Botanicals, endophytes and plant growth promoting rhizobacteria to control Black Sigatoka of banana in Uganda

Executive summary

Black Sigatoka caused by the fungus *Mycosphaerella fijiensis* is a devastating disease of bananas worldwide, and affects all cultivated Musa species. Worldwide, the disease is managed primarily through the use of pesticides which are expensive and often inefficient. In practise, pesticides are rarely used in Uganda due to their expense. This policy brief describes the development of some simple and inexpensive new methods which can contribute to the management of this disease. Thus plant (botanical) extracts as well as bacteria and fungi isolated from the rhizosphere of banana control this economically important disease in laboratory conditions.

The target group represents individuals working in extension services, at plant disease diagnostic laboratories and certification agencies as well as research workers, teachers and students of plant pathology. This document is based on outputs from the Danida-financed research project 09-084LIFE: “Saving a precious crop: sustainable management of the Black Sigatoka disease of banana”.

Introduction

An obvious possibility for disease control is to utilize the inherent ability of plants to defend themselves by induced resistance. All plants have the ability to defend themselves against disease-causing pathogens. However, disease occurs when the plant discovers too late that it is being attacked or if the reaction is not strong enough to stop the invading pathogen.

Induced resistance describes the phenomenon where the natural defence of the plant is stimulated so it can defend itself faster or to a greater extent than before. The stimulation is exerted by a so-called inducer and there are many different types of inducers including micro-organisms (fungi, bacteria), certain chemicals and plant extracts (botanicals). Common for all inducers is that they 'sensitise' the plant, so the defences are put on alert. When a pathogen attempts to infect such a ‘sensitised’ plant, it can defend itself faster and more strongly than before.

An important trait for an inducer for practical disease control is that it evokes a strong protective effect in the plant, but does not harm the plant or the environment. Furthermore, it should give a long-lasting protection to avoid the need for several treatments. Botanical extracts, an isolate of a plant growth-promoting rhizobacterium (*Pseudomonas fluorescens*) and an endophytic fungus (*Fusarium oxysporum*) were evaluated by the Ugandan partner in this project as inducers against Black Sigatoka. Selected plant extracts were applied as foliar sprays to 1-2 months-old plants, whereas soil drenching to banana plants was used for application of *Ps. fluorescens* and *F. oxysporum*.

Ugandan and many other East-African farmers may benefit from application of such alternative disease control agents. However, to implement new disease control strategies, it is necessary to communicate results and procedures to farmers, extension services and control agencies.

Background

Black Sigatoka is among the most damaging and costly diseases affecting banana production worldwide. It is caused by the fungus *Mycosphaerella fijiensis* and attacks all banana and plantain cultivars. Under favourable conditions, symptoms develop within three weeks under field and screenhouse conditions. The disease quickly destroys the photosynthetic capacity of the leaves as they develop and thus prevents accumulation of reserves. As a consequence, this reduces the weight of banana bunches by up to 60% and may also cause premature fruit ripening.

In many African countries, bananas constitute an important part of the diet, especially in Uganda, where matoke is an essential staple food. Both East African Highland bananas (AAA-EA genome group, dominant in East and Central Africa) and plantains (AAB genome group, dominant in West Africa) are susceptible to the disease. Yield losses can lead not only to reduced income to farmers, but also a decrease in country fiscal revenues and eventually a shortage of this popular food item, which is difficult to replace by other plant products.

A drastic reduction of productivity in the traditional banana growing areas of central and south-western Uganda has been reported. Black Sigatoka alone can reduce yields by 30-50%, affecting dessert types such as East African Highland bananas and the disease is considered a major threat to the country's food security (Gale 2012). Studies conducted in Uganda suggest a mean minimum temperature threshold of 14-15°C for the disease to be established in the field (Tushemereirwe 1996). This suggests that high elevation areas (higher than 1500 metres above sea level), in countries where the disease has been reported, are likely to escape infection by this pathogen.

Globally, the control of Black Sigatoka has mainly relied on the use of fungicides that initially yielded positive results in many countries. However, the pathogen easily develops resistance to the products, thus resulting in a demand for new fungicides, which consequently lose efficacy. The high frequency of fungicide applications conducted in commercial plantations (up to 60 sprays per growth season), increases the impact on the environment and on the health of the banana workers.

Reddish streak symptoms on leaves of banana cultivar Kayinja. **Left**: control plant inoculated with *Mycosphaerella fijiensis* alone (no pre-treatment with *Fusarium oxysporum*). **Middle**: plant pre-treated with *F. oxysporum* ($5x10^5$ cfu/ml) followed by inoculation with *M. fijiensis*. **Right**: plant pre-treated with *F. oxysporum* ($5x10^6$ cfu/ml) followed by inoculation with *M. fijiensis.* Symptoms recorded 45 days after inoculation with *M. fijiensis*. Observe the development of weakest symptoms on plants inoculated with the highest concentration of *F. oxysporum*.

Results

In this project we have identified rhizosphere micro-organisms (*Pseudomonas fluorescens*), an endophytic fungus (*Fusarium oxysporum*) and plant extracts that can provide a measure of control against this fungal disease. However, the most important part of the project has been development of robust methods for measuring the effect of potential treatments which can be used in different regions to develop local treatments appropriate for dispersed areas so that organisms are not spread. Three Ugandan scientists have been trained and implemented methods connected to work on induced resistance. The hope is that establishment of these methods for work on induced resistance will pave the way for future studies in sustainable disease control in other crops.

Implications

The publications are under preparation from the research carried out. To date, a technical bulletin has been prepared (Mortensen et al 2013), providing clear experimental guidelines for researchers and extension workers to make local solutions for combatting Black Sigatoka under varying climatic conditions and geographically diverse regions.

What needs to be done now is to consolidate the methods and provide the methods for other researchers through Africa and elsewhere. A first step is publication of the results in international peer-reviewed journals. However, if introduction and establishment of this set of new research methods should reach a high level of impact on future local development and sustainable plant disease control in the future, research funding for a longer time frame is required to secure continued scientific interactions.

Mortensen, C. N., Collinge, D. B., Jørgensen, H. J. L., Gumisiriya, C., Kumakech, A., Kateete, S. N., and Okori, P. Botanicals, endophytes and plant growth promoting rhizobacteria to control Black Sigatoka of banana in Uganda. 2013. University of Copenhagen.
http://plen.ku.dk/nyheder/2013/banan/Black_Sigatoka_Bulletin_final_version.pdf/