated. Nine of the 13 cultivars that had a mean severity rating of at least 2.5 were progeny of CP 81-1238. In contrast, no progeny of CP 81-1238 were in the group of 22 cultivars that remained symptomless.

Restriction of water flow. The rate of water flow was restricted through internodal sections from dry top rot–infected stalks of cultivars CP 88-1196 and CP 88-1614 compared to flow through healthy sections. The flow rate averaged 1.32 and 1.62 $ml/cm^2/15$ min through infected internodal stalk sections of CP 88-1196 and CP 88-1614, respectively, but was 6.20 and 7.89 $ml/cm^2/15$ min for healthy stalk sections of the same cultivars. Based on the least significant difference test (LSD = 1.36), the mean flow rates of infected and healthy stalks were statistically significant ($P < 0.01$). The evaluations were repeated with similar results using stalks obtained from the regrowth that developed after cutting (ratooning) the initial plants.

DISCUSSION

This is the first report of dry top rot in Florida. The disease was limited to one 0.5-ha field at the Sugarcane Field Station, Canal Point, Florida, and a single 10-m^2 plot of one cultivar evaluation experiment located at South Bay, Florida. Previously, the disease was reported in Puerto Rico, Barbados, Cuba, and Venezuela (1). In retrospect, the disease was probably observed in the same general location at Canal Point the previous year, and similar symptoms were observed approximately 10 yr before. However, dry top rot was not positively identified at any of these times. When and where the disease was introduced to Florida is unknown because there are no verified reports of it since the 1930s.

Dry top rot symptoms, including drying and subsequent death of leaves and stalks, appear similar to those of desiccation caused by drought stress. Restricted water flow in segments of stalks infected with dry top rot and spore masses within the vascular bundles support the idea of reduced water uptake by infected plants. Wilt, another disease of sugarcane caused by *Gibberella subglutinans* (E. Edwards) P.E. Nelson, T.A. Tousson, & Marasas, has similar symptoms; but the internal stalk tissue in affected plants is light purple or reddish. There was no general internal discoloration in stalks infected with *L. vasculorum*. Vascular bundles were light pink in the stalk where the spores were found within the xylem. Another disease, leaf scald caused by *Xanthomonas albilineans,* was present in the same general area, but its distinctive pencil-line leaf streaks and side shooting clearly distinguish it from dry top rot.

The occurrence in sugarcane, the masses of orange spherical spores (17–25 μm in diameter) in the xylem cells, and the lack of hypertrophy of the host tissue indicate that this is the fungus first described as *Plasmodiophora vascularum* Matz (6). These spore diameter measurements differed slightly from the 14–16 μm first reported by Matz (6). Abbott (1) erroneously cited Matz's (6) measurements as 0.4–0.6 mm. The taxonomic placement of this fungus has remained a source of controversy (3). Cook (2) transferred the fungus to the genus *Ligniera,* as *L. vasculorum* (Matz) Cook, because of the loosely aggregated resting spores and the lack of hypertrophy of the host tissue. Cook (3) also thought that it could be placed in *Sorosphaera,* but only if the description of this genus was revised. *L. vasculorum* is the more commonly used name for this fungus (8). Detailed studies of this fungus and other related species are needed to clarify its taxonomic relationships.

Isolations of infected stalk tissue on potato-dextrose agar and water agar plates failed to yield any one organism from dry top rot symptomatic stalks. However, it should be noted that *L. vasculorum* is an obligate parasite. No mycelium was observed either in or near xylem vessels that contained spores of *L. vasculorum.*

Table 1. Severity ratings of dry top rot caused by *Ligniera vasculorum* for 57 sugarcane cultivars

Cultivar[a]	Severity ratings[b] 1991	1992	Mean
CP 87-1121	1	0	0.5
CP 87-1214	1	2	1.5
CP 87-1226	3	3	3.0
CP 87-1248	0	1	0.5
CP 87-1490	0	1	0.5
CP 87-1628	1	2	1.5
CP 87-1733	2	1	1.5
CP 88-1066	0	1	0.5
CP 88-1165	1	0	0.5
CP 88-1196	3	3	3.0
CP 88-1293	2	3	2.5
CP 88-1426	0	2	1.0
CP 88-1449[c]	3	2	2.5
CP 88-1498[c]	2	3	2.5
CP 88-1508[c]	2	3	2.5
CP 88-1532[c]	2	3	2.5
CP 88-1540[c]	2	3	2.5
CP 88-1543[c]	1	0	0.5
CP 88-1561[c]	1	3	2.0
CP 88-1573[c]	1	0	0.5
CP 88-1604	1	1	1.0
CP 88-1614[c]	3	3	3.0
CP 88-1696	0	1	0.5
CP 88-1700	1	2	1.5
CP 88-1701	1	3	2.0
CP 88-1726[c]	2	3	2.5
CP 88-1762	1	1	1.0
CP 88-1826	1	0	0.5
CP 88-1870	0	3	1.5
CP 88-1880	0	3	1.5
CP 88-1889[c]	0	2	1.0
CP 88-1912	1	0	0.5
CP 88-2017	0	1	0.5
CP 88-2050[c]	2	3	2.5
CP 88-2052[c]	2	3	2.5

[a]The following cultivars did not exhibit any dry top rot symptoms for either year: CP 70-1133, CP 72-1210, CP 87-1018, CP 87-1475, CP 87-1737, CP 88-1138, CP 88-1179, CP 88-1409, CP 88-1491, CP 88-1656, CP 88-1678, CP 88-1703, CP 88-1718, CP 88-1834, CP 88-1836, CP 88-1931, CP 88-2006, CP 88-2024, CP 88-2039, CP 88-2044, CP 88-2046, and CP 88-2053.

[b]Based on a 0–3 scale: 0 = no symptoms; 1 = symptoms on only one stool (a plant with multiple tillers that are called stalks); 2 = symptoms on one to four stools per plot with at least one stalk per stool; and 3 = symptoms on five or more stools per plot affected, with several stalks per stool dead. Ratings taken from single plots of four rows 6.7 m long.

[c]Progeny of CP 81-1238.

Preliminary observations suggest variability in reaction of cultivars to dry top rot. Genetic variability is suggested, in that all progeny of CP 81-1238 had symptoms of the disease. Furthermore, of these 13 progeny of CP 81-1238, nine had a mean severity rating of at least 2.5. These observations of naturally infected plants need to be confirmed when an inoculation technique is developed.

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