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FAO RESPONSE TO THE BLACK SIGATOKA DISEASE PROBLEM IN THE CARIBBEAN

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ABSTRACT: Black Sigatoka disease (BSD), caused by *Mycosphaerella fijiensis*, is considered to be the most widespread and destructive disease of banana. The first outbreak in the Caribbean occurred in Cuba in 1991, and subsequently spread throughout the region. In all affected countries, BSD has had serious economic, social and environmental impact, causing yields losses of 30-50 % and significant (nearly 25%) rise in production costs. Five recently-affected countries (Dominica, Grenada, Guyana, St. Lucia and St. Vincent and Grenadines) requested technical assistance from the Food and Agriculture Organization (FAO) to carry out an assessment of ongoing national management programmes. A Regional Project was formulated accordingly under the Technical Cooperation Programme (TCP). Titled *Development of Integrated Programmes and Action Plan for Black Sigatoka Management in five countries of the Caribbean,* the project had four outputs, key among them being the formulation and endorsement, in each country, of a comprehensive National Management plan. The project had the endorsement and support of all Regional partners. The activities were undertaken by an Expert Consultant from Cuba between June and December 2012. In each country, the Consultant conducted an assessment of the existing management practices, benchmarked against well-studied and scientifically-sound practices. Recommendations made to fill the gaps formed the basis of the National Actions Plans for each of the five countries. Activities that could be undertaken at the Regional level were extracted from the National Plans and were included in the Regional Action Plan. Six draft proposals were also prepared (five National and one Regional). It is anticipated that the proposals will assist the countries and the Regional partners in mobilizing resources (both existing and potential) towards the long-term, sustainable management of BSD in the Caribbean.

Introduction

Globally, banana and plantains (*Musa* spp., AAA, AAB and ABB) are cultivated in more than one hundred countries. Approximately 107 million tonnes of bananas are produced on 5.3 million ha of land and 37.7 million tonnes of plantains on 5.1 million ha (FAOStat, 2011). Both crops are economically important for their contribution to the gross domestic product (GDP), exporting 18.7 million tonnes worth nearly USD 9 billion (FAOStat 2011) and as cash crops; 41-69% of total production is locally consumed. Thus, both bananas and plantains are principal staple foods for more than a hundred million persons in Asia, Africa and Latin America (Frison and Sharrock, 1998) and play an important social, cultural and political role in many rural communities. The imports to

the European Community and United States of America reached 7.8 million tonnes in 2007 (Loeillet, 2008). The current banana and plantain cultivars domesticated and planted in large acreages are hybrid polyploids from two wild diploid *Musa* species, *Musa acuminata* (AA) and *Musa balbisiana* (BB) (Stover and Simmonds, 1978).

Two leaf spots affect banana and plantain production tropical and subtropical America: yellow Sigatoka (YSD) caused by *Mycosphaerella musicola* and black Sigatoka (BSD) caused by *M. fijiensis*. Both diseases infect the leaves, reducing the plant's photosynthetic capacity and negatively affecting the size and weight of bunches. Premature ripening of fruit occurs as result of infected leaves, leading to rejection of exported fruit. The economic impact of the diseases is due to increased protection costs and production losses. *Mycosphaerella* spp. produce two types of spores: conidia (asexual) and ascospores (sexual) that under favourable humidity conditions, can infect the youngest leaf on the plant. These spores are the main source of dissemination between plants and fields. However, the introduction of infected leaves and planting material are the primary mode of dissemination among distant regions and countries across the world.

YSD was introduced and spread in the Americas during the late 1930s (Wardlaw, 1972). It seriously affects Cavendish cultivars (AAA) which require fungicide treatments for control, but cultivars with the *M. balbisiana* genome (AAB and ABB) are in general resistant and can be cultivated without fungicides (Vakili, 1968; Pérez *et al.*, 1981). The need for fungicide treatments for *M. musicola* control results in significant economic losses to the banana export industry. BSD is considered among the top ten most dangerous diseases to food security (Pennisis, 2010) and is by far the most widely-distributed, destructive and important diseases of banana. *Mycosphaerella fijiensis* is much more aggressive, has a shorter cycle than *M. musicola* (shorter incubation and transition period), produces 3-4 times more inoculum than *M. musicola* under the same conditions and very severely infects not only Cavendish banana but also plantains (AAB). In most cases, BSD displaces YSD in a period of three years (Pérez et al., 2002). In all affected countries, BSD has had a serious economic, social and environmental impact, causing yields losses of 30-50 % and significant rise in protection costs (up to 25 % of total production costs; Pérez et al., 2002; Guzmán et al., 2013). As a result, banana and plantain farms are frequently abandoned. Since the fungus produces large amounts of spores that are readily spread by wind, the abandoned fields and unprotected backyards are important inoculum sources to neighbouring commercial banana and plantain fields. *Mycosphaerella fijiensis* has a great capacity of adaptation to the external environmental pressures, including fungicide applications. BSD management is 3-4 times more expensive than for YSD, since more fungicide interventions are required.

BSD was introduced in Honduras in the late 1960s and the first epidemic was reported by 1972 (Stover and Dickson, 1976). Within ten years, the disease spread from Mexico to Ecuador due to the movement of infected leaves used for different purposes. The first outbreak in the Caribbean was in Cuba in 1991 (Vidal, 1992) and thereafter in Jamaica (1995), Dominican Republic (1996), Haiti (1999), Trinidad and Tobago (2003), Bahamas

and Puerto Rico (2004), Grenada (2005), Guyana (2008), St. Vincent and Grenadines (2009), St. Lucia (2010), Martinique (2011) and Guadeloupe and Dominica (2012).

In the Caribbean, the banana industry has traditionally been the economic backbone of four countries of the Organization of Eastern Caribbean States (OECS) - Dominica, Grenada, Saint Lucia and Saint Vincent and the Grenadines, while plantain production in Guyana accounts for a major share of the local food basket and intra-regional trade. The banana and plantain industry is thus a key source of rural employment and a contributor to the overall national development in these five countries. The banana industry has, however, been severely challenged over the past few years, already grappling with natural disasters (hurricanes, floods, drought) and YSD. It has been unable to compete with the low cost of production in other regions (e.g. Central America, Africa) for its exports to the United Kingdom (UK) and the European Union (EU). A number of interventions have been initiated by the EU in an effort to mitigate some of the resulting negative impacts on the livelihoods of small farmers. These include the Special Framework for Assistance (SFA) (1999-2008) and the Banana Accompanying Measures (BAM) (2010-2013), as well as the participation of banana grower associations (Dominica, Saint Lucia, Saint Vincent and the Grenadines) in Fair Trade Agreements. The banana producers already burdened with requirements for compliance with the export certification standards viewed BSD management as yet another, additional challenge.

Within 3-4 years of the introduction of BSD, there was a 90-100% reduction in banana and plantain exports from the five countries. The Governments requested support from FAO (and other regional organizations) for technical assistance to develop integrated programmes and action plans, resulting in a holistic and cost effective BSD management strategy. In order to effectively manage the delivery of assistance requests from the affected countries and avoid duplication, the regional/international institutions comprising FAO, the Inter-American Institute for Cooperation on Agriculture (IICA), the Secretariat of the Caribbean Community (CARICOM) and the Caribbean Agricultural Research and Development Institute (CARDI), worked together to develop a coordinated response. Accordingly, FAO sought funds for a project under the Technical Cooperation Programme (TCP), with the Ministries of Agriculture, IICA and CARDI as the main supporting partners and small producers in the region as beneficiaries. The assistance was approved in May 2012 as TCP-SLC-3402, *Development of Integrated Programmes and Action Plans for Black Sigatoka Management in five countries of the Caribbean*. The project activities began in June 2012 and ended in July 2013. The Ministry of Agriculture in each of the five countries was designated the counterpart agency for project implementation.

The overall objective was assist with the development of a programme for the effective management of Black Sigatoka Disease at the national level in the five participating countries and for coordination at the regional level. This objective was to be achieved through three main outputs:

- For each country, the formulation and endorsement of a comprehensive integrated BSD management programme and an action plan for its implementation
- Formulation and endorsement of a comprehensive regional integrated management programme for BSD and an action plan for its implementation
- Development of draft funding proposals for presentation to external donors

The planned activities were completed and the above outputs were achieved by December 2012. Savings made during project implementation were used for regional capacity building in keeping with the overall project objectives. This output, a regional training course: *Biological methods for monitoring fungicide resistance on Mycosphaerella fijiensis populations*, was hosted by the Government of Dominica from 17-22 June 2013.

Results

Activities Carried out Under the Project are Presented Below

An expert consultant from Cuba carried out the necessary activities during three missions: July 2012, August-September 2012 and June 2013, respectively. Prior to the first mission, the consultant drafted a technical manual: A holistic integrated management approach to control Black Sigatoka Disease of banana caused by *Mycosphaerella fijiensis* (Pérez, 2012). The manual was fine-tuned during the in-country missions and finalized and distributed in September 2012. Prior to the third mission, the consultant prepared a manual on fungicides and fungicide resistance monitoring in banana (Pérez, 2013), which was used extensively during training in June 2013.

Development of a National Integrated Management Programme and Action Plan

During the first two missions, the consultant spent one week in each country and conducted an assessment of the current status and control measures for BSD, which were benchmarked against the following recommended, science-based practices and used for BSD management in many countries in the region (e.g. Cuba, Belize and Costa Rica):

- area-wide implementation of management practices, aimed at elimination of inoculum;
- cultural practices (nutrition, water management);
- use of organic amendments;
- field sanitation;
- monitoring and bioclimatic warning systems for decision-making;
- chemical control: fungicides use and fungicide resistance monitoring;
- spraying technology and operation;
- use of resistant cultivars.

In each country, the consultant held discussions with key people from the public and private sectors. On field visits, he met with farmers and farm workers to obtain information on banana and plantain production, the impact of BSD, national BSD management programmes, cropping and disease management practices and technical and socio-economic constraints to BSD management. The consultant developed a draft action plan to fill gaps identified during the analyses of the information obtained. The results of the assessment and the draft action plan were shared at a national stakeholder workshop and at debriefing sessions with Ministry of Agriculture authorities (Permanent Secretary, Director of Agriculture, technical officers). A total of 191 participants attended the national stakeholder workshops in the five countries (Dominica: 54; Grenada: 34; Guyana: 33; Saint Lucia: 42; Saint Vincent and the Grenadines: 28). Feedback from the stakeholder workshop and the debriefing session was used to finalize the national action plans, which were formally submitted to the respective governments in October 2012.

Development of Regional Integrated Management Programme and Action Plan

During the last week of his second mission (15-22 September 2012), the consultant formulated a regional action plan based on activities from the national action plans that would be better addressed at the regional level. The consultant prepared for the Regional Stakeholder Consultation held in Barbados on 20 and 21 September 2012. Participants at the Consultation comprised two delegates from each of the five beneficiary countries and representatives from the Secretariats of CARICOM and OECS, IICA, CARDI (Dominica and Trinidad and Tobago), CIRAD-Martinique, Banana Board Jamaica, and Ministry of Agriculture, Trinidad and Tobago. On Day 1, the country delegates presented their respective action plans for feedback from other participants and reviewed the activities. They identified the resources required to implement the plan. On Day 2, participants reviewed the regional action plan (prepared by the consultant), and identified the activities and resources. Based on the feedback received, the consultant finalized the plan, which was formally submitted in December 2012 to the national governments and to all the partner agencies that had participated in the regional consultation.

Summary of Assessments and Proposed Action Plan at National and Regional Levels

The following is a summary of the assessments and the proposed action plans at the national and regional levels.

At the national level, key constraints to *Musa* spp. production in all five countries included:

- Natural disasters – hurricanes, floods and drought
- Low productivity / low bunch yield
- Insufficient inputs
- Lack of alternatives to fertilizers and pesticides
- Delays in weed control

- Lack of production and certification of planting materials
- Phytotoxicity due to high rates of oil
- Insufficient or lack of applied research and innovation

Most farms comprised of small properties (1.5-2.0 ha), close to communities. Planting material used was often of poor quality. Many farms suffered from severe Cucumber Mosaic Virus (CMV) infections due to intercropping with solanaceous and cucurbit crops and delay in removal of weeds (*Commelina* spp.). Together with insufficient fertilizer use as well as lack of organic amendments, this resulted in poor plant growth and nutritional deficiencies. Cost of management increased significantly due to increased level of fungicide application. In several islands, irregular topography made it difficult to apply the regular treatments necessary to keep BSD in check. High rainfall, particularly during the rainy months, resulted in high levels of infection (on the leaves) in the field and severe crop losses due to significant reduction in the level of fruit production (from reduced leaf production). Severe BSD infections led to early ripening of fruit, which were rejected for export. Many fields are either abandoned or not taken care of (except to reap available bunches for the local market). These fields became a source of infection to neighboring farms for BSD and other pests.

Use of mineral oil, by itself or as an adjuvant, had some advantages, including fungistatic effects, better penetration into the leaf and less evaporation, and improved extension of the newly-emerging leaf. However, if used frequently at high rates, it is phytotoxic and affects photosynthesis, delaying fruit development.

Key elements included in the national plan were:

- Allocation of emergency funds for immediate use: fungicide, oils, herbicides, labor etc.
- Capacity building and institutional strengthening of support agencies, governmental and non-governmental, in order to better assist the farmers[5]**
- Review and enhancement of legal frameworks (prevention, dissemination and management)
- Projects to introduce varieties, technologies, cropping practices and pest management in *Musa* and associated crops[1]**

For improved crop production, the following recommendations were included in the action plan:

- Improved cropping practices
- Compost production to improve soil pH and fertility to fulfill nutritional needs of plants
- Rigorous implementation of field sanitation practices
- Use of bio-climatic warnings to facilitate timely area-wide BSD management
    - Improved network of climatic recorders at local level

[5]** = some or all of these activities could be carried out at the regional level

    - Acquire equipment (pluviometers, evaporimeters, GPS, shelters and computers) for climatic network
- Production and use of entomopathogens (*Beauvaria bassiana* and *Metarhizium anisopliae)* for other pests
    - Recruitment of a consultant for capacity building in production technologies
    - Acquisition and introduction of isolates of *B. bassiana* and *M. anisopliae*
    - Infrastructure: Laboratory for production, as well as materials and equipment
- Spraying needs (materials and equipment)
- Fungicide and fungicide resistance assessment protocols and data interpretation (see section - Regional capacity-building activity) **
    - Training of two technicians from each country (see section– Regional capacity-building activity)
    - Acquisition of supplies and equipment
- Resistant hybrids cultural production packages[2]**
- Participatory breeding for improved yields[2]**
- Programs for production of high quality planting material**[2]
    - Improve disease diagnostic indexing and quarantine facilities for exchange of clean, disease-free germplasm
    - Two approaches:
        - Develop/improve diagnostic and quarantine facilities at country level
        - Develop a quarantine/ facility at regional level
    - Development of protocols for safe exchange of tissue culture materials

Preparation of Draft Proposals for Resource Mobilization

After completion of the second mission, the consultant drafted proposals using information from the country missions and the national action plans. A framework was developed under an integrated pest management (IPM) programme for the implementation of activities at the national and regional levels and their specific requirements (human, technical, material). Based on a request from the beneficiary countries, the consultant included a table in each national proposal, outlining the budget required for the annual crop protection costs for effective management of BSD. The draft national proposals were formally submitted to the governments in December 2012.

Along the same lines as the national proposals, the consultant drafted a regional proposal, which was shared with the national and regional partners in December 2012 for use in their resource mobilization efforts.

Regional Capacity-Building Activity

As indicated earlier in this paper, among the several recommendations in the regional action plan, one activity was considered key: Systematic assessment of fungicide sensitivity of *M. fijiensis* populations in a network of sites, with hands-on training for plant pathologists in theoretical and practical aspects of fungicide resistance tests

(benzimidazole, DMIs, amines strobilurine). The science-based rationale for this recommendation was:

- *M. fijiensis* is a heterothallic fungus with a high capacity for recombination and adaptation to environmental changes;
- the *Musa - M. fijiensis* pathosystem is continuous in space and time, which poses the risk of rapid adaptation of the fungus to change under high selection pressure;
- acquisition of resistance to key fungicides in use has been a common feature in all countries managing BSD and has an important socio economic impact; and
- systematic monitoring of *M. fijiensis* population sensitivity to fungicides is a principal component of integrated BSD management.

Accordingly, regional capacity building was planned and held in Dominica from 17-22 June 2013, facilitated by the expert consultant from Cuba. All outputs of the workshop were accomplished in accordance with the consultant's terms of reference and the work plan.

Conclusions

The project achieved its key objective of assisting the beneficiary countries with the development of national and regional programmes for the effective management of Black Sigatoka Disease, and action plans for their implementation. In addition, the beneficiary countries and regional partners were provided with draft proposals for resource mobilization. Additional capacity building was accomplished using savings accrued during implementation of the project activities.

The regional consultation brought together experts and partners from the region, resulting in viable working relationships being built at several levels. It is anticipated that these will continue well beyond the end of the project.

Recommendations

The national assessment provides a baseline of current BSD management against which the countries need to measure progress made under each component of the integrated management programme. The action plan provides a road map for the way forward, with a list of activities that should be carried out to achieve the specific, desired outputs. Several recommendations such as the area-wide implementation of management practices, field sanitation, cultural practices (water, nutrition) and improvements to spraying technology and operations can be carried out forthwith with existing resources.

In this regard, it is critical that, utilizing the training provided in June 2013, countries urgently establish a baseline of the sensitivity of the fungus to currently used chemical pesticides. This will assist the decision-making process resulting in the judicious and

informed rotation of pesticides, will reduce the risk of build-up of resistant populations and lengthen the effective life of the chemicals.

Other practices such as the use of organic amendments and alternate cropping practices (to reduce dependence on agro-chemical inputs and improve soil biology for the sustainability of the agro-ecosystem) and bioclimatic warning systems may require additional capacity building and procurement of equipment and materials. Resource mobilization efforts in the short to medium term, i.e. over the next few weeks and months, should, therefore, focus on these components.

Finally, over the long term, the procurement, testing for productivity and adaptation, and planting of BSD-resistant and or tolerant cultivars should be carried out to ensure the production of bananas and plantains for food security and nutrition. It has been noted that in most countries, farmer and consumer acceptance of new varieties of plantains and bananas has proved challenging. This is because of the sometimes striking differences in the size and shape of bunches and fingers, ripening, marketability, colour of skin and pulp, cooking time, appearance and colour of cooked products, taste and texture as compared to traditional varieties. Most popular BSD-resistant and tolerant varieties currently in use in Jamaica and Cuba are high-yielding and amenable to cooking and processing into chips and flour for baby-food, cakes, confectionery and cereals. It is, therefore, essential that necessary sensitization and awareness-raising be undertaken with all relevant stakeholders with regard to the importance of these varieties in the context of food and nutrition security both within the country and the Caribbean region.

FAO will continue to work closely with all its partners towards fostering a region-wide, collaborative approach in the fight against BSD in the Caribbean.

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