Impact of minor *Mycosphaerella* pathogens on bananas (*Musa*) in South Africa

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Abstract

Of the species of *Mycosphaerella* known to occur on bananas, only *M. musicola* and *M. musae* occur in South Africa. Since both species are less damaging than *M. fijiensis* and *M. eumusae*, they are considered minor *Mycosphaerella* pathogens of this host. However, both *M. musicola* and *M. musae* can cause significant damage to bananas in the subtropics. For several years, *M. musicola* seemed to be the dominant pathogen of banana leaves in South Africa. It was very severe in banana plantations in Southern KwaZulu-Natal in the early 1990s, and caused losses of up to 50% in Cavendish bananas due to early ripening and lower yields in the Komatipoort area in 1999 and 2000. A highly coordinated disease management programme involving severe deleafing and fungicidal sprays has reduced the impact of Sigatoka disease in the country since 2001. However, Mycosphaerella speckle now appears to have replaced Sigatoka disease as the dominant leaf pathogen in all banana growing areas of South Africa. Management strategies for Sigatoka disease seem to be less effective against Mycosphaerella speckle. Although this fungus primarily affects older leaves, the disease has become very severe in southern KwaZulu-Natal during 2002. Its economic impact and epidemiology, however, still have to be determined.

Resumen – Impacto de los patógenos de *Mycosphaerella* de menor importancia sobre los bananos (*Musa*) en Africa del Sur

De las varias especies de *Mycosphaerella* que ocurren en los bananos, solo *M. musicola* y *M. musae,* ocurren en Africa del Sur. Ya que ambas especies causan menores daños que *M. fijiensis* y *M. eumusae*, ellas se consideran patógenos de *Mycosphaerella* de menor importancia en este hospedante. Sin embargo, tanto *M. musicola* como *M. musae* pueden causar daños significativos a los bananos en los subtrópicos. Durante varios años, *M. musicola* se consideró el patógeno dominante en las hojas de los bananos en Africa del Sur. A principios de la década de los 90, este patógeno afectó severamente las plantaciones bananeras en el sur de KwaZulu-Natal, y causó pérdidas de hasta 50% en los bananos Cavendish, debido a una maduración precoz y bajos rendimientos en el área de Komatipoort en 1999 y 2000. Un programa coordinado de manejo de la enfermedad, que incluyó deshoje y rociados de funguicidas redujo el impacto de la

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Sigatoka amarilla en el país desde 2001. Sin embargo, la mancha causada por *Mycosphaerella* parece haber reemplazado actualmente la Sigatoka amarilla como patógeno foliar dominante en todas las zonas productoras de banano en Africa del Sur. Parece que las estrategias de manejo de la Sigatoka amarilla son menos eficaces contra la mancha causada por *Mycosphaerella*. Aunque este hongo afecta principalmente las hojas viejas, la enfermedad se hizo muy severa en el sur de KwaZulu-Natal durante el año 2002. No obstante, aún falta determinar su impacto económico y la epidemiología.

Résumé – Impact des pathogènes mineurs de *Mycosphaerella* sur les bananiers (*Musa*) en Afrique du Sud

De toutes les espèces connues de *Mycosphaerella* affectant les bananiers, seules *M. musicola* et *M. musae* se trouvent en Afrique du Sud. Vu que ces deux espèces provoquent moins de dégâts que *M. fijiensis* et *M. eumusae*, elles sont considérées comme étant des pathogènes mineurs de cet hôte. Toutefois, *M. musicola* et *M. musae* peuvent toutes deux provoquer des dégâts significatifs aux cultures de bananes dans la zone subtropicale. Pendant plusieurs années, il semblait que *M. musicola* était le pathogène dominant des feuilles de bananiers en Afrique du Sud. L'infection était même très grave dans les plantations du sud du KwaZulu-Natal au début des années 1990 et en 1999 et 2000 a provoqué chez les bananiers Cavendish de la région de Komatipoort des pertes pouvant aller jusqu'à 50% dues à un mûrissement prématuré des fruits et à des rendements réduits. Un programme de gestion de la maladie parfaitement coordonné impliquant un défeuillage massif ainsi que des traitements fongicides a réduit l'impact de la maladie de Sigatoka dans le pays depuis 2001. Toutefois, Mycosphaerella speckle semble maintenant avoir remplacé la maladie de Sigatoka et se trouve être le pathogène dominant dans les régions de culture de la banane en Afrique du Sud. Les stratégies de gestion de la maladie de Sigatoka semblent moins efficaces envers le Mycosphaerella speckle. Bien que ce pathogène affecte en premier les feuilles les plus âgées, la maladie est devenue très grave dans le sud du KwaZulu-Natal en 2002. Son impact économique ainsi que son épidémiologie restent encore à être déterminés.

Introduction

Fungi that cause disease on leaves of banana and plantain include *Mycosphaerella fijiensis* M. Morelet (the causal agent of black leaf streak disease), *M. musicola* Leach ex J.L. Mulder (the causal agent of Sigatoka disease), *M. eumusae* Crous et X. Mourichon (the causal agent of eumusae leaf spot disease) and *M. musae* (Speg.) Syd. et P. Syd. (the causal agent of Mycosphaerella speckle). *M. fijiensis* is the most virulent and economically important of the four *Mycosphaerella* spp. Since its discovery in Fiji in 1963, *M. fijiensis* has replaced *M. musicola* as the main leaf pathogen in all tropical countries that produce banana (Jones, 2000). However, Sigatoka disease is still the main leaf disease in the subtropics and at higher altitudes in the tropics. In 1995, a new disease, eumusae leaf spot, was reported on *Musa* (Carlier *et al*., 2000). Eumusae leaf spot has only been found in Southeast Asia and in Nigeria, West Africa, (Jones, these proceedings) but is very damaging there. Black leaf streak disease, Sigatoka disease and eumusae leaf spot disease comprise the *Mycosphaerella* leaf spot disease complex on banana. Mycosphaerella speckle is not considered to be important on banana. It is limited to the subtropics and is severe only on Cavendish bananas in Australia (Jones, 2000).

The dominant *Mycosphaerella* spp. pathogens that occur in the subtropics are *M. musicola* and *M. musae*. Since neither consistently damage banana leaves, they

are considered minor pathogens. The objective of this manuscript is to report the impact of such minor *Mycosphaerella* pathogens on bananas in South Africa.

Banana production in South Africa

Bananas are produced in six areas in South Africa (Figure 1). The crop was introduced from India at the beginning of the 19th century. Production began along the southern and northern sections of the KwaZulu-Natal (KZN) coast, then introduced in the former Transvaal province and planted in Kiepersol, Tzaneen and Levubu. The largest production area, the Onderberg (4600 ha), became important in the 1990s. The total area of commercial banana production is 12 500 ha, and is with Cavendish cultivars only. Almost 90% of new plantings are from tissue culture, and transport of banana plants between production areas is strictly controlled. All bananas are consumed locally, but there is a possibility of export to the Middle East.

Leaf diseases of banana in South Africa

Since 1999, regular surveys of areas where banana is cultivated have shown that Sigatoka disease, Mycosphaerella speckle and Cordana leaf spot (caused by *Cordana musae* [Zimm.] Höhn.) are present in all production areas. Cladosporium speckle (*Cladosporium musae* E.W. Mason) was found only in Levubu. Sigatoka disease and Mycosphaerella speckle were the most important.

The banana leaf diseases in the southern part of Africa have not been studied very much. Black leaf streak disease is present in most tropical African countries (Jones, 2000), and has been reported as far south as northern Malawi (Ploetz, 1992). However, black leaf streak disease is not known in Zimbabwe (which borders the Levubu area) and Mozambique (which borders the Onderberg area) (Figure 1).

Figure 1.
The six banana production areas of South Africa: Levubu, Letaba (Tzaneen), Hazyview (Kiepersol), Onderberg, and northern and southern KwaZulu-Natal.

A severe outbreak of Sigatoka disease in 1999-2000, prompted an investigation into the identity of the causal agent. Samples were collected in all production areas, and the fungi identified using morphological and molecular techniques (Surridge *et al*., these proceedings). PCR primers developed by Johansen and Jeger (1994) were used to distinguish between Sigatoka disease and black leaf streak disease. Isolates from single conidia were further sequenced (ITS region) and compared with sequence data of *M. musicola*, *M. fijiensis* and *M. eumusae* from GenBank. All local isolates proved to be *M. musicola*, which causes Sigatoka disease. There was no evidence of *M. fijiensis* and *M. eumusae*, suggesting they have not been introduced in South Africa. The severity of the outbreaks was attributed to favourable weather conditions and increases in the amount of inoculum.

The life cycles of *Mycosphaerella* leaf spot diseases have a sexual (teleomorph) stage, which produces ascospores, and an asexual (anamorph) stage, which produces conidia (Jones, 2000). Conidia are the main spore produced by *M. musicola* (Meredith, 1970). Conidia are dispersed within the leaf canopy and to neighbouring plants by rain, which dislodges and washes them onto adjacent leaves. Ascospores are forcefully discharged and spread by wind currents over bigger distances than conidia. Both types of spore require moisture for production, release, infection, growth and sporulation. Most stages in the life cycle take place over a wide range of temperatures; however, minimum night temperatures of 18ºC and 21ºC are needed for the production of conidia and ascospores of *M. musicola,* respectively (Meredith, 1970). Conidia are produced on both leaf surfaces, while ascospore production is almost three times greater on the upper (adaxial) than lower (abaxial) leaf surface (Meredith, 1970).

Climatic conditions in South Africa

The banana production areas of South Africa are located in the east between 25º and 30º latitude and 30º and 32º longitude. The areas have a subtropical climate with cool, dry winters and warm, wet summers. Rainfall and temperature data for the Onderberg over a period of 10 years showed that November and March were the most favourable months for infection and disease development (Figure 2). During this time minimum night temperatures exceed 18ºC, which is necessary for the production of conidia. Minimum night temperatures exceed 21ºC only in January and February, therefore the period for ascospore production is short. Disease development is most rapid between November and March but slows substantially during the cooler months from May through September. Climatic conditions in South Africa provide ample opportunities for the management of Sigatoka disease.

The impact of *Mycosphaerella* diseases

Van den Boom and Kuhne (1969) first reported Sigatoka disease in South Africa, although the disease was also mentioned in 1954 (Meredith, 1970). The first report of Mycosphaerella speckle in South Africa was in 1973 (Brodrick, 1973). Despite these late reports, both diseases have been associated with banana leaves for as long as producers can remember.

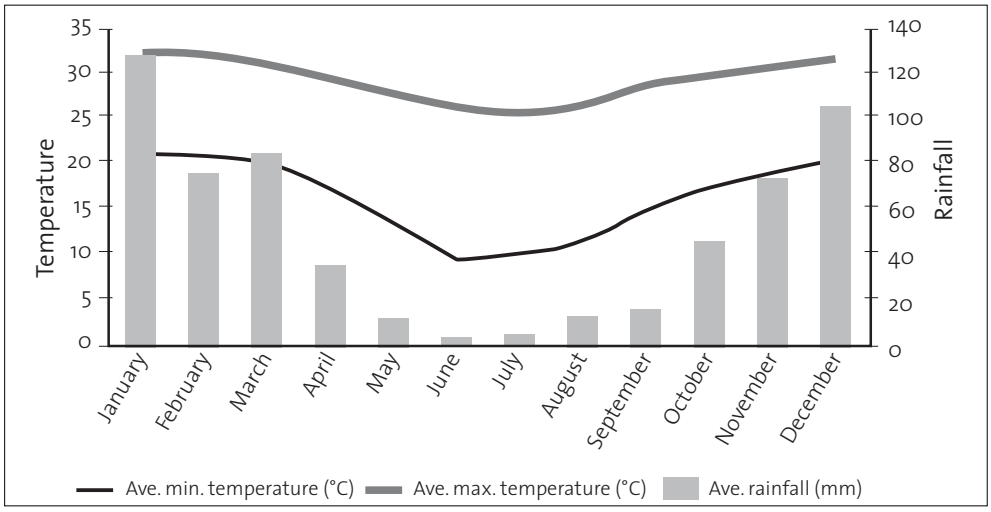

Figure 2. Average annual temperature range and rainfall in the banana growing areas of South Africa.

Sigatoka disease first became severe in South Africa during the 1960's (Van den Boom and Kuhne, 1969). The disease devastated production in southern KZN in the 1990s and in the Onderberg in 2000 (Viljoen, unpublished data). *Mycosphaerella musicola* infects the first three leaves of the banana plant. The symptoms first become visible on the third or fourth leaf (Jones, 2000). Under favourable weather conditions and with large amounts of inoculum, *M. musicola* can destroy all leaves after the stage when bunches are produced. This is what happened during the 1999-2000 outbreaks of Sigatoka disease in the Onderberg. Damage included smaller fruits, smaller bunches, and premature fruit ripening in the field and in boxes. Farmers reported losses of up to 50% of the crop. An extensive disease management programme was implemented in October 2000 to halt the devastation. All leaves with Sigatoka lesions were cut and turned over on the plantation floor to limit the release of air-borne ascospores. Many bunches were sacrificed, in one instance amounting to nearly 18 000 bunches on a farm of about 40 ha. A fungicidal spray programme with protectant and systemic fungicides when the rainy season started and night temperatures exceeded 18°C was recommended to growers. A total of six sprays of systemic fungicide were recommended, interrupted with a protectant fungicide after every second application of systemic fungicide (Peterson *et al.* these proceedings).

None of the farmers applied the recommended number of sprays, and only 2-4 sprays were applied in total. The cost of fungicides, therefore, was small compared with the costs of fungicide sprays used to control black leaf streak disease in the tropics. Sigatoka disease was almost absent from banana fields in 2001, and current control strategies are now limited to cutting leaves and the application of one or two sprays, dependant on pre-seasonal leaf spot incidence, per year.

Mycosphaerella musae infects older leaves of banana plants (Jones, 2000). Mycosphaerella speckle is rarely visible above the fifth fully open leaf, and seldom affects fruit quality and quantity after bunching. Since 2000, Mycosphaerella speckle has become

more severe, and now is the main leaf disease of banana in South Africa. The symptoms are leaf yellowing (chlorosis) and death (necrosis). Necrosis is most visible on the older leaves, but, in 2002, chlorosis affected leaves as young as the third leaf after bunching in southern KZN. The effects on yield have not yet been determined. Control strategies are similar to those for Sigatoka disease, and include removing leaves and applying fungicides.

Conclusion

Mycosphaerella musicola and *M. musae* are the only *Mycosphaerella* leaf pathogens of banana in South Africa. They are considered to be minor pathogens, but become damaging under favourable weather conditions and in the presence of large amounts of inoculum. Subtropical climatic conditions and a clear understanding of the biology and epidemiology of *M. musicola* make the management of Sigatoka disease relatively easy. The increased severity of Mycosphaerella speckle may result from the management of Sigatoka disease. The quantity of *M. musicola* ascospores released into the air is reduced by placing leaves upside down on the ground, but this probably increases the quantity of *M. musae* ascospores, which are mainly released from the lower leaf surface (Jones, 2000). A better understanding of the biology and epidemiology of *M. musae* is needed to develop the necessary management practices for Mycosphaerella speckle in the subtropics.

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