THE OCCURRENCE OF FUSARIAL WILT IN NORMALLY RESISTANT 'DWARF CAVENDISH' BANANA

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Abstract

In the Canary Islands, fusarial wilt caused by Fusarium oxysporum f. sp. cubense has destroyed areas of up to 1 hectare of normally highly resistant 'Dwarf Cavendish' bananas in some farms. Scattered isolated cases of wilt are more common than these acute attacks. Severe localized attacks have also been reported from Taiwan. Where scattered isolated plants are attacked in Gran Canaria, recovery from wilt often occurs in the following suckers. Pathogenicity tests with F. oxysporum f. cubense isolates from Dwarf Cavendish from Gran Canaria and Taiwan, other Cavendish varieties from Central America, and from the susceptible Gros Michel variety showed that all isolates are race 1 and a new race capable of attacking Cavendish varieties has not developed. The breakdown of resistance of Dwarf Cavendish in localized areas in Gran Canaria is attributed to adverse growing conditions; poor drainage and soil permeability appear to be the main contributing factors. Low seasonal temperatures and, in some areas, low soil pH and salinity may also contribute to reduced resistance to wilt. A certain combination of all factors contributing to adverse growth prevents the expression of the full genotypic resistance of the variety and wilt occurs.

The 'Dwarf Cavendish' banana, a member of the Cavendish sub-group AAA of Musa, has been the major export crop of the Canary Islands for more than 50 years (3, 6). Fusarial wilt of the normally highly wilt resistant Dwarf Cavendish variety was first reported by Del Cañizo and Sardiña (2) from Tenerife in 1932. It was not until 1961, however, that Waite (13) showed that the Canary Island fungus attacking Dwarf Cavendish was not different from race 1 that attacks the susceptible Gros Michel variety worldwide. Stover and Waite (12) described two races of F. oxysporum Schlecht. f. cubense (E.F. Smith) Snyd. & Hans. based on the reaction of the varieties Gros Michel (AAA) and Bluggoe (ABB). The former is susceptible to race 1 and the latter to race 2. The genotypic background of these varieties has been described by Simmonds (9). Rishbeth (7, 8) reported five different small outbreaks of wilt on the resistant Lacatan variety in Jamaica, also a member of the Cavendish subgroup (Musa AAA). He also mentioned a report of wilt on Dwarf Cavendish in one area of Natal, South Africa. Rishbeth did not find any difference in pathogenicity between the fungus from resistant Lacatan and that from susceptible Gros Michel in Jamaica. In 1962, Champion and Monnet (3) described symptoms of fusarial wilt on Dwarf Cavendish in the Canary Islands. Increased wilt attacks in 1970-71 in the Canary Islands and a report by W. C. Snyder (personal communication) of a severe attack on Dwarf Cavendish in Taiwan prompted a study of the fungus attacking Dwarf Cavendish. In addition, an examination of disease outbreaks in the field in Gran Canaria was undertaken to determine to what extent the resistance of Dwarf Cavendish was breaking down. The results of these studies are reported here.

METHODS

Fusarium oxysporum f. cubense was isolated directly from diseased rhizome tissue of Dwarf Cavendish from Gran Canaria and cultures isolated from diseased Dwarf Cavendish were obtained from Taiwan. Cultures were also isolated from wilted Valery, Bluggoe, and Gros Michel varieties in Central America. The first named variety is a member of the highly resistant Cavendish subgroup (Musa AAA) but a rare case of wilt is sometimes found on this and all other Cavendish varieties in Central America (11, 13). The Bluggoe variety is attacked only by race 2 and Gros Michel by race 1 (12). The first pathogenicity test was carried out near Homestead, Florida to avoid introducing any possible new races into Central America. Subsequent pathogenicity tests were undertaken in Honduras when no evidence of a new race was found.

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Inoculum for the Florida tests was grown in liter bottles on an oatmeal-vermiculite medium. Rhizomes of Bluggoe, 'Highgate' (a dwarf, mutant strain of Gros Michel) and Dwarf Cavendish were planted in galvanized containers 17 inches deep by 15 inches wide. The soil used was an acid (pH 5.5) muck-sand mixture containing 21% organic matter, with a complete fertilizer added. Two months after planting, the vigorously growing bananas were inoculated by removing soil from around the roots in the top of the container and covering the exposed roots with about 100 cc of the oatmeal-vermiculite culture of Fusarium. The cultures were 13 days old at time of inoculation and the plants were 10 to 24 inches tall. The plants were removed from the containers 76 days after inoculation and the rhizomes dissected to determine extent of Fusarium invasion.

Two additional pathogenicity tests were carried out in Honduras using 35-gallon concrete tanks and the techniques previously described (12). Inoculum was grown on 2% corn-meal-in-sand for 10-14 days and about 400 cc of inoculum was placed over the exposed roots 4-5 weeks after planting.

A field study of fusarial wilt outbreaks was made in Gran Canaria in April 1972. Soil profile characteristics as well as weather records and cultural practices were noted. The origin and wide range of chemical and physical properties of Canary Island banana soils have been reported (4, 5, 6).

RESULTS

Pathogenicity Studies: The results of all three pathogenicity tests are summarized in Table 1.

In banana plants growing in containers, aboveground symptoms of fusarial wilt often do not develop except on Bluggoe inoculated with race 2. Extensive rhizome invasion in containers, however, is correlated with pronounced symptoms in field-grown plants that are susceptible to one of the two wilt races. There was no extensive invasion of Dwarf Cavendish rhizomes by any of the isolates. The Canary Island and Taiwan isolates from Dwarf Cavendish readily invaded the Highgate dwarf mutant of Gros Michel but not Bluggoe. Therefore, these isolates were classified as race 1. Race 1 cannot extensively invade Dwarf Cavendish rhizomes except under the peculiar conditions existing in certain fields of the Canary Islands and Taiwan.

Field Observations: Typical wilt symptoms were found on Dwarf Cavendish at scattered locations throughout Gran Canaria. There was yellow to dark red or almost black vascular discoloration in the rhizome (Fig. 1) and pseudostem. Aboveground symptoms consisted of yellowing and dying of the older leaves, rosetting of the leaves caused by stunting of growth, yellow to yellowish-gray streaking of the petioles of the older leaves, and eventual death of the plants.

It is estimated that less than 10% of the fields in Gran Canaria had a history of wilt cases. Of these 10%, destructive attacks have occurred in only 1-2% of the fields. In the majority of fields wilt cases were scattered and tended to appear and disappear. The follower suckers of a diseased shoot frequently showed no signs of disease and produced a normal bunch of fruit. Often, where recovery occurred, vascular discoloration was confined mostly to the rhizome with very light or no discoloration in the pseudostem.

In the few areas with acute attacks (Fig. 2) up to one hectare of bananas had been abandoned because of disease or poor growth. Suckers in these areas were frequently diseased.

Table 1. Virulence of cultures of Fusarium oxysporum f. cubense from 'Dwarf Cavendish' bananas with symptoms of wilt in comparison with known races of banana wilt pathogen.

Cultures and source	Race indicator hosts		
	Bluggoe ABB	Gros Michel (dwarf mutants) AAA	Dwarf Cavendish AAA
Race 2 (Bluggoe)	+++[a]	-	+
Race 1 (Gros Michel)	-	+++	-
Taiwan (Dwarf Cavendish)	+	+++	-
Canary Islands (Dwarf Cavendish)	-	+++	-

[a]+++Rhizome stele extensively invaded, sometimes the invasion progresses into pseudostem; ++Rhizome stele partially invaded, no movement into pseudostem; +Rhizome stele lightly invaded; - No invasion of rhizome or only a trace of invasion at junction of root and rhizome stele.

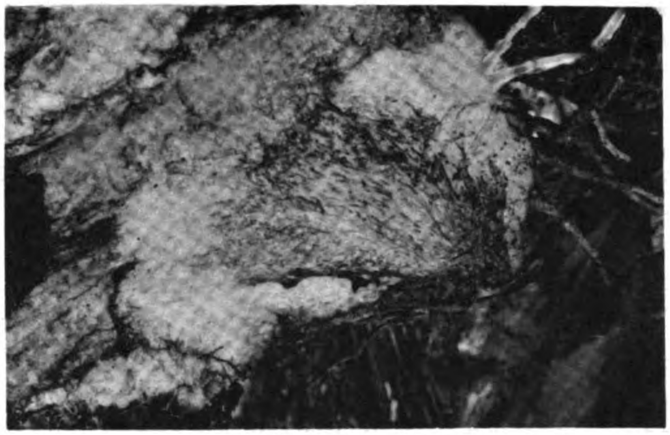

FIGURE 1. Internal rhizome symptoms of fusarial wilt in 'Dwarf Cavendish' banana in Gran Canaria.

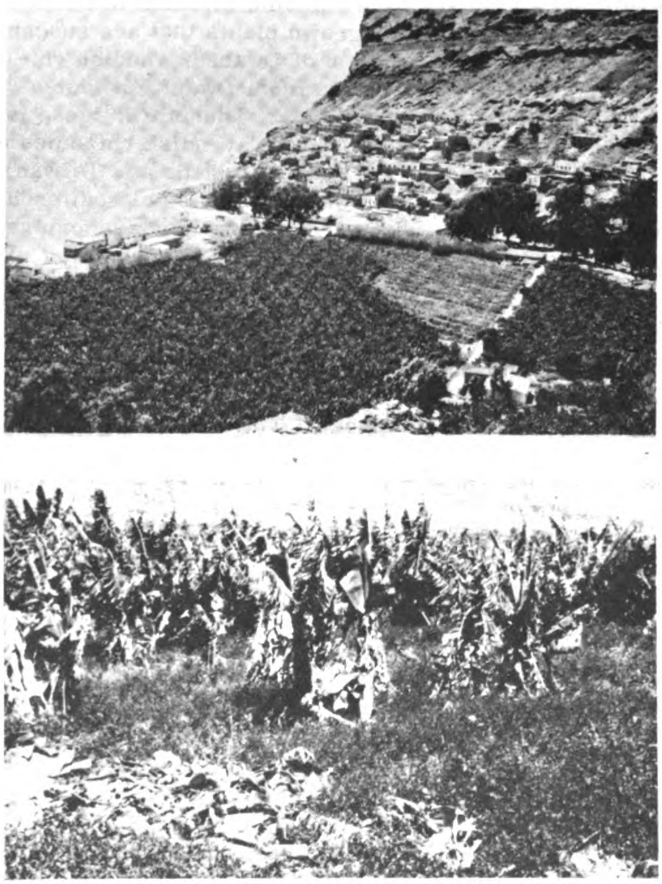

FIGURE 2. Upper -- Abandoned portion of field of Dwarf Cavendish banana in Gran Canaria, because of fusarial wilt. Most of the field has remained healthy. Lower -- Portion of abandoned area of a field of Dwarf Cavendish affected by fusarial wilt showing poor growth of survivors.

Replants in these areas often succumbed to disease within 6 months of planting. Often fields with acute attacks would have areas within 50 meters with few or no cases of wilt, and the bananas were growing vigorously. Thus, areas of acute attacks appeared confined to specific portions of certain fields.

Wherever acute attacks were found, careful examination revealed soil conditions which were not optimum for good banana growth. These conditions consisted of compact, impermeable soils high in clay content, a high water table at 60-75 cm in a shallow soil underlain with gravel, and impermeable clay soils at about 30 cm below the soil surface that would impede drainage, especially following heavy rains or flood irrigation.

DISCUSSION

Dwarf Cavendish is attacked by fusarial wilt in limited areas in the Canary Islands. Similar attacks have been reported in Taiwan and in one area of Natal in South Africa. Lacatan was attacked in localized areas in Jamaica (7, 8). Single shoots of all Cavendish varieties occasionally show symptoms of fusarial wilt in Central America (11, 13). Nevertheless, suckers produced by these infected shoots remain healthy. Apparently, the high genotypic resistance of the Cavendish group can break down under adverse conditions. Only in specific areas in the Canary Islands, and more recently Taiwan, is the resistance of a Cavendish variety overcome with any degree of frequency. There is no indication that a change in the pathogen is involved.

Dwarf Cavendish in Gran Canaria and Taiwan is often subjected to temperatures far below the optimum for good growth for several months of the year (1). In addition to low temperatures, soil conditions were not suitable for good banana growth in those parts of Gran Canaria where acute attacks of wilt occurred. Poor drainage, shallow soils underlain with gravel, and clay soils with low permeability all impede good root growth and maximum plant development. In years of excessive rainfall, drainage in these soils would be even more of a factor in retarding plant development.

This may account for a tendency for wilt to increase in the Canary Islands following years of above normal rainfall. Wilt outbreaks on the resistant Lacatan variety in Jamaica were associated with poorly drained heavy clay soil following prolonged rain (7). Soil pH is low in some locations in the Canary Islands (4, 5) and there are reports from local farmers as well as in the paper by Del Cañizo and Sardiña (2) of a response to liming in reducing wilt incidence. Acid soils are known to favor wilt, and where wilt occurs in Dwarf Cavendish, soil acidity (when below pH 6.0) should be corrected. Wilt also occurs in soils with a pH of 7.0 or higher, however. Soil salinity is high in some areas of the Canary Island (4) and where wilt occurs at pH levels above 7.0 salinity factors should also be considered in relation to plant growth and lowered resistance to wilt.

In summary, a combination of factors, as yet not well defined, that impede optimum plant development can prevent the full expression of the genotypically high resistance of Dwarf Cavendish bananas to fusarial wilt. The relationship between environmental factors and the host contributing to reduced resistance is subtle and complex. Thus Cavendish varieties growing in poorly drained, acid clays in some areas of Central America and Surinam are rarely affected by wilt. Presumably, a specific combination of complex interacting factors, involving soil, weather, and the vigor of the host, must be present to lead to the acute attacks of wilt found in Gran Canaria and Taiwan.

Correction of soil and drainage factors adversely affecting plant growth should reduce wilt incidence. Where conditions cannot be readily or sufficiently altered and wilt persists, then other crops more tolerant of these conditions should be grown.

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