Mycosphaerella fijiensis

Introduction

Black Sigatoka was first reported from Fiji in 1964. On account of its more rapid development and more extensive destruction of infected leaves, black Sigatoka causes greater yield losses and is more costly to manage than yellow Sigatoka. These features of the disease, in addition to the greater susceptibility of plantains to *M. fijiensis*, make the black Sigatoka particularly threatening to small farmers, many of whom have had to abandon banana/ plantain cultivation. The average small farmer is unable to bear the cost of a fungicide spray programme to manage the disease. His hope lies in the success of the international breeding programmes coordinated through the International Network for the Improvement of Banana and Plantain (INIBAP).

Identity

Authority : Morelet
Classification : (Alexopoulos et al., 1996)
Kingdom : Fungi
Phylum : Ascomycota
Order : Dothideales
Family : Dothideaceae
Genus : *Mycosphaerella*
Species : *fijiensis*
Synonyms : *M. fijiensis var. difformis* Mulder & Stover, *Pseudocercospora fijiensis* (Morelet) Deighton, *Cercospora fijiensis* Morelet
Common names : Black Sigatoka, black leaf streak, Sigatoka negra, royado negro del platanero, maladie des racis noires, schwarzstreifigkeit
Anamorph : *Paracercospora fijiensis* (Morelet) Deighton
Role : Pest

Signs & Symptoms

The first symptom to appear is reddish-brown flecks (1-5 mm x 0.25 mm) parallel to the veins on the lower surface of the third or fourth fully expanded leaf. There is a greater concentration of spots towards the edge of the lamina (Fig. 1). The flecks enlarge to 10-20 mm x 1-2 mm and rapidly darken in colour to dark brown or black, frequently with a purplish hue, at which stage they become visible on the upper surfaces of leaves. As the disease progresses, the spots become very numerous, somewhat wider, almost elliptical and extending across the lamina to the midvein (Fig. 2). This is the most characteristic feature of the disease: the blackened tissues interspersed with water-soaked, chlorotic areas. As the infected tissues dry, they turn light gray-brown with dark borders and totally collapse. Entire leaves can desiccate and be killed within three to four weeks of the appearance of first symptoms (Fullerton, 1994).

The rapid and early collapse of leaves lead to smaller bunches carrying prematurely ripening fruit. In very severe cases all the leaves may dry completely (Fig. 3) and the bunch may fall from the plant. In a recent study, *M. fijiensis* was reported, for the first time, as causing a fruit spot on plantain cv. Harton in Venezuela (Cedeno et al., 2000). The disease appears as tiny reddish specks which later become dark-brown to almost black, each with a water soaked halo. Fully developed spots are 0.25- 1mm in diameter and are confined to the skin of the fruit. Symptoms were reproduced on one-week-old fruits, using a suspension of mycelium and conidia as the source of inoculum.

Morphology

Anamorph: Conidiophores pale to olivaceous brown borne in loose or dense fascicles, continuous or septate, smooth, cylindric up to 25µm long and 3-4 µm wide. Stroma none or moderately developed, substomatal, erumpent or on young spermagonia. Conidiogeneous cells apical, sometimes sessile, straight or bent, simple, smooth, olivaceous brown, with 1-3 visible scars on the apices or on geniculations. Conidia solitary, obclavate or cylindric-obclavate, subhyaline, base truncate, with a visible scar, 1-6 septa, smooth, straight or slightly curved 10-120 x 1.5-2µm at the widest point.

Teleomorph: Perithecia 42-81µm in diameter, submerged, dark brown, erumpent, with a rounded ostiole. Asci with two walls, eight-spored, obclavate, 28-34.5 x 6.5-8µm. Ascospores hyaline, fusiform, clavate, 2-celled with slight constriction at the septum, 14-20 x 4-6µm.

Problems of differentiation between *M. fijiensis* and *M. muscicola*

Although descriptions of black (*M. fijiensis*) and yellow Sigatoka (*M. musicola*) in various publications may give the impression of clear distinctions between the two diseases, accurate diagnosis in the field can be very difficult. Symptoms can be confused where infection by yellow Sigatoka is severe; depending on the cultivar being examined; or in a situation where oil with or without fungicide have been applied (Johanson, 1997). Accurate diagnosis can also be made difficult by the presence of other leaf-spotting *Mysosphaerella* species and even of banana streak virus, which induces symptoms similar to the elongate flecks typical of the early stages of black Sigatoka. Johanson (1997) has highlighted difficulties in performing confirmatory isolations of the two pathogens from diseased leaves.

The difficulties in confirming field diagnoses, in the laboratory, posed by the existence of two pathogens so alike morphologically and in symptomology have led to the development of molecular diagnostic techniques. Two such methods are one based on ELISA and one on the amplification of fungal DNA by the Polymerase Chain Reaction (PCR) (Johanson, 1997). The latter permits accurate identification to species level, which can be valuable in surveillance and epidemiological studies.

Biology and Epidemiology

All of the AAA dessert cultivars, the AAB Silk and Pome clones, most AAB plantain cultivars as well as the AAB and ABB cooking bananas are highly susceptible to *M. fijiensis* (Stover and Simmonds, 1987). Pasberg-Gauhl (1991) reported that ABB cooking banana clones, Saba, Chato and Pelipita were partially resistant, while *Musa acuminata* (AA) showed significantly less leaf spotting than the ABB clones. *M. fijiensis* produces conidia and ascospores both of which are capable of initiating infection. However, the numbers of conidia are approximately 100 times fewer than those of ascospores and, consequently, conidia are less important in the dissemination of black Sigatoka (Gaul, 1993). Both spore types are released from infected banana/plantain leaves and are readily captured in spore traps set in plantations. Conidia are borne on conidiophores that emerge through stomata at the stage in the development of a leaf spot when the tissues in the centre of the spot have started to collapse. They are produced mainly, but not exclusively, on the lower surface of the leaf. At this stage, the spot is visible on both surfaces of the leaf. The spore-bearing structures are developed on leaves wet by rain/irrigation or even under very humid conditions. Conidia are liberated by splashing water and they are dispersed primarily by water movement and splash. Thus, conidia are responsible for short-range dissemination on the same or nearby plants. The ascocarps bearing the asci and ascospores are immersed in necrotic areas of the leaf that have recently dried. Warm rainy weather, even very light rain, triggers the forcible release of ascospores which are disseminated by wind or meteoric rain (rain with wind) to neighbouring or even distant locations. The infection of a leaf by an ascospore completes the life cycle of *M. fijiensis* (Fig. 4.)

The different modes of dispersal lead to characteristic types of leaf spotting. The water-borne conidia are able to pass under the folds of the unfurling heart leaf and, since the left side of the leaf (examined from the base) is on the outside, early spotting due to conidia appears in lines on this exposed side of the leaf. Wind-borne ascospores infect the tips and margins of the unfurling leaf. When conditions are favourable for severe infection- mainly wet, humid, warm weather and a susceptible cultivar- tip spotting may be less evident, due to the rapidly increasing numbers of spots all over the leaf. After germination, the spore grows for 2-6 days before infection is established.

There is an incubation period of 15-20 days between infection and the appearance of first symptoms and a further 20-25 days before ascospore development in the mature, drying spot (Gaul, 1993).

Several factors affect disease development:

1. **Weather- ascospore/ conidia release and germination are favoured by high humidity, rainfall and temperatures of 23-30 C.**
2. **Leaf age- leaves are less susceptible with increasing age after leaf 4; new infections on leaf 7 and older are rare.**
3. **Plant vigour- poor vigour increases the time for the formation of new leaves, which, in conditions favouring severe infection, will lead to symptom development on younger leaves.**
4. **Quality of plant care- proper execution of pruning, weed control, detrashing and drainage operations to achieve conditions less conducive to fungal development can contribute substantially to disease management.**

Dispersal/Vectors

M. fijiensis produces conidia and ascospores, both of which can initiate infection.

Ascospores are disseminated by wind or meteoric rain and are responsible for both short and long-range dispersal. Conidia are dispersed primarily by water movement from splashing rain or irrigation and bring about short–range dissemination.

Management

Plant quarantine

The destructive potential of black Sigatoka calls for the imposition of strict quarantine measures by countries where *M. fijiensis* does not exist. The prime danger lies in the introduction of the pathogen on uninspected planting stock and on leaves used as packing material by higglers and farmers in local markets. The recent discovery of fruit infection on plantain in Venezuela adds a new dimension to the problem.

Field sanitation

Measures in this area are aimed at reducing humidity that favours leafspot development.

The most important are:

a) Drainage - provide adequate drains to eliminate soggy conditions and water standing for prolonged periods.
b) Maintaining plant density - ideal plant numbers are achieved by periodic removal of suckers to avoid overcrowding, which restricts airflow and humidity.
c) Weed control - heavy weed growth also contributes to increasing the humidity.
d) Detrashing - removal of dead leaves improves air flow as well as removes a potential source of inoculum in the form of ascospores in dead leaf tissue.
e) Irrigation - where this is used, below-canopy irrigation or, more advisable, drip irrigation are superior to over-canopy sprinklers.
f) Closed canopy - allowing the leaf tips of adjacent plants to just touch or to overlap no more than 25% reduces the length of time leaves remain wet, by inhibiting dew formation on lower leaves.

Plant vigour

Healthy plants suffer less damage than less vigorous, stressed plants. Vigour is enhanced by optimal fertilization, effective soil drainage and the removal of undesirable competition from weeds and excessive suckers.

Fungicide Application

A vigorously growing banana plant carries 10-15 green leaves by the time it flowers. Once the bunch has emerged, leaf production ceases which means that, for the three months required for the fruit to reach maturity, no new leaves are forthcoming. Severe leaf spot infection can reduce the number of functional leaves to five or six, the minimum number required to ensure successful transportation and to avoid reduced shelf life. Since the arrival of yellow Sigatoka into the Caribbean region in 1934 and that of black Sigatoka in 1972, maintaining the number of functional leaves has been achieved through the application of fungicides by aircraft or back-pack machines. Stover (1989) has reviewed the various spray regimes and the chemicals that have been employed.

The regimes that are presently in use are:

- **oil or oil/water emulsion with benzimidazoles**
- **oil or oil/water emulsion with tridemorph**
- **oil or oil/water emulsion with triazoles**

Oil is a fungistat, i.e., it retards fungal growth within leaf tissues up to the streak stage of disease development. It complements the action of protectant fungicides, enhances the uptake of systemic fungicides and functions as an effective spreader/sticker for all fungicides. Less phytotoxic oils than Texaco 522 are now available, which reduces concerns about yield reductions and fruit disfiguration.

The timing of fungicide application is guided by either of the following forecasting systems:

1. Fungicide is applied when the number of streaks on a prescribed number of plants averages 50 or 100 on leaves two or three.
2. The development of leaf spots is divided into 6 stages, from the first visible fleck to mature spots with grey, dry centres. The stages of spot development are followed weekly on leaves 2, 3 and 4 and the rate of leaf emergence is recorded. The number of spots per leaf above 50 is recorded. A coefficient of spot development is assigned to each stage and fungicide is applied when the sum of coefficients reaches a certain level and temperature and rate of evaporation are favourable for disease development.

The use of a forecasting system in the application of systemic fungicide/oil mixes was first employed in the Cameroon in 1983 for the control of black Sigatoka. Effective disease management was achieved with 10-14 spray cycles annually, compared with 35-45 in Central America. The introduction of the Cameroon system in Central America from 1986 achieved a reduction in the number of cycles to less than 20.

Fungicides and Resistance

The first systemic fungicide to be used (for yellow Sigatoka control) was the benzimidazole, benomyl, in the early 1970s, which approximately coincided with the appearance of black Sigatoka in Central America. However, by 1978, resistant strains of both pathogens had been found and this extended to all benzimidazole fungicides. Reintroduced dithiocarbamates and chlorothalonil protectants, although efficacious against *M. musicola,* were ineffective against *M. fijiensis* due to their inability to prevent infection by ascospores on the unfurling leaf of the plant. Today, the fungicides in widest use are propiconazole, flusilazole and the morpholine, tridemorph.

Resistant Cultivars

Banana breeding was initiated 50 years ago in Jamaica and since that time other programmes have been established in Brazil, Nigeria and (the largest) in Honduras. The devastating effect of black Sigatoka on plantain, a small farmer crop in many parts of the world, was the main reason behind the development of the Nigerian programme. INIBAP is the prime facilitator of the international breeding effort on *Musa*. Success in the development of export -type, desert banana cultivars with resistance to yellow and black Sigatoka has been limited. The most acceptable, to date, has been FH9A-23 (Fundación Hondureña de Investigación Agrícola) from Honduras, now being grown in Cuba without the necessity for fungicide application (INIBAP, 1977). Its utilization for large scale production is handicapped by the fact that it is one meter taller than Grand Naine. More rapid success is anticipated in developing disease resistant plantain and cooking banana cultivars because of the less stringent requirements for bunch and fruit conformity.

Host Notes

Musa spp. and cultivars.

Distribution

It appeared in Honduras in 1972, Africa in 1974 and has been reported from Taiwan and mainland China as well as from Cuba, the Dominican Republic and Jamaica in the Caribbean islands. It is now widespread in East and West Africa, where it is the major disease of plantains, and has spread extensively into northern South America, including Ecuador, and Central America.

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Web Resources –

http://www.apsnet.org/education/feature/banana/Top.html

http://www.tpp.uq.edu.au/nadnhighlights28june02.pdf
http://www.dpi.qld.gov.au/shop/1503.html

Fig. 1: Black Sigatoka symptoms on banana showing elongate lesions on adaxial leaf surface

Fig. 2: Black Sigatoka: dark brown to black streaks and spots coalesce, giving characteristic necrosis from severe infection. (Note heavy infection near midvein).

Fig. 3: Collapsed banana plants with very severe infection of Black Sigatoka

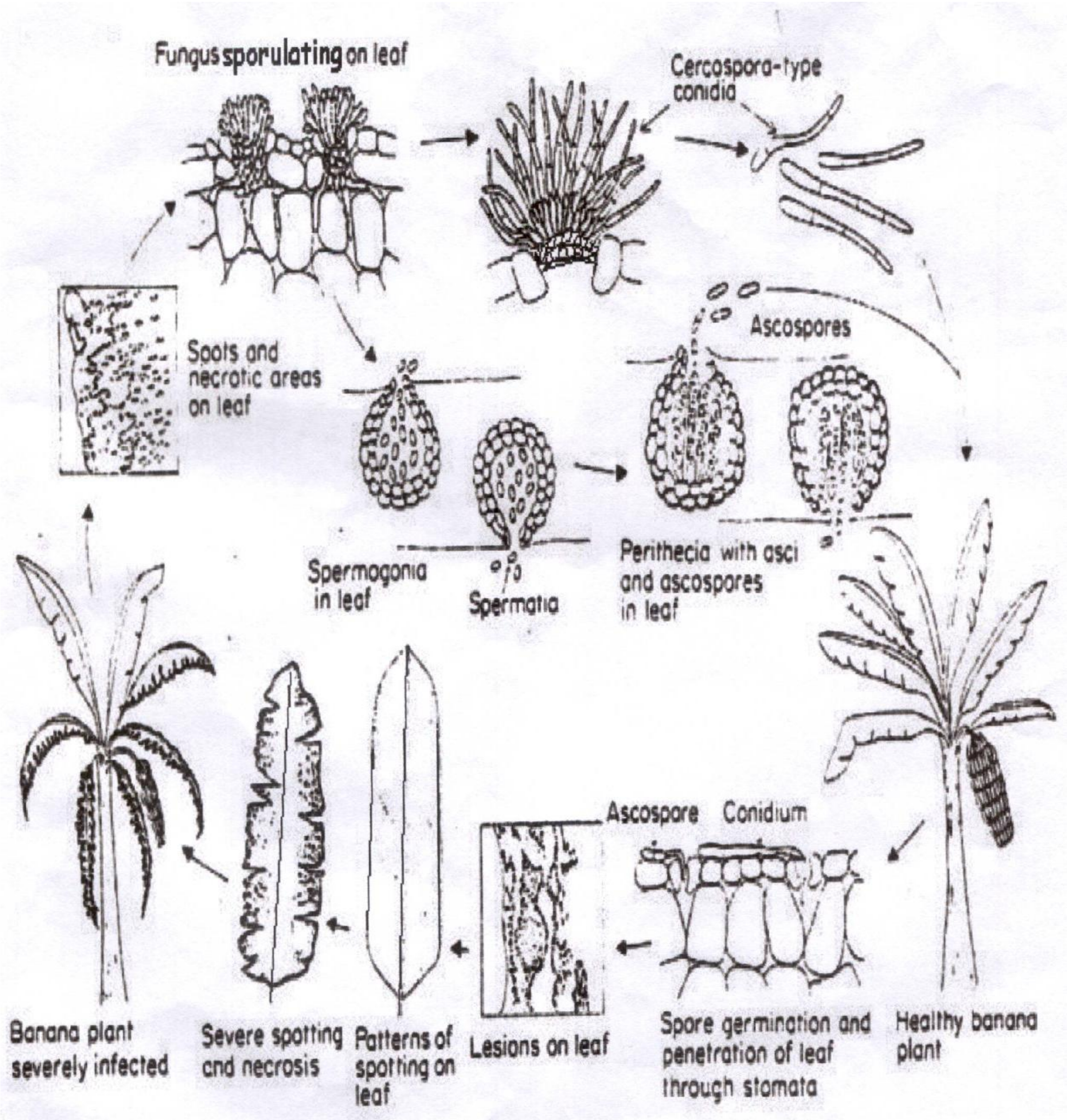

Fig.4 Disease cycle of *Mycosphaerella fijiensis*