

***Mycosphaerella* foliar diseases of bananas: towards an integrated protection**

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Assessing Black Leaf Streak Disease on banana leaves. © Charles de Wulf

Mycosphaerella foliar diseases, the major threats to the banana industry



Severe defoliation induced by Sigatoka Disease. © Luc de Lapeyre de Bellaire, CIRAD, France.

Black Leaf Streak Disease (BLSD, caused by *Mycosphaerella fijiensis*) and Sigatoka Disease (SD, caused by *Mycosphaerella musicola*) are the main constraints of export dessert banana production. These foliar diseases threaten the major banana-producing countries in the world as all export banana cultivars (Cavendish cultivars) are highly susceptible. *Mycosphaerella fijiensis*, which is more aggressive than *M. musicola*, has totally replaced the latter in countries where it has been introduced. Today, virtually all banana-exporting countries suffer from BLSD, with the exception of some islands of the Caribbean (such as Guadeloupe and Martinique) where *M. fijiensis*

has not yet been reported, and the Canary Islands where very dry conditions prevent the development of these fungal foliar diseases.

Infection results in substantial necroses of the foliage and consequently yield loss, but - most importantly - in immature ripening that renders the fruits unfit for export. Hence, protection of the crop is critically important for the entire industry. In these production environments with conducive tropical humid conditions for *Mycosphaerella* diseases, the only current practice is chemical control. In addition, to be highly cost effective, the high frequency of sprayings is a constant worry because of the development of fungicide resistance, and also because of the potential effects on both the environment and workers. This situation represents a technical, economical and environmental impasse. Hence, alternatives to chemical control are urgently required to provide sustainable solutions for the management of *Mycosphaerella* foliar diseases.



Important leaf spotting caused by Black Leaf Streak Disease on a commercial farm. © Josue Ngando, CARBAP, Cameroon



Premature ripening as a consequence of important *Mycosphaerella* leaf spotting, which renders bananas unfit for export.

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A forecasting strategy for rational chemical control

In most countries exporting bananas, traditional disease management strategies rely on weekly applications (40-60 treatments/year) of fungicides. Nevertheless, in some countries, a forecasting strategy has enabled growers to reduce the number of applications to only 5-6 treatments/year for SD control in the French West Indies, and to 12-14 treatments/year for BLSD control in Cameroon and Ivory Coast. This biological forecasting system is based on early detection of the disease through the calculation of a Stage of Evolution of the Disease (SED).

SED: Ten plants in a plot are observed weekly to monitor continuous disease development. The most advanced stage of the disease is scored on the youngest leaves of the banana tree (leaves 1 to 5 for SD and 2 to 4 for BLSD). Leaf number/ disease development associations are expressed in coefficients (Cs). The SED is derived from multiplying the sum of all Cs with the Foliar Emission Rate (FER), and its graphic representation is used for timing of decisions (See figure 1).

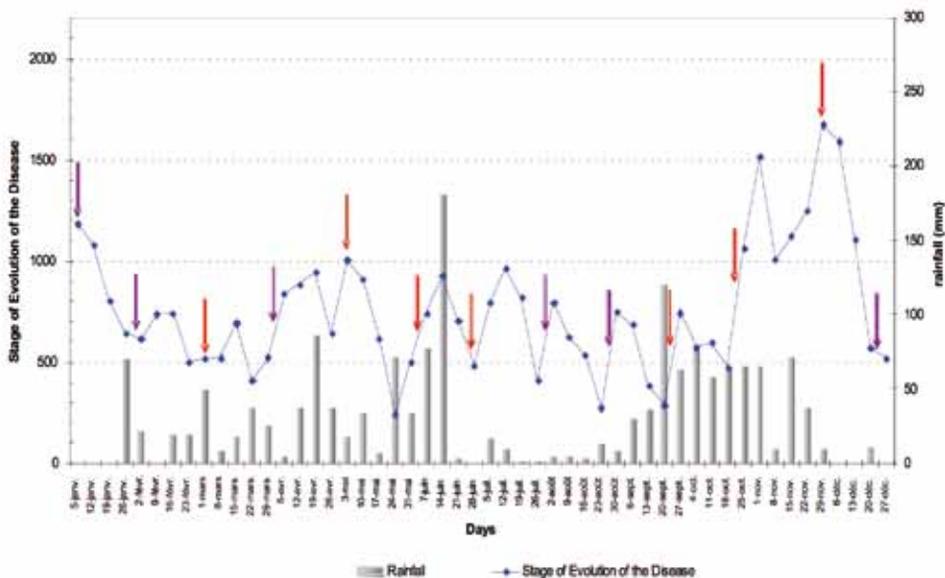


Figure 1. Example of Black Leaf Streak disease forecasting. Aerial spraying (purple arrow: antimetabolic product; red arrow: DMI fungicide) was decided according to the Stage of Evolution of the Disease (blue line). © Luc de Lapeyre de Bellaire, CIRAD, France.

The reliability of this forecasting strategy depends on very specific technical requirements:

- The time between decision and spraying should be minimised and requires appropriate logistics for aerial applications
- Strong curative effect of systemic fungicides (100g a.i./ha) mixed in pure mineral oil
- Apply chemicals with different mode of action to reduce development of fungicide resistance
- Collaborative and centralized action of banana growers to delimit the aerial distribution of the disease.

Evolution to an integrated strategy

Chemical control of SD and BLSD is unsustainable due to the continuously increasing fungicide resistance that drives up the frequency of applications. Where fungicide resistance is established, control relies on weekly applications of contact fungicides. However, legislation also contributes to pesticide reductions as shown under European conditions, for example there are two authorised fungicides in the French West Indies (FWI) versus more than 25 in West Africa and Latin America. In the FWI, requirements for buffer areas around urbanised areas and rivers reduce aerial applications that could probably be banned soon. So, even where forecasting strategies are performed, disease control becomes increasingly difficult (Figure 2 on following page). Hence, alternatives should be developed and applied. Such alternatives should be integrated with other agronomic measures such as field sanitation to manage inoculum dispersal (for instance, the mechanical ablation of lesioned leaves).

Short-term solutions

Forecasting strategies should be devoted and implemented in areas where specific conditions are fulfilled: (i) areas free of fungicide resistance, (ii) new banana areas, (iii) low disease pressure areas. Where fungicide resistance is established, the reintroduction of forecasting strategies relies on possible fungicide resistance reversion and incoming of new mode of action fungicides with a high curative effect. Possible fungicide resistance reversion requires a better understanding of gene flow between unsprayed and sprayed areas and of the competitiveness of resistant strains.

The development and introduction of fungicides with low negative environmental effects is a necessity. Recently, various bio-fungicides have been tested. Unfortunately,

none of these bio-fungicides enables alone a good control of BLSD under high disease pressure. Nevertheless, recent data show that their combination with contact fungicides could result in significant reductions of these latter which are currently sprayed at high rates (1000 g/ha versus 100 g/ha for systemic fungicides).

Mid to long-term solutions

In the long term, the introduction of resistant cultivars in banana cropping systems should ensure a sustainable control at low cost. Currently, there are no resistant cultivars that can commercially replace Cavendish bananas, and banana breeding is complicated by sterility.

However, new dessert banana cultivars with partial resistance to BLSD and SD, produced through breeding programmes, do exist and are presently being evaluated (pictured right). A potential brake on their widespread adoption is that they will have to be accepted in the market and their post-harvest processing adapted to an export industry that is currently adjusted mainly for Cavendish bananas. The adoption of new cultivars released by conventional breeding programmes, or that of genetically modified bananas, could thus be a very long process that should also take into account innovative ways to preserve sustainability of resistance.

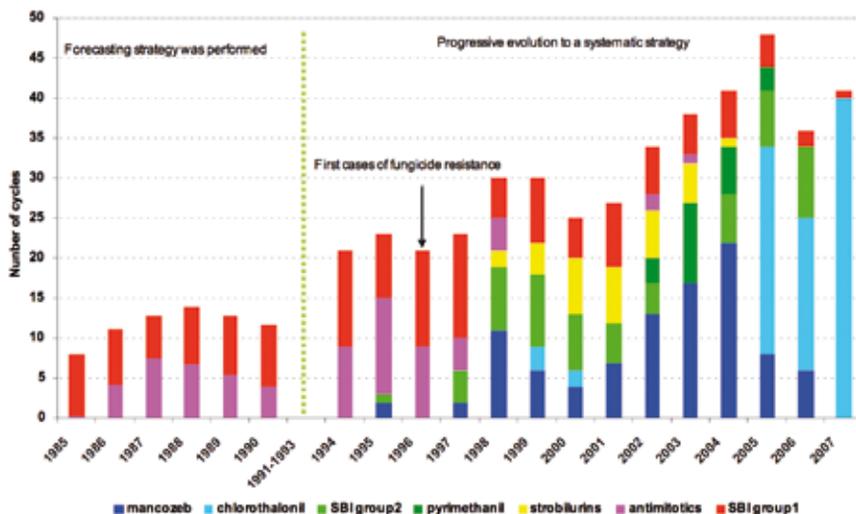


Figure 2. History of fungicide use for BLSD control in a representative commercial banana farm.
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New banana varieties produced through the CIRAD breeding programme in the FWI showing partial resistance to Sigatoka. © Catherine Abadie, CIRAD, France.

Mycosphaerella foliar diseases of bananas: towards an integrated protection - Summary

Mycosphaerella foliar diseases, Black Leaf Streak and Sigatoka diseases caused respectively by *Mycosphaerella fijiensis* and *M. musicola*, are by far the main parasitic constraints for export bananas. They result in substantial necrosis of the foliage and consequently yield loss, but - most importantly - in immature ripening that renders bananas unfit for export. In the absence of commercial resistant varieties, banana exports can only be achieved through intensive chemical control. In most countries, fungicides are applied systematically following a fixed-schedule treatment programme (40-60 applications/year) to protect the young leaves against infection. In some places, forecasting systems are used to schedule treatments in function of the stage of evolution of the disease (5-14 treatments/year). In all countries chemical control has to face increasing difficulties in terms of efficacy, cost and environmental impact. This situation results mainly of two major events: (i) the development of fungicide resistance to systemic fungicides that lead to a systematic use of protectants and (ii) the evolution of the legislation which becomes increasingly restrictive. New alternatives that must be associated with basic prophylactic measures such as the mechanical ablation of lesioned leaves are needed for a sustainable control of these diseases. They are presented as (1) short-term solutions: implement the forecasting strategy where it is feasible or introduce fungicides with low negative environmental effect where this forecasting strategy is impached by fungicide resistance; (2) mid-to-long-term solution: develop and introduce resistant cultivars in the cropping system.

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About ENDURE

ENDURE is the European Network for the Durable Exploitation of Crop Protection Strategies. ENDURE is a Network of Excellence (NoE) with two key objectives: restructuring European research and development on the use of plant protection products, and establishing ENDURE as a world leader in the development and implementation of sustainable pest control strategies through:

- > Building a lasting crop protection research community
- > Providing end-users with a broader range of short-term solutions
- > Developing a holistic approach to sustainable pest management
- > Taking stock of and informing plant protection policy changes.

Eighteen organisations in 10 European countries are committed to ENDURE for four years (2007-2010), with financial support from the European Commission's Sixth Framework Programme, priority 5: Food Quality and Security.

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