



Developing a regional strategy to address the outbreak of banana *Xanthomonas* wilt in East and Central Africa

Proceedings of the banana *Xanthomonas* wilt regional preparedness and strategy development workshop held in Kampala, Uganda — 14-18 February 2005

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Organized by the International Network for the Improvement of Banana and Plantain – Eastern and Southern Africa Regional Office



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Executive summary

In 2004, an outbreak of Banana *Xanthomonas* wilt (BXW) was reported in the Democratic Republic of Congo, following Uganda and Ethiopia, and it was becoming clear that all banana-growing countries of East and Central Africa were threatened by the epidemic. A workshop was, therefore, organized to bring together the region's banana research for development (R4D) stakeholders to discuss the problem. The workshop intended to provide a platform for more effective action to slow the spread of the disease and mitigate its impact within affected areas. In particular, the workshop presentations and discussions helped to identify gaps in existing knowledge of the pathogen and the disease it causes, leading to recommendations on: a) enhancing farmer-adoption of BXW management practices; b) reinforcing farmer-coping mechanisms and c) research that needs to be carried out to provide a sound foundation for containment and control efforts. The output of these discussions is captured in this report, in particular in the recommendations and the regional strategy for BXW management and containment that were developed in the final discussions of the workshop.

This regional strategy for BXW aims to help mobilize and equip communities to prepare for potential outbreaks in advance of the disease, to respond to the epidemic at the advancing disease front, and to sustain production within the affected areas and provide a coordinated response. The strategy adopts both short- and long-term perspectives. In the short-term, robust diagnostic tools to facilitate disease recognition, management and control must be developed and disseminated, disease surveillance must be facilitated and mechanisms put in place to share critical, up-to-date information between countries. At all levels of the production–consumption chain, capacity to make positive contributions must be strengthened.

In the medium-term, successful management tactics should be integrated into regional integrated pest and disease management strategies. A regional impact tracking mechanism should be established that provides feedback not just to scientists and research managers but also to policy makers; and a regional policy dialogue must be initiated to strengthen the coordination and management of trans-boundary epidemics that threatened food security and household income.

In the long term, a systems approach should be adopted to boost the health of farming systems, taking full account of genetic diversity, the resource base and biotic stresses. Grass-roots ownership and sustainability should be ensured by deploying a livelihoods approach to improve prospects for marketing bananas and banana products. Indigenous germplasm threatened by the disease must also be effectively conserved in perpetuity to ensure that farmers can replant traditional genotypes once the effects of the epidemic have lessened.

This strategic regional approach to address BXW is based on essential learning, from within and outside the region, gained from successfully controlling various other bacterial wilt diseases, and is in itself a model of a regional response to a disease epidemic. Such a strategic and comprehensive approach has the potential to bring the BXW epidemic in East and Central Africa under control and prevent its further spread. However, its success depends on the ability of the diverse partners in this effort to mobilize resources and government support to reach communities throughout affected areas and beyond – and then to ensure commitment to the disease management campaign and good practice in the longer term.

Background and workshop objectives

by E.B. Karamura

The Banana *Xanthomonas* wilt epidemic

Until 2001, Banana *Xanthomonas* wilt (BXW), caused by the bacterium *Xanthomonas campestris* pv. *musacearum*, was restricted to Ethiopia, where it attacked both *Musa* (banana and plantain) and *Ensete* spp. (Figure 1). The situation has since changed drastically. In September 2001, the disease was recorded for the first time in Uganda and by the end of 2003, it was reported in the eastern part of the Democratic Republic of Congo (DR-Congo). While the disease caused limited damage in Ethiopia and farmers were able to cope with

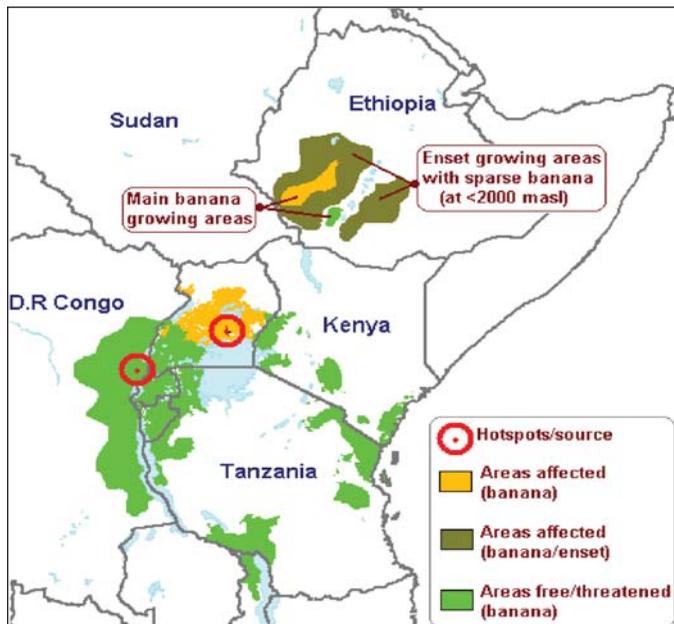


Figure 1. Distribution of banana and enset bacterial wilt caused by *Xanthomonas campestris* in East and Central Africa

the losses, in Uganda and DR-Congo it has assumed epidemic proportions. In Uganda, the disease prevalence in farmers' fields reached up to 70% in a period of one year, affecting 23 of the 56 districts of Uganda. In many of the affected districts, the disease wiped out entire banana gardens. It is estimated that Uganda is losing up to US\$ 360 million a year as a result of the disease outbreak. In the North Kivu province of the DR-Congo, unlike in Uganda, the disease has moved rather slowly covering 10-20 km radius from the source of outbreak in a period of two years. This is perhaps related to the fact that the outbreak has occurred in an area of higher altitude. Nevertheless, the damage and yield losses appear to be equally severe as in Uganda.

At the household level, BXW drastically reduces food security and income of communities, some of which depend on the banana crop for up to 90% of their earnings. The implications for food security are particularly worrying for the eastern districts of DR-Congo where normal economic activities continue to be disrupted by violence in the aftermath of a long period of conflict. The disease also has very serious implications for the natural resource base where communities, no longer able to grow bananas, may replace the perennial, no-till system with annual food crops requiring yearly tilling. This practice can lead to a severe decline in fertility, especially in mountainous areas of high-population density that are prone to soil erosion.

Efforts to control the disease

In Uganda a national task force has been formed and various actions undertaken to track the spread of the disease and to bring it under control. Recommendations have included the uprooting and burying of affected plants to prevent transmission from infected residues. Given the size of the plant, this represents a huge investment of labour for smallholder farmers. Any management strategy for the disease will need to take into account labour availability already constrained in rural areas by HIV-AIDS. The National Agricultural Research Organization (NARO) and Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) have mounted a massive programme, the Participatory Development Communication (PDC), to inform the public about measures to prevent infection in those districts that are at the 'frontline' of the disease.

Based on experiences elsewhere in addressing other banana bacterial wilt diseases (e.g. Moko in Latin America and Bugtok in Asia), measures to halt the spread of the disease focused on the removal of the male bud to prevent insect transmission of the disease and strict discipline by farmers to avoid transmission through contaminated tools and crop residues. The challenge to adequate-

ly educate farmers on the nature of the disease and its transmission so that measures are applied rigorously over large areas and at the advancing front of the disease is immense. In DR-Congo only brief fact-finding visits have been made to affected areas and in the neighbouring countries, Rwanda, Burundi, Tanzania and Kenya, which are threatened by the spread of the disease, little or no action has been taken to prepare plant protection services and farmers to deal with disease incursions.

In the absence of specific biological and epidemiological studies of BXW and practical evaluations of the proposed control tactics, some doubts remain as to whether management strategies developed for Moko and Bugtok will be fully effective against BXW. These questions need to be resolved to provide confidence for planning and action.

In recognition of this situation, the most recent Steering Committee meeting of the Banana Research Network for Eastern and Southern Africa (BARNESA) noted that “while the actions of individual NARS are extremely important in providing useful lessons, there is a need for a ‘big-picture’ analysis of the epidemic to ensure that actions in different countries are complementary and coordinated”. In this way the balance will be shifted from crisis management to strategic planning.

Objectives of the workshop

To respond to the increasing concern for BXW a workshop was held in Kampala, Uganda, from 14 to 18 February 2005 with support of the Food and Agriculture Organization (FAO) of the United Nations, the International Development Research Centre of Canada (IDRC) and the International Network for the Improvement of Banana and Plantain (INIBAP). The aim of the workshop was to develop a coherent regional and international response for containing the spread and mitigating the impact of banana *Xanthomonas* wilt on rural livelihoods in East and Central Africa. Specifically, the workshop sought to:

- review research progress, identify knowledge and technology gaps and agree on ways of addressing them;
- review extension efforts, including technology/information dissemination and exchange and devise new approaches to strengthen current activities at national and regional levels;
- agree on the framework for regional cooperation/collaboration.

A total of 65 participants representing and bringing essential knowledge from national governments, national research institutes, non-governmental organizations (NGOs), advanced research institutes, extension departments from

Ethiopia, Rwanda, DR-Congo, USA, UK, Tanzania, Philippines, Ghana, Nigeria, Cameroon, the Caribbean and Uganda were convened.

During the workshop expertise and experiences relating to banana bacterial wilt diseases were shared through presentations and general discussions. The meeting then focussed on developing specific recommendations and a regional strategy for dealing with the threat posed by BXW. This report represents the output of the workshop. The presentations are represented as papers of varying lengths. A brief summary is provided of the main discussion points. The recommendations are listed on page 69 and the regional strategy on page 73.

**Infested plot,
Democratic Republic
of Congo.**

Photo G. Blomme, INIBAP

EXPERIENCES WITH BANANA BACTERIAL WILTS



Banana bacterial wilts: the global picture

by S. Eden-Green

A number of bacterial wilt diseases are known to infect bananas world-wide. A bacterial wilt disease, known as Moko and caused by *Ralstonia solanacearum* biovar 1 race 2, exists in the Cavendish (AAA) commercial plantations of Latin America, the Caribbean and in the Philippines. The disease is characterized by plant wilting and is largely transmitted mechanically through farm tools and implements. The same bacterial agent is believed to cause a fruit rot, known as Bugtok, on cooking bananas (ABB) also in the Philippines. Another bacterial wilt disease, Blood disease in Indonesia, similarly affects subsistence cooking-banana (ABB) systems. The causal agent of this latter disease is not officially confirmed but is closely related to Bugtok and Moko.

The African banana bacterial wilt recently reported in East and Central Africa, has been confirmed as *Xanthomonas campestris* pathovar *musacearum*. The symptoms of this disease are similar to Bugtok when occurring in smallholder cooking/beer (ABB) banana systems, but are closer to Moko when occurring in the more intensively managed green-cooking EAHB-East African Highland banana (AAA) systems. As the banana bacterial wilt in East and Central Africa, Moko, and Blood disease are all bacterial wilt diseases of banana, the term “Banana bacterial wilt” as used in East Africa is rather generic and perhaps confusing. It would, therefore, be appropriate to refer to the East and Central African disease as Banana *Xanthomonas* wilt (BXW) to be specific and facilitate wider understanding of terms.

The three disease groups differ in many aspects including causal organisms, host range and geographical location of disease outbreaks, but are quite similar in their symptoms and other aspects. The diseases spread on tools, planting materials, through vectors, and in soil and water run off. They are reported to be poor soil survivors. They usually cause 100% fruit loss. In intensively managed systems, they are generally minor but persistent diseases, but in subsistence farming systems they are causing dramatic yield losses.

The national strategy for the management of BXW in Uganda

by W. Tushemereirwe

Banana is a very important food and cash crop supporting over 70% of the population of Uganda. Production is all year round potentially yielding up to 60 tonnes/ha/yr. The crop, therefore, has high industrial potential. It has however been constrained by a number of factors: socio-economic factors (marketing, management costs, underdeveloped post-harvest handling/ utilization) as well as declining soil fertility and pests (banana weevil, nematodes) and diseases (black Sigatoka, Fusarium wilt, Banana streak virus and recently BXW).

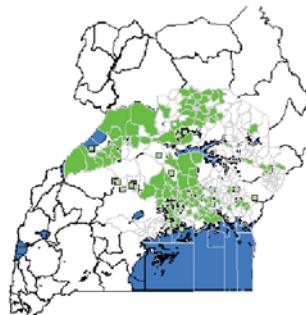
In Uganda BXW was reported first in October 2001 in Mukono District; soon after in Kayunga in February 2002. By December 2003, the disease had been confirmed in 12 districts (Mukono, Kayunga, Lira, Kaberamaido, Apac, Kumi, Mbale, Sironko, Kamuli, Jinja, Luwero, Wakiso) and in 26 districts by the end of 2004 (Figure 1).

The disease has been observed to affect all cultivated varieties. Losses can reach 100% in juice banana (Kayinja, also known as Pisang awak) plantations. If the disease is not controlled the potential annual losses are estimated to be equivalent to US\$ 360 million (i.e., 90% of the contribution of bananas to Uganda's Gross Domestic Product).



November 2003 — 12 districts

■ Affected subcounties
■ Water bodies



December 2004 — 26 districts

Figure 1. Distribution of BXW in Uganda

Response by the Government of Uganda

After the first report of the disease outbreak, the Government of Uganda responded by putting in place a Task Force to formulate an emergency action plan to eradicate the disease, committing 215 million Uganda Shillings to implement the plan. The disease was soon discovered to be more widespread than previously thought and a change of strategy was necessary, stepping up actions to “contain and control”. NARO was directed to form another Task Force to formulate a research/development strategy and action plan to contain and control the disease.

This research/development strategy and action plan identified the following objectives:

- Establish the current status of banana bacterial wilt
- Generate information on the etiology and epidemiology of BXW
- Develop appropriate technologies for the control of BXW
- Disseminate appropriate technologies for use by farmers to contain and control BXW
- Develop capacity for research and development (R & D) to control the disease at all levels (central Government, district, sub-county and community/village)
- Develop appropriate policies for management of pest and disease epidemics
- Identify and promote alternative enterprises as a coping strategy for farmers overwhelmed by BXW
- Assess and monitor the impact of research and development activities.

In addition, the government instituted a management and coordination framework named the BXW Control Initiative (BCI) that included the following elements:

- Steering Committee to oversee the implementation of the project, provide policy guidelines and mobilize local and international resources
- Technical committee to plan and guide execution of BXW management/control activities
- National coordinator to spearhead implementation of project activities
- Working groups to bring together implementers of related activities (Research, Awareness creation, Disease containment and control, and Monitoring & Evaluation) to share information
- Task forces at various levels (district, sub-county, parish and village) to maintain surveillance at the grass-root level and monitor/ supervise execution of disease control activities at respective levels.

Uganda's BXW Control Initiative is expected to deliver a number of outputs, including:

- 1. Collection of the baseline information**, covering disease severity, farmer perceptions and coping measures being implemented; the establishment of disease status with respect to disease distribution and the determining economic importance of the disease and likely impact on the banana industry. A database is being continuously updated with this information at NARO's Kawanda Agricultural Research Institute.
- 2. Generation of information on etiology and epidemiology** to include the evaluation of inoculation methods for early screening of young plants [Leaf petiole injection has been selected]; determination of pathogen variability, the methods of pathogen penetration into the host, and modes and rates of transmission to other hosts; determination of survival mechanisms of the pathogen, duration in different environments and on alternative hosts [four alternative hosts so far identified].
- 3. Development of appropriate technologies for disease management** using farmer participatory approaches to evaluate and promote control measures known to be effective against other bacterial wilt diseases elsewhere, including removing male buds; rouging diseased plants to eradicate the disease; developing resistant/tolerant banana clones through conventional and genetic engineering methods and disseminating appropriate technologies for the containment and control of the disease.
- 4. Creation of awareness about the disease to reinforce control strategies** through the mobilization of farmers and their leaders to deploy agronomic practices (de-budding and sanitation) with the goal of protecting as yet unaffected areas, blocking further disease spread, eradicating the disease in the 'frontline' areas and coping with or eradicating the disease in already-affected areas.
- 5. Development of research and development capacities at all levels**, including training scientists in specialized skills for handling BXW [6 Msc. students registered at Makerere University]; training of trainers at district, sub-county and community levels [296 well-trained trainers so far]; strengthening capacity of farmers' grass-root institutions to handle BXW in pilot sites; and developing infrastructure for handling BXW.
- 6. Monitoring the impact of research and development** in order to make appropriate adjustments in the BCI strategies and accordingly inform the government policy processes with respect to the management and control of epidemic agricultural diseases [A draft ordinance based on the crop protection act (1962) to guide and give a legal framework for formulation and enforcement of byelaws on control of BXW is being discussed].

In the implementation of the national action plan, a number of challenges have been encountered, including the shortage of resources to implement priority activities; the mobilization of key stakeholders along the production-consumption chain (e.g. central and local governments, development partners,

community leaders, faith-based organizations, NGOs and farmers) to support the control efforts, and weak linkages between research and extension. At the farm level, the initiative has met challenges posed by the traditionally low levels of adoption of agronomic practices in affected areas and negative attitudes towards implementing some of the recommended practices (e.g. de-budding Kayinja, which is regarded as a hardy variety that does not normally require agronomic attention). These challenges however are being addressed through participatory approaches and awareness campaigns.

Banana *Xanthomonas* wilt in DR-Congo

by Ndungo Vigheri and D. Lunze Lubanga

Banana *Xanthomonas* wilt was first observed in 2001 at Bwere, in the North Kivu Province bordering Uganda and Rwanda, two years before it was officially recorded. Since then, the disease has been spreading consistently in all directions from Bwere, gaining about 5km per year. A second outbreak was discovered in 2003, 10 km from Bwere, with the same spread pattern.

Bananas represent the main staple food in North Kivu. Prior to the disease infestation in the region, 70% of the cultivated land was occupied by bananas, generating 60% of household income. A survey conducted in the Bwere region indicated that the BXW outbreak has caused complete failure of banana harvests in most farmers' fields. Yields have declined from 20 tonnes/ha/year to almost zero (Figure 1), with a corresponding income loss of about 1600 \$/ha/year.

Wild onset is affected in Congo, supporting the idea that the disease is related to the onset bacterial wilt in Ethiopia. Among the cultivated bananas the disease mainly affects Kayinjas, Ndizi, plantains, EAHB and Cavendish in that order. The symptoms observed usually involve yellow discoloration of the stem, yellowing and dying off of the leaves, and yellow ooze and discoloration of the fruit. Farmers believe that the infection gets into the plant through the leaves or flowers and continues down to the stem and corm.



Figure 1 – A seriously damaged field



Figure 2 – Cut and chopped plants

Movement of the disease has been associated with the lakes and there is a suspicion that migrating birds that regularly visit the lake shores may be involved with the introduction of the disease to the region. It is also suspected that leaf-feeding insects are involved in disease spread.

In affected areas, the farmers are losing hope. Strict sanitation measures are under adoption, including chopping the pseudostem into pieces and leaving them to dry (Figure 2). Actions are being taken to address the situation. Immediate actions include:

- Sensitization of policy makers, farmers, service providers, to become aware of the threat
- Quarantine to limit planting materials movements from the infested zones
- 40 ha of infected bananas have been destroyed by cutting and chopping, and 30 ha replanted with other crops like beans, maize, sweet potatoes and cassava with the support of FAO
- A National Task Force on BXW has been set up
- Epidemiological studies leading to understand the disease dynamics and distribution have been initiated
- Varieties showing tolerance or resistance to other bacterial diseases in other countries have been introduced and are under evaluation in partnership with the CGIAR Centres
- Local germplasm is being collected for evaluation
- Participatory development of strategies for BXW disease control is underway using a Farmer Field School (FFS) approach (cassava FFS are already operational).

Actions planned for the longer term are:

- To put in place production facilities for clean planting materials (tissue culture lab, screen house, etc.)
- Genetic improvement is under way
- Capacity building to deal with various issues regarding BXW is underway: Scientists are training together with other stakeholders
- To establish a banana research programme.

Importance of banana *Xanthomonas* wilt in Ethiopia

by F. Handoro

Banana is the staple food of millions of people in tropical countries, providing food and income security. Ethiopia has various agro-ecological zones favourable to the cultivation of a range of crops, including horticultural crops among which banana is second only to citrus of the major fruit crops. Bananas are produced mainly in traditional agricultural systems by small-scale farmers throughout the country, but mainly at low to mid altitudes where there is adequate rainfall or irrigation. Banana's potential as an export commodity, has not been fully realized and production is largely for the local market and home consumption. The dessert banana is a popular fruit crop among producers and consumers (Seifu 1999).

The major banana growing areas, in southern and western parts of the country, are geographically separated from enset-growing regions, which are mainly confined to lower altitudes. At mid altitudes banana is planted either as a monoculture but also in multiple cropping systems together with enset, coffee, sugar cane, taro, vegetables. The yield and quality are poor both in farmer and state sectors, mainly due to the lack of technologies such as improved varieties and disease management practices, and declining soil fertility.

Bacterial wilt diseases

Of the range of pests and diseases affecting both enset and banana, bacterial wilt is considered to be the most serious in terms of its effects on productivity (Dagnachew and Bradbury 1968, Eshetu 1982, Dereje 1985, Archido and Mesfin 1996, Gizachew 2000). The wilt (BXW) caused by *Xanthomonas campestris* pv. *musacearum* (Welw) Cheesman was first reported and described in Ethiopia by Dagnachew and Bradbury in 1968 on enset. The pathogen is very destructive as it kills the plants at all growth stages and regularly causes total losses. According to Million *et al.* (2003) in some parts of the country, the acreage under these crops as well as productivity has declined due to bacterial wilt. It

seems that bacterial wilt is more common on banana than on enset and Ashagari (1981) added *Canna orchaooides*, an ornamental plant, to the list of host plants of the pathogen.

In Ethiopia, the characteristic symptoms of the disease are yellowing of the leaves, wilting and finally collapse. The first external symptom is the wilting of the central heart leaf (shoot leaf) at the apex, followed by yellowing and wilting of newly-expanded leaves and when the corm is affected, the entire plant dies. A transversal cut of the pseudo-stem reveals yellowish-brown vascular bundles and light-yellow or cream coloured bacterial ooze.

According to Dagnachew and Bradbury (1974) the first natural epidemic of BXW occurred in banana in Keffa-Sheka zone, south-western Ethiopia. By the 1980s, reports indicated that the disease was becoming a serious problem for enset and banana production. BXW is now recognised as a national problem, having increased in severity, particularly at lower altitudes, and spread into most enset and banana growing agro-ecology zones of the country.

Diseased plants are considered to be a potential source of primary inoculum. Extensive experiments to explore the survival conditions of the pathogen suggest that the bacteria survive in air pockets on leaf petioles (Gizachew pers. comm.) and sheaths for about three months and serve as primary inoculum (Dagnachew and Bradbury 1968, Ashagari 1985, Archido and Mesfin 1996). The pathogen apparently survives in the soil for about 2 weeks. With regard to farm tools, the bacteria were found on the surface of a contaminated knife for up to 3 days under humid conditions and up to 4 days under dry conditions (Dereje 1985).

Under most agro-ecological conditions in Ethiopia, the main means of wilt spread are disease-infected planting materials (i.e. suckers) and contaminated farming tools. It is known that infection occurs by contamination through wounds, breaks or through the natural openings (stomata). Animals (domestic and wild), including insects such as the leafhopper (*Poecilocardia nigrinervis*), the banana aphid (*Pentalonia nigronervosa*), and nematodes, and splashing rain or run-off are possible vectors of the pathogen according to Adhanom *et al.* (1986).

Research on bacterial wilt management

The nature of farming systems and the pathogen transmission present significant challenges to the successful management of the disease. In addition, there is no active BXW research programme in Ethiopia, although a number of activities are under way at the Southern Agricultural Research Institute (SARI). These activities are principally based on the use of cultural practices and

screening for resistant/tolerant varieties to BXW that could prevent or minimize the spread or eliminate the pathogen inocula in the field. These are:

- Management of the diseased plants/debris
- Removal, destruction and burial of diseased plants/debris
- Disinfecting farming and processing tools through sterilization by fire or chemicals before and after using
- Restrictive measures concerning planting materials and other banana products for the prevention of pathogen spread into new areas
- Use of disease-free clean planting materials
- Crop rotation, where feasible, or spot crop rotation to exploit the fact that the disease cannot survive in the soil beyond three months
- Plant spacing to prevent diseased plants coming into contact with healthy plants
- Male bud removal (an as-yet unknown management practice in Ethiopia) would be effective in low land regions growing cooking/beer bananas.

The use of resistant/tolerant varieties offers the most practical approach to manage BXW, requiring few special skills. Farmers already grow a diverse range of banana varieties as a means of risk aversion, but none of the popular varieties are totally resistant to BXW. The preliminary findings of a screening of more than 20 banana cultivars against BXW suggest that all are susceptible. However, low to moderately resistant banana varieties such as Dwarf Cavendish are not readily affected by the disease. In the long-term, the disease demands an integrated pest management (IPM) approach.

Research gaps

It is clear that attempts to combat BXW have been very limited in relation to the severity of the problem. This can be attributed to:

- **Lack/unavailability of improved varieties:** Shortage of improved clean planting material (suckers) is one of the most important problems of banana production in Ethiopia. In most of the banana-growing areas, farmers use low-quality planting material. Most of the farmers grow a local variety (Abesha muz) and Cavendish. Some commercial farms grow Dwarf Cavendish, Giant Cavendish and Ducasse. These varieties are not high yielding and are susceptible to BXW.

To date, there is no responsible agency for multiplying and distributing clean planting material to users in the country. Although there are tissue culture laboratories in some agricultural research centres, none of them can supply the ever-increasing demand for clean planting materials.

- **Lack of collaborators working on the problem:** Strains of the pathogen have not been well studied, nor has indigenous knowledge about BXW control been collected and integrated in management strategies. Losses are not well documented and disease transmission mechanisms (especially insect vector) have not been well explored. BXW has been reported in other countries (Uganda and DR-Congo). The scientists from these countries should work together and develop strategies to stop the spread of this pathogen. Experience-sharing, technology and information exchange are needed to help in the management of this devastating disease.

So far very little work has been done on the development and deployment of resistant/tolerant genotypes. Research is needed to:

- Screen and evaluate a range of banana varieties
- Study prevalence, distribution, severity of pests (fungal, bacterial, nematodes, virus, weevils)
- Study and identify strain types of the BXW pathogen in the region
- Develop IPM strategies, including varietal evaluation, biological and chemical control, and cultural options
- Study relationship between nematodes, insect vectors and the BXW pathogen
- Evaluate the role of clean materials and use of tissue culture and community nurseries
- Assess and evaluate indigenous BXW control practices in the region and develop control strategies for BXW.

Managing banana bacterial wilts in Latin America

by I. Buddenhagen

Experience over the last 45 years has resulted in a number of publications on bacterial wilts caused by *Ralstonia solanacearum* to which reference can be made and knowledge can be gained (e.g. Buddenhagen and Elsasser 1962).

Four banana bacterial wilts are now known, Moko, Blood, Bugtok and *Xanthomonas* wilt. *R. solanacearum* was originally a pathogen of *Heliconia*. Introduction of banana into *Heliconia*-growing sites enabled *R. solanacearum* to make several critical jumps over the years into banana, the most recent occurring in Jamaica in 2004.

Moko is known to be caused by one of the diverse *Heliconia* strains, race 2 (Buddenhagen 1962). Initially, Moko was locally transmitted in roots by contact and on tools. This problem was resolved by sterilization. After its establishment in banana, Moko disease was moved from area to area by shipment of planting material and later by insects. Insect transmission became increasingly important and today the pathogen is mainly transmitted from flower to flower by insects, leading to the development of epidemics that are driven by the presence of ABB bananas like Bluggoe (Pisang awak). This insect-mode of transmission has been confirmed by the isolation of the pathogen from the insects. *Trigona* bees are found to carry most of the inoculum on ABBs in the field.

Under insect transmission, it is proven that bacteria are transmitted from oozing bud to cushions or to female bract scars. It is also possible that bacteria may be transmitted from oozing bud to cut sucker, from fruit to cushion, from cut surface to cut surface, from fruit to cut sucker, from *Heliconia* flower to *Heliconia* or banana flower. Apart from insects, birds and bats may play a role in transmission (Buddenhagen and Elsasser 1962). Transmission by insects is related to phenology of the flowers.

Control measures

Previous findings on bacterial wilts conform with the observations made on *Xanthomonas* wilt in Uganda. *Xanthomonas* was first found in 1939 in Ethiopia

on wild enset, from where it jumped to banana. It is recommended that time be spent in the field to gather more information.

Previous experiences with banana bacterial wilts suggest the following disease management/control measures should be adhered to:

a. Disinfect tools to limit transmission

Currently contaminated tools need sterilization (with sodium hypochlorite) before and after use in any one field. Modifications may be appropriate for different agro-ecological conditions. By and large this practice has been successful only in well-managed Cavendish plantations where routine measures are regularly enforced.

b. Debud promptly

The standard approach is to remove the male bud immediately after the last cluster of the female flower has been released from the flower bracts. Many traditions have evolved different ways of achieving this and different kinds of tools have been adopted. Regardless of what is used, it is critical that the action does not facilitate the transmission of the disease from one plant to another. A forked stick has been used to break off of male flower buds and farmers need to be taught how to use the stick correctly.

c. Survey often and carefully with intent to halt spread

Routine surveillance is paramount to effective bacterial wilt control campaigns. Farmers need to be taught how to recognize the disease symptoms correctly and mechanisms for reporting and sharing information and delivering prompt action need to be in place. In this regard local bye-laws and the involvement of local authorities may be important.

d. Purpose of treatment: eliminate inoculum foci

From asymptomatic plants, the only possible source of inoculum found so far is nectar, but some plants that appear asymptomatic in the field may show internal symptoms. For stage 1 plants, BXW may be isolated from both nectar and other parts of the male bud, but other sources of inoculum are possible and infection may have spread beyond the bud. Assuming no previous infection in the stool, then unaffected fruit bunches will be protected by removing asymptomatic male buds. The destruction of all diseased plants may be important in order to avoid moving infected materials or for replanting. There is little evidence for other modes of spread from diseased plants so it may be better for farmers to avoid cutting and contaminating tools. By and large, the use of clean planting materials, combined with the restriction of the movement of planting materials and debudding may create a sufficient barrier to disease spread. There is little or no evidence to show that other plant materials (leaves, fruits) spread disease, except perhaps in cases of mechanical contamination.

e. Halting epidemics

Epidemics will occur when a number of conditions are obtained in a given farming system, including pathogen or host introduction, an abundant set of hosts having easily infectable courts and the presence of an inoculum oozing to the surfaces of peduncles. In addition the agro-ecosystem will also have abundant vector visitors such as bees, bats or birds to carry the pathogen from a source to new sites, plants and farms. The severity of an epidemic may also be influenced by the combination of the strain of bacteria, the variety of bananas and vector density. In the quest to halt the epidemic, multi-disciplinary, multi-stakeholder and multi-sectorial teams must be brought in to address the problem.

An effective strategy may need a holistic approach that looks at the agro-ecosystem, the host-pathogen-vector system and the traditional pest/disease management systems. In trying to substitute varieties lacking infection courts it is necessary to consider the utilization options that the communities have been deploying. In all cases the intended users of the technology must be educated about the strategy so that they can contribute their own experiences. In all circumstances to halt an epidemic there is no single solution but a combination of tactics is needed (disinfecting tools, early debudding, rouging infected plants and clean planting material).

Managing bacterial wilt/fruit rot disease of banana in Southeast Asia

by A.B. Molina

Bananas and plantains are an extremely important crop in Asia, a region that is recognized as the centre of *Musa* genetic diversity and at the same time a hotspot for many serious banana pests and diseases.

Moko and Bugtok in the Philippines

The term Bugtok, describes a discoloured and hard fruit even when ripe. A diseased plant may look normal, but the fruit pulp is rotten (dry), black and unfit for human consumption. The disease is caused by bacterium *Ralstonia solanacearum* (formerly known as *Pseudomonas solanacearum*). It was reported in 1965 although similar fruit hardening and rotting on Saba was reported as early as 1954. The disease affects Saba and Cardaba (ABB) cooking bananas and reached epidemic proportions in the late 80s to early 90s. The bacterium is known to be transmitted mechanically through soil on tools, but is mainly carried by insects feeding on infected flowers of cooking bananas.

Moko, another wilt disease caused by *R. solanacearum*, is known to affect commercial Cavendish plantations in the Philippines. External symptoms are the yellowing and collapse of the youngest leaves. These symptoms progress to the older leaves. Internally, the vascular tissues are discoloured and necrotic, especially near the centre of the pseudostem. The bacterium is more systemic in Moko infections, as it moves upward through the transpiration system in contrast to the slower downward movement of the bacterium (from the flower down the stem) in Bugtok infections. Advanced infection in fruiting plants may also cause fruit rotting. This seldom occurs in commercial plantation since early detection leads to early elimination of infected plants. If it does occur however, rotting of the pulp in Moko infections is similar to that of Bugtok symptoms.

The spread of Moko in commercial Cavendish plantations is mainly by way of contaminated knives used in regular desuckering and other pruning activities.

Hence, infection commences from the basal parts of the plant resulting in vascular infection that causes leaf yellowing and wilting. Fruit inoculation is practically absent in Cavendish commercial plantations, since the fruits are bagged, thus protecting them from insects. Moreover, the male buds are also removed, thus further reducing the chance of insect inoculation through the male flowers.

Moko and Bugtok are caused by the same strain of *R. solanacearum*. The observed differences in symptomology of Bugtok and Moko are due to differences of banana varieties and in the management systems under which the different varieties are produced. In the case of cooking banana production by smallholders, desuckering, fruit bagging and removal of the male bud were rarely practiced. Moreover, the male buds of cooking banana varieties are sweeter and are used as food. These seem to be more attractive to insects than the male buds of Cavendish, which are bitter and cannot be eaten.

In the Philippines, the disease Moko and Bugtok refer more to the type of symptoms and cultivar affected rather than the causal organism. Hence when *R. solanacearum* infects Cavendish in commercial plantations, people call it Moko. The same pathogen when it infects Saba is called Bugtok or other local names that describe fruit rotting. Thwaites *et al.* (2000), although recognizing that both diseases may be caused by the same pathogen, classified Moko under vascular wilt diseases and Bugtok under fruit rot diseases.

Blood disease in Indonesia

Blood disease, a similar disease reportedly caused by *Pseudomonas celebensis* (the true taxonomic identity is yet to be worked out), is a devastating banana disease in Indonesia. It was reported in Sulawesi in the 1920s, and spread to West Java in the 1980s. Recently, it has been causing damage to banana plantations in Sumatra. Like Bugtok in the Philippines, it causes significant damage to the cooking banana, Pisang kepok (syn. Saba), an ABB cooking banana and one of the most popular cooking varieties, as well as the dessert banana. This disease has practically eliminated P. kepok from the Sulawesi.

Blood disease is systemic like Moko. It is soil-borne and can be spread by contaminated pruning tools. However, field observations indicate that the fruit rotting symptoms are most common in P. kepok. This indicates that like Bugtok, disease inoculation is through the flowers. This inference is supported by the observation that a P. kepok-type cultivar, which does not produce a developed male bud is significantly less affected by Blood disease.

In an effort to understand the disease better and develop disease management tactics, several practical studies have been carried out by Indonesian sci-

entists. In a varietal screening conducted at the Indonesian Fruit Research Institute (IFRI) in Sumatra, involving artificial inoculation on potted plants in greenhouse, none of the Indonesian varieties were found to be resistant to *P. celebensis*. All varieties exhibited wilting symptom within 9 to 17 days of inoculation. Field trials, however, showed that cooking bananas such as P. kepok, Pisang raja and Pisang nangka are more seriously affected by Blood disease compared to dessert bananas such as Pisang ambon (Cavendish) and Pisang berangan. Moreover, it is a common observation that dessert bananas, grown in commercial farms, show the wilting symptom (Moko-like) whereas the cooking bananas, usually subsistence farmers' cultivars, are most affected by fruit-rotting (Bugtok symptom).

The early male-debudding programme that was adopted for Bugtok control in the Philippines was evaluated in Solok Sumatra in 2000 and was reported to be also effective for Blood disease (Djatinika 2003). Further work to evaluate control programmes and promote cultivars that are less easily infected is being pursued.

The presence of a bacterial wilt, reminiscent of Moko, in commercial Cavendish plantations in Indonesia has been recently reported in local scientific literature. While the Blood disease pathogen is distinctly different from the Moko pathogen, the relationship of Moko to Blood disease may be similar to that of Bugtok and Moko in the Philippines. As discussed earlier, Cavendish farm management may yield to wilt (Moko) symptoms rather than fruit rot symptoms (Blood disease).

Moko and Bugtok management in the Philippines

The dynamics of the bacterial wilt/fruit rot pathogens have long been sufficiently understood to design a practical and effective disease management system. The effective management of Moko by commercial Cavendish plantations in Central America as well as in the Philippines is based on the etiological and epidemiological studies carried out by company researchers as early as in the 60s and 70s.

Implementing a rational and cost-effective disease management system is easier to achieve in a well-organized and coordinated commercial plantation than in very dispersed, numerous, small-scale farms. Commercial companies have the technical and financial capabilities, as well as strong incentives, to implement an effective disease management system. By contrast, the broad-ranging socio-economic status, motivations and support systems of small-scale

The disease management system for Bugtok and Moko in the Philippines is based on the traditional concepts of disease control:

- Regular disease scouting and early detection
- Eradication of infected plants and treatment of affected soil
- General sanitation to reduce insect infestation
- Quarantine
- Debudding tools
- De-budding and bagging (part of general commercial production practices)
- Use of healthy planting materials(tissue culture) and improved production system.

growers make it difficult to implement a comprehensive disease prevention and eradication programme.

In the Philippines, while insect transmission through the floral parts was scientifically demonstrated decades ago, removal of male buds as a disease control tactic for small scale farmers did not get serious attention until just seven years ago when the Bugtok epidemic hit the heartland of Mindanao where the banana chip industry thrives. Farmer's demonstration trials were carried out to show to small-scale farmers as well as to local government officials and extension workers the value of this simple control practice. One such study was conducted in the southern Philippines where the Bugtok epidemic had practically devastated the small-scale Saba production catering to the banana chip industry, as well as other processed products. The results of the farmer trials (Tables 1 and 2, Figure 1) were enough to convince farmers and local government alike to implement a sustainable Bugtok management system through extensive extension activities.

Table 1. Prevalence of Bugtok before implementation and after implementation of management practices (six months and 1 year) (n=50 farms).

Management practices	Prevalence (%)		
	Before	6 months	12 months
Untreated control	82	89	96
Sanitation	86	65	40
Debudding	91	52	22
Debudding+Sanitation	82	39	11
Debudding+Sanitation+Desinfect tools	88	34	6
Debudding+Sanitation+Desinfect tools+bagging	78	23	0

Data taken from G.C. Molina 1996.

Table 2. Percentage control of Bugtok before implementation and after implementation of management practices (six months and 1 year) (n=50 farms).

Management practices	Disease control (%)		
	Before	6 months	12 months
Untreated control	-	-	-
Debudding	-	43	76
Sanitation	-	24	54
Debudding+Sanitation	-	53	86
Debudding+Sanitation+Desinfect tools	-	61	93
Debudding+Sanitation+Desinfect tools+bagging	-	70	100

Data taken G.C. Molina 1996.

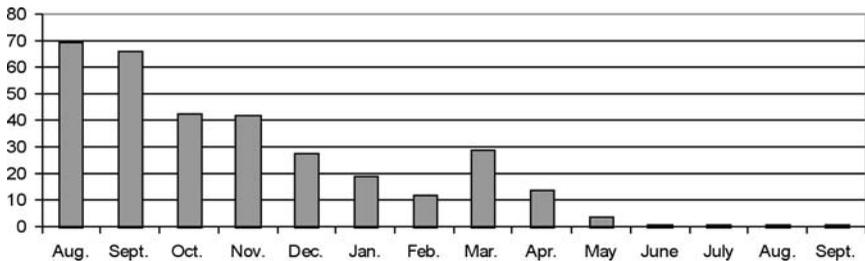


Figure 1. Bugtok prevalence in 5 farms with high disease pressure over the 12 months following the implementation of IPM (August 1997 to September 1998, Camiguin) (From Opina *et al.* 1999)

With time and official backing, the management tactics have become a part of routine cultural practices. Most of the Saba growers regularly practice debudding and some bigger farms also practice fruit bagging, which is less popular because of the costs and practicalities of bagging very tall plants. While Bugtok cannot totally be eradicated the effects are reduced.

Another technology, which is now widely practiced in India, China, and the commercial Cavendish plantations in the Philippines and has significantly improved pest and disease management in Asia, is the wide use of healthy seedlings through tissue culture. Commercial plantations in the Philippines commonly use tissue culture in their annual cropping system, and in establishing new plantations. The management of *Fusarium* wilt Race 4 through tissue culture in Taiwan has served as a model in this respect. The practice has significantly reduced other pests and diseases such as Banana Bunchy Top Virus, nematodes, Moko and even Sigatoka diseases.

The major thrust is now focused on bringing this technology to small-scale farmers. A cost-effective clean seedling system for small-scale farmers is now being developed in the Philippines, Indonesia, Sri Lanka and other developing countries. Increasing numbers of small-scale farmers are now using tissue culture and the control of seedling-borne diseases like bacterial wilt is expected to improve.

In conclusion, the studies in the Philippines show that control and/or eradication on farm is possible one year after implementation of management practices but a lot of team work, resources, commitment and dedicated leadership are needed on the part of the implementers to ensure management practices are comprehensively adopted.

BXW-affected bunch.
Photo G. Blomme, INIBAP

DISEASE SURVEILLANCE AND PROSPECTS FOR MANAGEMENT

At the time of the workshop, only Uganda and DR-Congo had reported the presence of BXW. The discussions concerning unaffected countries, at the time therefore, revolved around national preparedness strategies to keep out the disease. Since then, the disease has been confirmed in Gisenyi district of western Rwanda, bordering DR-Congo and in Kagera region of north-western Tanzania, bordering Uganda.



Disease status in Kenya

by E. Kimani

Banana is a major crop in Kenya covering 74 000 hectares (2% arable land) and over 1 million tons/year are produced. The Ugandan phytosanitary department informed Kenya when BXW broke out in 2001. Scouting surveys were later conducted in Western and Coastal regions of Kenya in September and December 2004, deploying interviews and transect walks, and collecting samples. BXW was not encountered but a range of other pest and disease problems were (Weevils, Fusarium wilt, Sigatoka etc.). It was also noted that bananas are imported from Uganda (through Busia and Malaba) and Tanzania (through Taveta) and marketed in major towns. The introduction of the disease into Kenya is likely to occur through plant materials.

Action taken to address BXW in Kenya

A number of actions have been taken since the scouting surveys, including stepping up border inspections, instituting a system of import permits to control and monitor cross-border movement of banana materials and products; issuing phytosanitary certificates for bananas entering Kenya; banning sucker importation (except tissue cultured materials under quarantine); intensifying information exchange with Ugandan counterparts (two plant inspectors visited Uganda to familiarize themselves with the disease); instituting regular communication with stakeholders about the threat of the disease; and certifying nurseries distributing banana seedlings.

Further public sensitization and continued surveillance is planned. A BXW working group will be established with the Ministry of Agriculture (MOA) taking the chair, the Kenya Plant Health Inspectorate Service as secretariat and Kenyan Agricultural Research Institute, Horticultural Crops Development Authority, Agricultural Development Corporation and Plant Protection Department of MOA as members. Funding for most activities is being sought from the MOA and other development partners.

It should be emphasized that the apparent lack of the disease during surveys does not mean the disease is absent. There is an urgent need to train scientists,

extension officers, plant inspectors, farmers on BXW disease symptoms and harmonize quarantine efforts in order to prevent the introduction and spread of BXW.

Banana *Xanthomonas* wilt surveillance activities in Tanzania

by M.S.R. Byabachwezi

Banana diseases in Tanzania pose varied threats according to the geographical area and dominant banana varieties grown. While the coastal regions of Tanzania, including Zanzibar and Pemba islands, are affected mainly by black Sigatoka (*Mycosphaerella fijiensis*), this disease is not a threat in the highlands of Kilimanjaro, Kagera and Southern highlands. Likewise in areas where the EAHB have been replaced by the dessert varieties, due to banana weevils (*Cosmopolites sordidus*), nematodes or poor soil fertility, the threat by Fusarium wilt (*Fusarium oxysporum*) has increased.

Recent studies carried out in Tanzania to assess the extent of pest and disease problems associated with banana (e.g. Bosch *et al.* 1996, Rajab *et al.* 1999 and Mohamed and Mgenzi 2004), did not reveal the presence of BXW. To establish a close watch on the disease, the Ministry of Agriculture and Food Security (MAFS) in Tanzania, sent two scientists in January 2004 to study the disease in affected areas in Uganda with the support of the Kawanda Agriculture Research Institute (KARI). A survey was then undertaken in the whole Kagera region to see if the disease had crossed the border to Tanzania. During the survey, apart from visual observations, farmers and agriculture extension staff were asked if they had noted any strange banana diseases. There was no evidence of BXW in the region.

The resulting survey report made the following recommendations (Mohamed and Mgenzi 2004):

- To produce and distribute extension materials (leaflets, posters or brochures) both in Kiswahili and other vernacular languages, to inform farmers and extension staff about this new disease
- To encourage farmers maintain proper sanitation in banana plots
- To encourage farmers to remove male buds once the female fingers have emerged

- To instruct farmers to harvest bananas from their fields themselves rather than allowing traders to cut bunches, and to sterilize tools with a flame before they are used
- To reinforce and announce banana plant quarantine measures, instructing plant inspectors at the border to make sure that vehicles crossing to Tanzania do not contain any banana or other plant wastes and if present to be burned at the entry point
- To ensure that routine monitoring in border villages is carried out on a quarterly basis and to institute frequent communications with farmers, extension staff, NGOs and government organizations to minimize chances of the disease entering the country. In case the disease symptoms are observed, necessary measures should be taken to control the disease to prevent further spread.

Since the survey a number of activities and events have been initiated:

Implementing agency	Activities
MFS	<ul style="list-style-type: none"> – In August 2004, facilitated the production and distribution to farmers of 3 million coloured leaflets and 3,000 coloured posters concerning banana bacteria wilt disease – Called on a team of trainers from Maruku Agricultural and Development Institute (MARDI) and the Plant Health Service to train farmers in Kagera region about the disease (Mgenzi <i>et al.</i> 2004) – Instructed quarantine to restrict importation of raw bananas and other banana plant parts – Facilitated the monitoring of the disease by researchers.
Kagera region	<ul style="list-style-type: none"> – Facilitated the distribution of leaflets and posters – Announced the outbreak of the disease at various meetings – Ensures that quarantine measures are respected by following up border plant inspectors.
Districts	<ul style="list-style-type: none"> – Are reporting any strange symptoms to MARDI for verification by a researcher – Facilitated the study tour of two senior staff to BXW affected areas so that they can identify symptoms. Training of other extension staffs and farmers is planned – Facilitated the production of a training video for extension staff and farmers – Are conducting a campaign about the disease at gatherings.
Villages	<p>Farmers formed Banana wilt monitoring committees, which are responsible for:</p> <ul style="list-style-type: none"> – Assisting plant inspectors to ensure farmers do not import bananas

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- Report any strange banana disease symptoms to agriculture extension staff
 - Meeting local leaders to report the situation on the disease on a quarterly basis
 - Running campaigns about the disease
 - Reporting to the district on the situation.
-

MARDI	<ul style="list-style-type: none"> – Is taking the lead in verifying banana disease symptoms – Organized a study tour for the senior agriculture staff to <i>BXW</i> affected areas in Uganda – Is coordinating information gathering from village committees and following up on recommendations. – Is conducting a quarterly monitoring of the disease especially in border areas and among fishing communities along Lake Victoria – Is regularly communicating with KARI on the developments of the disease and reporting to MAFS – Is sending flash reports to MAFS about events on the disease – Is searching the internet for information on the disease and making recommendations whenever necessary.
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Several constraints have been recognized:

- Communication among stakeholders is limited (e.g. communicating to remote districts)
- Banana is given low priority in funding and activities have been relying on ad hoc funding. There is no clear source of funds for monitoring the disease, organizing village committee discussion meetings, or for following up on reports of disease symptoms
- Lack of facilities and materials, especially chemicals, to identify the diseases.

Based on the experience with other diseases such as Coffee Fusarium wilt, Cassava Mosaic Virus, Sweet potato diseases, etc., it is more cost-effective to prevent a disease outbreak than to control but this requires preparation. Funds are needed to support immediate actions in the event of an outbreak. Presently, there is a single pathologist covering the entire Kagera region and unless more are trained this will remain a bottleneck for any control strategy.

Recommendations:

- Frequent communication among research institutes in the region is necessary to understand the current situations and findings about the disease
- Regional efforts are needed to solicit funding for managing the disease
- A regional coordinator for the disease should be identified to coordinate the circulation and dissemination of news and events concerning the disease

- A regional network mechanism should be in place to enable the delivery of information.

Although BXW is not yet reported in Tanzania, efforts should be made to ensure it does not cross the border. The efforts to contain the disease are not limited to Uganda alone but to all banana-growing areas in the region. This necessitates strong collaboration between stakeholders in the region (including policy makers, researchers and agriculture extension).

Disease surveillance for BXW in Rwanda

by S.V. Gaidashova

The Rwandan economy is based on agriculture, which contributes nearly 40% of GDP and occupies 90% of the active population (Lassoudière 1989). Banana is one of the major commodities in the agricultural sub-sector, occupying 23% of arable land. It is used as a cash and food crop and contributes between 60 and 80% of household income (Okech *et al.* 2004). About 2.4 million tons of banana are produced annually (MINECOFIN 2004).

Major constraints to banana production include pests and diseases, inadequate plant nutrition and poor crop husbandry. Fusarium wilt which affects ABB, AAA and AAB exotic brewing and dessert varieties causes significant economic losses across banana production zones (Okech *et al.* 2002).

No symptoms corresponding to BXW have been observed in Rwanda to date. Sixty farms, which took part in a diagnostic survey in 2001, were revisited in April-June 2004 by the *Institut des Sciences Agronomiques* (ISAR) and IITA scientists but neither symptoms nor reports of BXW were evident. However, more comprehensive surveillance has yet to be conducted in areas bordering Uganda and DR-Congo, and the possibility that BXW is in Rwanda cannot be excluded.

Factors influencing the risk of BXW incursion from Uganda or DR-Congo are:

- Proximity - the Rwandan border is 100 and 300km from the BXW affected areas in DR-Congo and Uganda, respectively
- Lack of phytosanitary control for fresh produce and plant material on customs and lakeshore markets
- Occurrence of fresh banana bunches imported from: Uganda, by road via two entry points (Gatuna and Kagitumba) and DR-Congo, by boat via Lake Kivu at Gisenyi and Kibuye shore markets.

To prevent or delay entry of BXW in Rwanda, the major strategies should focus on:

- Building awareness at all levels, from policy makers, lawyers to different public service providers and farmers
- Strengthening customs control for imported banana goods (both fresh bunches and planting material)

- Restricting plant material movement between districts with special attention to the areas bordering DRC and Uganda
- Strengthening national plant quarantine service.

As a first step to initiate awareness campaigns, leaflets about BXW have been developed by ISAR and will be disseminated through Village Information Centres in 2005. The Agricultural Technology Development and Transfer (ATDT) project, funded by USAID and managed by the *Centro Internacional de Agricultura Tropical* (CIAT) and ISAR, is already providing funds to produce extension material for farmers and assist in implementing the awareness campaign.

Country needs for plant protection specialists are far from being covered. ISAR has one scientist specialized in plant pathology. The institution is currently installing a plant pathology laboratory at Ruhengeri Research Centre (Northern Rwanda). The National University of Rwanda has several specialists in crop protection who are involved mainly in teaching activities. The Ministry of Agriculture has a plant quarantine service which is responsible for plant health control for imported plants. The extension service working under the supervision of the Ministry of Agriculture employs about 297 officers (of which 99 are in charge of agriculture) in 99 districts including provincial cities. The number of NGOs and community-based organizations (CBOs) and their field staff is unknown but may be significant in some zones.

Research gaps and challenges

Still many gaps exist in our understanding of disease epidemiology, transmission vectors, and existence of resistance or tolerance in local and exotic banana

There exist many challenges to successfully deal with the potential BXW problem in the country. These include:

- **Lack of trained man power:** especially for disease identification. BXW is easily confused to the untrained eye with Fusarium wilt, which has been present in Rwanda for 15 years
- **Need for public awareness campaigns:** targeted at policy makers as well as farmers to underscore the threats of BXW, especially in high risk areas (Gisenyi and Kivu Lake border)
- **Need for bye-laws:** weak quarantine service and lack of customs control on plant material allows all possible pests and diseases to enter Rwanda without a "visa"
- **Existing cultural practices and production systems:** may themselves be constraints to implementing BXW control options. For example, bananas are grown without replanting and little or no land is available for rotation. Debudding is not practiced and one of the most susceptible varieties, Kayinja or Gisubi (ABB), is highly popular in many regions, especially in Central Rwanda
- **And finally, farmers' minds and perceptions about the new technologies are often negative:** the demonstration of immediate effect is needed.

germplasm. Lack of plant pathologists at the country level makes it difficult to develop and implement an effective programme against BXW and other threats (Cassava mosaic virus, etc.). There is also a lack of expertise in the identification of BXW symptoms and no monitoring system to provide information on disease occurrence, if any.

To address the risks posed by BXW, a national action plan, based on a regional initiative and the experiences of Uganda, should be developed as soon as possible, and resources mobilized for its implementation.

**Infection on a male bud,
Democratic Republic
of Congo.**

Photo G. Blomme, INIBAP

EPIDEMIOLOGY



Biology and epidemiology of BXW

by A. Viljoen, J. Smith, F. Ssekiwoko,
V. Aritua and S. Eden-Green

Little is known about the causal agent of BXW, *Xanthomonas campestris* pv. *musacearum* (Xcm) other than the general knowledge concerning xanthomonads and other wilts. Knowledge needs to be continuously generated because only some of it will be useful in developing applicable measures. Most field observations need to be backed up by well-planned, scientifically-rigorous studies.

In planning disease epidemiological studies some basic questions need to be asked:

- Why is this disease all of a sudden a threat? Is this really the first introduction?
 - Is the bacterium now in Uganda and DRC the 'same' as that present in Ethiopia?
 - Have agricultural practices changed?
 - Have trading routes changed?
 - Are people more mobile?
 - Does global climate warming have an affect?
- What do we need to know of its biology?
 - How does the bacterium spread; and what is the primary pathway?
 - How long does the bacterium survive in soil and plant debris?
 - Does it have hosts other than banana and enset, maybe some latently supporting populations?
 - What genetic diversity exists amongst populations [geographic and host]?
- What role does the banana plant play?
 - Are all varieties of banana equally susceptible or is there resistance, tolerance and/or disease escape types?
 - To what extent can banana plants support latent infection; can this be detected?
 - How long does the bacterium survive in banana plant debris?
- What are the consequences of BXW?
 - Do we know enough on disease incidence, spread rate and loss to predict impact?
 - What are the coping strategy options and what will the consequences be to farmers, consumers and the environment?

Studies on BXW are ongoing in Ethiopia, Uganda, South Africa and the UK on host range and resistance, pathogen survival and characterization. So far, it has been revealed that bacterial growth is good on certain isolation media (YPGA, YPSA and YDC) and poor on others (NA). It can also grow in nectar as demonstrated by turbidity change.

Systems for locating resistance genes for other banana diseases are available at the University of Pretoria's Forestry and Agricultural Biotechnology Institute (FABI), which could be used to locate resistance to BXW once identified. Artificial inoculations by needle injection (with about 10⁸ cfu/ml) showed that cultivated banana, *Ensete*, wild *Musa ornata*, wild *Musa zebra* and *Canna indica* are affected by Xcm. Out of these, only enset and cultivated bananas have been found to be natural hosts.

Laboratory and field observations should be mutually informing, the following tools and methods may need to be developed:

- **Characterization studies** (Population studies using molecular markers - AFLP, rep-PCR, MR-PFGE, or protein profiling and more specific studies such as multi-locus sequence typing, cDNA-AFLP; Fatty acid, Biolog, etc.).

Outputs: refined taxonomy and data in support of developing diagnostic tools and breeding.

- **Diagnostics** (Specific primers and PCR; ELISA).

Outputs: methods for detection and identification; insect vector studies; protocols to support quarantine and movement of planting material.

- Plant breeding
- Bionomics
- Marker assisted breeding
- GM approaches [Golden bullet].

- **Persistence studies** (Selective media enumeration; PCR-based detection, community analysis [Real time PCR; DGGE, TRFLP]).

Outputs: methods for quantified monitoring within the environment [host range, soil / plant debris persistence, impact of farmer practices etc]; recommendation to farmers on preferred practices.

- **Lab-to-pot trial to-field trial to-farmer trial to-farmer and consumer;** a continuum of increasing realism (the time scale in realising any impact varies according to the research; a clear vision on what is needed in short, medium and long-terms).

**BXW on banana in
Southern Ethiopia.**

Photo Fikre Handoro, SARI

CONVENTIONAL BREEDING AND TRANSGENIC APPROACHES



Screening and breeding

by W.K. Tushemereirwe and M. Pillay

Breeding for resistant genotypes is one of the solutions to BXW. Thus far, no banana cultivars in Uganda appear to be resistant to BXW. However, some are known to escape infection in the field. This short paper describes a screening trial, managed in collaboration between NARO and the International Institute for Tropical Agriculture (IITA), of a range of banana genotypes to detect which are capable of escaping BXW infection. Sixty eight genotypes, each represented by 15 plants, were studied (Table 1). These include representatives of each of the five clone sets of EAHB, (Karamura 1999) tetraploid and triploid hybrids, exotic hybrids from FHIA, wild, cultivated and synthetic diploids.

The male buds of five plants per genotype were infected with the pathogen by drenching soil with inoculum at flowering with five non-inoculated plants per genotype used as control. Data on disease incidence, extent of systemic disease development, disease severity and type of infection and plant wilting were recorded. Preliminary findings indicate that the diploid plants (SH-3362, Kokopo, Calcutta 4, Pisang lilin, 7197-2, 8075-7, Opp79/1201K-1, Nakayonga, 9128-3, SH-3217) are susceptible to soil drenching so far. The experiment is continuing and data collection ongoing.

Table 1. 68 genotypes used for screening for BXW resistance.

IITA hybrids (TMB-bananas)	EAHB landrace	Other introductions	FHIA hybrids	PNG accessions	IITA hybrids (TMB-plantains)
8386S-19	Nyamwihogora	Nakatansese	FHIA-25	Yalim	5511-2
9750S-13	Kibuzi	Pisang Ceylan	SH-3640/10	Kokopo	4479-1
2409K-3	Nakayonga	Pahang	FHIA-01	Pagatau	7197-2
7798S-2	Kabula	Pisang lilin	SH-3640/9	Cachaco	
9187S-8	Nakyatengu	Calcutta 4	FHIA-23	Merik	
9494S-10	Enyeru	Paji	FHIA-21	Porapora	
1438K-1	Nakasabira	Mushale	SH-3217		
9128-3	Kabucuragye	<i>M. balbisiana</i>	FHIA-17		
1201K-1	Mpologoma	Dwarf Cavendish	FHIA-18		
6142-1	Tereza	Kayinja	SH-3362		
222K-1	Mbwazirume	Yangambi Km5			
660K-1	Kisansa	Long tavoy			
Opp79/ 1201K-1	Enzirabahima	Kisubi			
466S-1	Entukura				
807S-7	Kikundi				
917K-2					
401K-1					
1968-2					
365K-1					
6930-3					
376K-7					

Prospects for using biotechnology against BXW

by L. Tripathi, J.N. Tripathi and
W.K. Tushemereirwe

The livelihoods of millions of farmers have been threatened by the current outbreak of a banana bacterial wilt disease caused by *Xanthomonas campestris* pv. *musacearum* (Xcm), which is very destructive and spreading rapidly throughout Uganda. The apparent rapidity of pathogen spread in Eastern Africa, and concomitant increase in inocula load in regional locations, poses the threat of an epidemic outbreak and demands urgent measures.

Bacterial diseases are difficult to control. Chemical control appears to be impossible, although several antibiotics have been tried. Using antibiotics also presents the possibility of antibiotic-resistant bacterial strains arising. Resistant varieties, when they are available, are favoured by commercial growers and farmers. Resistance has been the best and most cost-effective method of managing bacterial diseases. However, attempts to develop bacterial disease-resistant varieties through conventional breeding have resulted in only limited success, as little existing genetic diversity shows resistance to Xcm and because new races of the pathogen continue to appear. Even if resistant germplasm sources are identified, a conventional breeding cycle for improved banana germplasm development may be expected to take 6-20 years. Therefore, use of genetic transformation technologies, may provide a timely and cost-effective measure to address the spread of this disease.

Molecular biological studies have revealed several new options for the management of bacterial diseases. One approach to control bacterial disease is to improve a plant's defence against a particular pathogen. Plant defence genes and naturally-occurring anti-microbial proteins in insects, plants, animals, and humans are a potential source of plant resistance.

Anti-bacterial proteins from insects, bacteriophages, animals and plants can be transferred to plants to confer resistance to bacterial pathogens. Several reports of success have been published recently. The important criteria for exploiting this technology are the stable expression of transgenes, absence of toxicity and low environmental impact.

Pathosystem-specific plant resistance (R) genes have been cloned from several plant species. Several R genes, against many different pathogens, have now been cloned from a variety of plants. The majority of R proteins contain tandem leucine-rich repeats (LRRs): the NB-LRR contain a nucleotide-binding site, the eLRR protein family consists of extra cytoplasmic leucine-rich repeats or LRR-kinase consist of an eLRR fused to a cytoplasmic serine-threonine kinase domain. Successful transfer of resistance genes to heterogenous plant species gives another new option to develop disease resistant plants. R gene-mediated resistance has several attractive features for disease control. When induced in a timely manner, the concerted responses can efficiently halt pathogen growth with minimal collateral damage to the plant. No input is required from the farmer and there are no adverse environmental effects. Unfortunately, R genes are often quickly defeated by co-evolving pathogens. Many R genes recognize only a limited number of pathogen strains and therefore do not provide broad-spectrum resistance. Also efforts to transfer R genes from model species to crops, or between distantly related crops, could be hampered due to restricted taxonomic functionality.

Plants employ a wide array of defense mechanisms against pathogen attack. Among those, hypersensitive response (HR) is an induced resistance mechanism, characterized by rapid, localized cell death upon their encounter with a microbial pathogen. Several defence genes have been shown to enhance the hypersensitive response induced by bacterial pathogens in non-host plants through the release of the proteinaceous elicitor. Elicitor-induced resistance is not specific to particular pathogens. Hence, manipulation of such defence genes may be more ideal. The two genes *pflp* and *hrap*, isolated from sweet pepper, can be used as potential candidates to protect bananas against this pathogen as these transgenes are effective against many pathogens including *Xanthomonas* species. We are trying to procure these genes from *Academia Sinica*, Taipei, Taiwan.

The introduction of transgenes into the desired plant species for the development of stable transgenic plants requires an efficient regeneration system amenable to genetic transformation and the stability of transgenes under field conditions. To date, there is no report of genetic transformation of EAHBs. Therefore we are first trying to optimize the protocol for genetic transformation of EAHBs using the shoot tips.

The shoot tips isolated from *in vitro* grown shoots were used for micro-projectile bombardment with the binary vector, pCAMBIA 1201 with the hygromycin resistance gene as a selection marker and GUS-INT as a reporter gene. Transient expression of β -glucuronidase (*uid A*) gene was achieved in transformed apical

shoot tip. The explants were transferred to the selection medium and some putative transgenic shoots were regenerated. The stable GUS assay was performed using the leaf segments and blue colouration was observed confirming the expression of the transgene in the shoots. Further genetic analyses have to be performed to confirm the integration of the transgene in the plant genome.

**New field planted
6 months after sick
plants were removed.**
Photo G. Blomme, INIBAP

FIELD MANAGEMENT, PUBLIC AWARENESS AND STATUTORY CONTROLS



Control of trans-boundary pests and diseases

by P. Kenmore

Many plant diseases and pests have emerged in the last millennium. The major drivers are pathogen pollution, agricultural change, evolution and weather. Pest and disease introduction (pathogen pollution) is caused by movement of pathogens by people and traded goods. Pests and diseases commonly emerge after agricultural change through intensification, diversification, or globalization. In other cases pest and disease epidemics may be the product of evolution through increased genetic interactions, recombination or selection. Weather changes may also lead to the emergence of pests and diseases.

Introduction is responsible for most plant pest and disease problems. Other important drivers are weather change, changes in farming technologies, changes in vector populations, recombination and habitat disturbances (Table 1).

Table 1. Factors driving the emergence of plant pests and diseases.

Factor	% Contribution to pest & disease problems
Introductions	56
Weather	25
Farming techniques	9
Change in vector populations	7
Recombination	2
Habitat disturbances	1

From Anderson *et al.* 2004

The major pathogenic taxa are viruses, fungi, bacteria, phytoplasma and nematodes (Table 2). Viruses contribute, by far, the largest proportion of pest and disease problems, followed by fungi and bacteria. This provides some reflection as to the priority areas where research and development effort is most needed.

Table 2. Major pathogenic taxa and their contribution to emerging pest and disease problems.

Pathogen group	% Contribution to pest and disease problems
Viruses	46
Fungi	30
Bacteria	16
Phytoplasma	4
Nematodes	1
Unknown	2

From Anderson *et al.* 2004

Several pathogens have emerged and re-emerged. Cassava mosaic, Mealy bug and Green mite emerged out of genetic recombination, invasion and resurgence. Bacterial wilt on onset and banana may be the result of epidemic waves within ecological zones determined by varieties and vectors. Many problems cross boundaries; for instance Soybean rust from Asia to Africa, North America and Latin America; Mango fruit fly from Asia to East Africa and the rest of Africa. These problems can no longer be eradicated.

Many emerging pest and disease problems have an impact on efforts towards the Millennium Development Goals (MDG). BXW affects households' capacity to subsist and will increase hunger (MDG 1). The Mango fruit flies affect international mango market affecting fair trade access to markets (impacting on MDG 8). The Desert locusts cause political threats thereby affecting countries' capacity for national good governance.

Community approaches used in managing BXW in Uganda

by C. Nankinga and O. Okasaai

At the onset of the BXW epidemic in Uganda, the government adopted an eradication strategy and hired labour to cut down plantations and dig deep pits to bury infected materials. Both human and financial resources were quickly overstretched as more districts reported the disease. It was thus realized that mobilizing farmers and communities would be essential to augment the research and extension services' efforts. Hence Uganda's strategy to address the outbreak of BXW focused on equipping people with knowledge and tools to manage, control and ultimately eradicate BXW (*National action plan Output 4: Appropriate technologies and information utilized to contain and control BXW*).

Specifically, the strategy involves analyzing the BXW situation, creating awareness/sensitization at all levels along the production-consumption continuum (national to village), effecting control measures that contain and eliminate the disease, and monitoring and evaluating impact. The strategy is based on multi-stakeholder, multi-sector and multi-disciplinary approaches bringing into play national, regional and international organizations to exchange information and technologies in the quest of identifying lasting solutions to the BXW epidemic in Uganda. In this respect BXW Task Force, Steering and Technical Committees as well as working groups were formed with the membership of MAAIF, NARO, DANIDA's Agricultural Sector Programme Support, National Agricultural Advisory Services (NAADS), Global Plant Clinic (GPC), Agricultural Productivity Enhancement Programme (APEP), Ecotrust, IITA and INIBAP. In addition, BXW control activities have been integrated into on-going banana research programmes at NARO, NAADS, MAAIF, a number of NGOs, CGIAR centres (IPGRI-INIBAP, IITA) the Pest Knowledge Partnership (GPC/MAAIF), a number of research projects (e.g. the IPM-CPP-DFID-NARO), as well as research networks (Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and Banana Research Network for Eastern and Southern Africa (BARNESA)).

Approaches adopted

Training and raising public awareness

To date, 198 agricultural officers from 22 districts have participated in a training-of-trainers and these in turn have trained grass-root organizations such as farmers' associations, extension workers and NGOs (Uganda Farmers association, World Vision, KULIKA Charitable Trust, VEDCO, CARITUS etc.). Course materials were developed in workshops and tested with farmers. In addition an intensive publicity campaign has taken place through radio, TV, newspapers and posters (on symptoms and control). In all, 40 000 posters were distributed to 32 affected and 'frontline' districts; 12 radio programmes on local FM stations were run; 67 000 brochures were produced and distributed to service providers; newspaper pull-outs were distributed in five local newspapers; and TV programmes in six major spoken languages and documentaries were aired.

In order to reinforce the message, a public awareness approach, "going public", was borrowed from the HIV-AIDS campaigns to reach markets, social functions, churches, mosques, school speech days and public transport systems.

Participatory development communication (PDC)

Farming communities were directly targeted using a participatory development communication (PDC) approach. This approach involves members of the community to take part in problem identification and analysis, and enables the community to analyse and explore alternative solutions to the problem and to identify the best solutions which they are ready to implement. PDC helps to know why some members in the community don't implement some control measures and to identify the constraints that they face in implementing control measures. Using community knowledge, researchers are able to develop technologies more effectively. The model was tested in three BXW-affected zones and stakeholder planning workshops took place involving district agricultural extension staff, sub-county agricultural extension staff, political leaders (Local Council level 1-3); educational institutions, schools, cultural and religious leaders, NGOs, CBOs and farmers.

The workshop participants identified and prioritized banana-related community needs and constraints and agreed on technologies to address them. Through PDC, interactive discussions identified IPM and BXW problems (pests, diseases, soil fertility, banana cultivars, etc.), and agreed solutions, including field demonstrations to show BXW symptoms, transmission and control measures. Subsequently, the information acquired was used to develop

community BXW action plans to be executed by task forces at various community levels.

In the execution of PDC, a number of challenges emerged. Participants had diverse perceptions about the cause of BXW (including deliberate introduction by scientists, exotic bananas, tissue culture plants, degraded soils, the Mulinga tree, use of molasses in banana systems, etc.). They also discussed reasons why some people in the communities did not implement the recommended control measures. The reasons given included ineffective measures, labour intensive measures, laziness, lack of effective alternatives, costly disinfectants, miscommunication from neighbours, researchers wanting to stamp out traditional technologies, negative attitudes towards technologies, contradictory messages, and fear that new cultivars might degrade the soil.

The PDC's interactive approach enabled farmers, who were ignorant of basic crop management and IPM practices, to take advantage of the extensive experience of other farmers. Community leaders, having been made fully aware of the threat, pledged to support the effort to fight the disease, and it was recognised that the responsibility for the BXW problem has to be shared by the whole community.

Community organizational framework

In Uganda, the community task forces, consisting of at least four people, mobilized individual communities in partnership with parish and village councils, trained people on BXW, directed the development and implementation of community actions plans, and monitored and communicated progress to the task force at the next community level. The task force was also responsible for the establishment of demonstration plots and maintaining networks with other partners in control of BXW (agric-extension, NGOs, NARO, MAAIF and others).

Training videos in different languages were used to disseminate information on BXW symptoms, transmission and control, PDC methods, the sensitization process and success stories of BXW control in model districts. Fact sheets on BXW symptoms, transmission and control; guidelines for formation of BXW task forces in the community; posters and brochures on BXW; and banana production manuals were also disseminated.

The experiences gained from the initial PDC model in the pioneer areas were used to scale out activities to other areas. The original model was slightly modified in order to gain more political backing and funding support, by targeting the chief Administrative Officer and the Local Council chair person at the highest level in the district rather than the District Agricultural Extension (DAE).

Results of PDC effort

There has been widespread adoption of PDC approach in most banana growing districts of Uganda and communities have undertaken a number of actions as given below:

- PDC outputs have been used by the BXW field working group on control to sensitize district officials in more than 10 districts in 'frontline' and unaffected areas
- Using the PDC process and communication tools, district, sub-county, parish and village taskforces have been formed in some districts (Mpigi, Kibale, Bushenyi, Hoima, Masindi, Kabarole, Mubende and Kyenjojo)
- District BXW task forces have been formed and action plans for disease control have been developed and activities prioritized
- Most district officials are aware of the disease and they are doing 'all that is within their means' to sensitize people on BXW
- Quarantine has been established in some district BXW task forces (e.g. Kabalore, Hoima, Kyenjojo), prohibiting movement of banana plant parts
- Awareness campaigns are aired on local radio involving other stakeholders and members on the district Task Force (e.g. Kabalore, Hioma, Mubende)
- CBOs have supported BXW sensitization (e.g. Kyabigambire Vanilla and Horticultural Association in Hioma)
- Local radio stations such as Voice of Toro, Radio West, Radio Hioma, Radio Kagadi and Sky Net are being used to sensitise Local communities
- NGOs are currently using the PDC videos to sensitise communities (World Vision in Mpigi, Kiboga; VEDCO and Plan International in Luwero; AMREF in Mubende; Kulika in Kyenjojo; NAADS in Kabarole and Hioma and Kyawada in Kibaale)
- Bulindi NARO-Agricultural Research Development Center (ARDC) provided improved cassava as an incentive and encouragement to BXW affected farmers to destroy affected plantations in Hoima district
- Some community leaders are taking the lead in cutting and destroying infected banana plantations and planting alternative crops
- Demonstrations on early de-budding are being established on farmers' fields. Some communities have tried to copy this practice.

Challenges at farming community level

- By-laws need to be enacted urgently to reinforce community action on BXW
- BXW training and sensitization communication tools, such as posters, brochures, facts sheets and videos, need to be disseminated at the village level

- Communities need a quick cure for BXW
- Communities want government to provide alternative crops and clean banana planting materials for people who have cut down BXW-affected gardens
- Community action in destroying infected plants is still limited in Kayinja beer banana systems
- Removal of male buds as preventive measures for BXW is an uphill task in some communities
- BXW task forces need reinforcement in some districts from political leadership at national, district, sub-county and community levels
- Integration of BXW control activities into general IPM strategies at district and lower community levels is still slow
- Lack of funding in many districts has delayed the progress of some BXW activities at lower district community levels
- Follow up and feedback on BXW community action needs strengthening.

Prospects for management of BXW through Farmer Field School approaches

by J. Okoth

In the endemic region of BXW, farming communities need approaches that help them cope with the disease and manage its impact within an IPM framework so that economic losses are minimized. Farmers need to have a strategy for learning and integrating their knowledge into their day-to-day crop management routine. The Farmer Field School (FFS) framework provides an approach through which farmers can learn together through testing and demonstrating technologies on their farms.

The term “farmer field school” was derived from an Indonesian expression *Sekolah Lapangan* meaning “field school”. This approach was initiated in the Far East in 1989. FFS is a community-based and practical-oriented field study process involving groups of farmers under the guidance of a facilitator. It provides a forum where farmers are able to make regular field observations that they relate to the ecosystem and apply experience before making a crop management decision.

A typical FFS contains up to 20 – 30 participants with a minimum group of five participants. They hold regular meetings, sometimes frequency depends on the nature of the problem being addressed. The grouping may be dynamic, receiving training for a season or even for long-term training. Basically the study takes place in the field with the field conditions defining most of the curriculum. The field problems are observed and analysed chronologically from planting to post harvest.

Objectives of Farmer Field School Programmes

- Empower farmers to make logical crop management decisions and implement own solutions
- Expose farmers to new ways of thinking and problem solving
- Shorten the time between research stations to adoption in farmers' fields by involving farmers in experimentation of their own ideas
- Enhance interaction between farmers and extension/research service agents
- Facilitate the building of coherent farmer groups able to demand for services relevant to them.

Fundamental elements of FFS

The FFS is farmer centred but must have a competent facilitator who ensures that agreed principles are scientifically viable with respect to the problem being faced by the communities, and that there is systematic training, critical observation, discussions and action plans made. The FFS curriculum will depend on the natural cycle of the subject, usually the crop cycle.

The cornerstone of the FFS model is dynamic, hands-on farmer training, leaning on innovative, participatory and discovery-learning processes; agro-ecosystem analysis (AESAs) to empower farmers to acquire an understanding of the field ecology and integrated crop management and participatory technology development and testing.

As a principle, the curriculum is based on a holistic community gap analysis, whereby issues are prioritized, entry points identified and resource needs established (human, material and financial). The curriculum may be developed for a season or a year and may be included as a subsidiary of a larger curriculum if necessary.

Organizational strengths

FFS is a model for enhancing cohesion, networking, cost reduction and diffusion of innovations within the groups of the community that depend on and exploit community initiatives. The approach encourages and may lead to group bank accounts. Some successful FFS systems grants have been transformed into revolving funds.

Opportunities

There are currently new reforms in the agricultural sector that are aimed at empowering the communities where the FFS approach fits in very well. These include decentralization processes to empower communities; the increasing interest from local governments and NGOs in operating at grass-roots level. Moreover the people trained are always available in the region to provide critical institutional memory.

Challenges

The FFS as an innovation is not without challenges. In the first place the learning process hinges on the facilitator's skills and innovativeness. The strategy produces a limited number of cadres so the message is not spread around as fast as

it should. Moreover there is usually a slow attitudinal change in the communities from the conventional, top down approach to one that is bottom up, and the tendency is to deviate from the original core focus. In some cases, there is a conceptual confusion between FFS and on-farm research and the increasing tendency to refer to any on-farm work as FFS. In practice also there is a problem of sustaining the continuous attendance of the participants, and follow-up and sustainability questions are frequently raised by policy makers.

**Trial at SARI Awassa,
Ethiopia.**

Photo E.B. Karamura, INIBAP

GENERAL DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS



The following section of the report represents a summary of the discussions and the resulting conclusions and recommendations agreed at the workshop. These elements provided the basis for what is now a regional strategy for *Confronting the threat of Banana Xanthomonas wilt in East and Central Africa*, which is found on page 73.

BXW nomenclature

The use of “Banana bacterial wilt” (BBW) to refer to the specific disease in East Africa is confusing because it is a generic term, which includes other bacterial wilts such as Bugtok and Moko. “Banana *Xanthomonas* wilt” confers specificity to the causal organism and is a better alternative.

Research gaps

Participants agreed the need for an impact assessment to understand better the effects of the disease on both banana and enset production and producers’ livelihoods, and strategies adopted by farmers to cope with the situation. INIBAP is leading a multi-disciplinary impact assessment in Uganda with funding from UK Department for International Development (DFID) and IDRC, which will partly address these needs.

Reports from DR-Congo and Uganda imply that the BXW rate of spread is higher in Uganda than in DR-Congo. Additional research was thus recommended to ascertain rates of disease spread and the factors that drive the epidemic in order to understand these differences. The role of insects and other vectors, ambient conditions and altitude will require investigation.

Other knowledge gaps requiring further research include levels of cultivar resistance, infection pathways, and efficacy of male bud removal. Reports of leaf infection should also be investigated because de-budding would not be an appropriate control solution if infection passes through other plant parts than the flower. Cases of leaf infection may be caused by transmission from diseased mother plants or contaminated tools.

The need to isolate and characterize the bacterium was raised but DNA fingerprint studies by CAB International (CABI) of samples from DR-Congo, Ethiopia and Uganda confirm that the strains are similar.

The costs and benefits of using rotation as a BXW management tool should be elaborated. More research is needed to identify which crops should be

involved so that they neither compete with each other for nutrients nor share the same pests and diseases.

The workshop further discussed the medium-long term solutions, including the use of tolerant/resistant genotypes as well as escapees in a systems management approach that looks at host-vector-pathogen relationship. The variety Pelipita is reported to escape Moko infection probably due to its persistent, neuter flowers and bracts. The variety, however, can still be infected artificially by contaminated implements. The need to identify escapee genotypes for possible multiplication and distribution to farmers on one hand and the urgency to collect and conserve threatened genotypes, on the other was underlined.

It was noted from the presentations that selective media for isolating Xcm is yet to be discovered and that isolation is still a major problem. Participants suggested that studies should be conducted as a matter of urgency to screen isolation media and identify the one(s) that is/are selective to Xcm.

Some new findings have important implications for disease management strategies: Xcm is known to survive between 3 and 4 days on dry and moist surfaces, respectively, under laboratory conditions. Further information is available in various research centres but has not been published, emphasizing the need for better communication.

Extension and agricultural advisory services

Participants noted that extension workers have been successful in informing farmers about the disease problem. However, whole communities are still not being reached and the approaches currently used do not necessarily exploit multiplier effects. Participants suggested that central Government mechanisms might be better involved. In Uganda, the President's office has a banana programme, which should be involved and may assist in public awareness campaigns.

Participants discussed and agreed that the Participatory Development Communication and Farmer Field Schools (FFS) methodologies should be integrated. Experiences in FFS can be borrowed and adapted for BXW control. For areas as yet unaffected by the disease, existing FFS should be used as entry points to introduce BXW as special topic. Where BXW is already in place, FFS should be established and curriculum for BXW developed. FFS should be established in Tanzania ahead of the disease front. There are also FFS focusing on cassava in DR-Congo, which can be adapted for use in the BXW-affected areas.

Disease diagnostics

CABI volunteered to provide diagnostics services for BXW for affected countries. Affected countries are advised to get in touch with CABI (Julian Smith) to get information on how samples should be collected and sent to UK for identification.

Participants also discussed the use of surveillance vis-à-vis formal surveys to monitor the disease spread. It was argued that continuous surveillance carried out by local grass-root platforms (markets, faith-based fora, village and local council meetings, etc.) when combined with an efficient communication system (radio, mobiles and telephones, etc) would be more cost-effective than formal surveys conducted by research scientists. Continuous surveillance also has the advantage of picking up new disease incursions. Whereas it is possible that the disease might occur in an area just two weeks after a formal survey has been undertaken.

Conclusions and recommendations

A. Conclusions of the workshop discussions

1. BXW is an emerging epidemic in the East and Central African region and clear steps need to be taken to manage its spread. The disease has now been reported in three countries: in Ethiopia on enset, and in Uganda and DR-Congo on banana. The disease is likely to spread to bordering countries if left uncontrolled
2. In light of the number of banana bacterial wilt diseases known worldwide, such as Moko disease, Blood disease and others, for nomenclature purposes, banana bacterial wilt caused by *Xanthomonas campestris* pv. *musacearum* (Xcm) should be called Banana *Xanthomonas* wilt (BXW)
3. Current management practices for BXW are largely based on experiences to deal with Moko and Bugtok diseases in Asia
4. There are still research gaps relating to BXW, including study of its transmission
5. A lot of information exists at various research centres (e.g. in Ethiopia) that is not yet published. INIBAP was urged to facilitate access to such information
6. Xcm is known to survive 3 days on dry surfaces and 4 days on moist surfaces under laboratory conditions
7. Isolation of the BXW causal pathogen using selective media is still difficult. Further isolation media need to be developed
8. Farmer Field Schools, together with other methods, such as Participatory Development Communication, can be more effectively used as a channel to disseminate information and develop good practice for farmers in both endemic and disease free areas.

B. Recommendations

Research

Research should provide recommendations for management of the disease. Urgent and longer-term research strategies are needed to ensure that present

control tactics are based on sound science and practice and to generate new options for the future.

The following areas need urgent research attention:

1. Reports from DR-Congo and Uganda imply that the rate of BXW spread is higher in Uganda than in DR-Congo. Additional research is thus recommended to ascertain the factors that influence rates of disease spread
2. Further exploration is needed of the infection pathways, including determining the surfaces where inoculum is produced, the vectors involved, mode of transmission, and the infection courts, as well as the influence of altitude. Reports of leaf infection should also be investigated because de-budding would not be an appropriate control solution if infection passes through other plant parts than the flower
3. The systemicity of the infection (flowers to roots or suckers to mother flower) needs to be determined and the efficacy of male bud removal confirmed
4. There is need to undertake BXW impact studies in East and Central Africa on banana and enset to understand farmers' coping strategies so that policy- and decision-makers can be fully informed and strategies for managing trans-boundary pests and diseases are based on sound information
5. There is a need to undertake studies to confirm the causal pathogen in all areas where the disease has been observed.

Extension

Extension efforts should involve participatory approaches to ensure that farmers gain full ownership of disease management strategies. The following areas should be addressed to support extension:

1. Unpublished information on all aspects of BXW management should be made available to all stakeholders as soon as possible
2. De-budding and field sanitation should be reinforced by:
 - a. statutory measures at national and local levels (quarantine regulations and bye-laws) for enforced containment and control tactics;
 - b. awareness raising efforts at international, regional, national and local levels, directed towards decision-makers and the general public, in order to mobilize resources and assure support and ownership for the control campaign;
 - c. improved 'seed' systems for supplying clean, high-quality planting material; and
 - d. improved agronomic practices to increase productivity and sustainability, combined with the dissemination of diversified utilization options for new and existing varieties to improve livelihoods.

3. Banana varieties that are acceptable to farmers and consumers but less susceptible to infection (e.g. those with floral morphology not conducive to infection) should be evaluated and introduced
4. Steps should be taken to ensure that alternative ways are explored to manage highly susceptible cultivars
5. Mechanisms should be put in place for shared planning, information exchange and coordination at the national and regional level to ensure the most cost-effective use of resources.

Coordination

The strategy to address BXW in East and Central Africa is envisioned to have applications at both the national and regional levels. At the national level the meeting recommended the following actions to be urgently undertaken:

- Strengthening and coordinating national networks (farmer-extension-research systems)
- Intensifying surveillance in frontline regions of Kenya, Tanzania, Rwanda, Burundi, and unaffected areas of Uganda and DR-Congo
- Conducting surveys in endemic regions of DR-Congo, Uganda, and Ethiopia;
- Mounting awareness campaigns
- Strengthening capacity of stakeholders
- Forming and empowering national task forces to coordinate activities and link into the regional task force
- Mobilizing resources.

At the regional level, the meeting recommended that efforts should focus on those actions that add value to what national organizations are already doing and to promote synergy, pool knowledge and optimize use of resources by:

- Programming regional activities
- Coordinating monitoring and evaluation efforts, specifically:
 - monitoring NARS activities in a timely manner;
 - budget monitoring - to assure compliance with agreed budgets.
- Tracking impact to inform policy processes
- Capacity building and back-stopping
- Clearing research proposals
- Networking:
 - regional meetings/workshops;
 - establishing and running a Web portal.
- Soliciting funds
- Promoting input from external partners.

The two coordination levels will be linked by having the chairpersons of national taskforces form a regional taskforce, within the framework of BARNESA, with a regional coordinator selected from among the members of the regional taskforce or from the BARNESA team.

Control of further spread and effective management or rehabilitation of existing plantings, urgently require the generation of new knowledge and validation of new technologies by researchers and farmers working closely together. An effective response will also depend on large numbers of farmers, over a vast area, changing their perceptions of the disease and adopting significant changes in their crop management practices. The resources currently available for both research and outreach are totally inadequate to address a problem of such magnitude. The scale of the present problem is daunting and the seriousness of the threat to livelihoods is alarming. National governments and donors are invited to invest in the proposed framework as offering the best strategy for containing the spread of the disease, mitigating its immediate effects on livelihoods and eventually restoring the productivity and sustainability of banana-based production systems.

CONFRONTING THE THREAT OF BANANA *XANTHOMONAS* WILT IN EAST AND CENTRAL AFRICA

A regional strategy



Background

Xanthomonas wilt was long-known as a disease affecting enset in Ethiopia and only appeared in Uganda in 2001 and soon after in DR-Congo. Disease incidence has reached levels of 70-80% within the space of a year in Uganda and yield losses of 100% are recorded for many juice banana (Kayinja = Pisang awak). It has been estimated that, by 2010, losses of up to US\$ 4 billion will be incurred by the banana industry for Uganda alone if no action is taken to rectify the situation.

INIBAP/BARNESA Strategy

Since the report of the disease outbreak in Uganda in 2001, the BARNESA Steering Committee has rated BXW as a top R4D priority and has taken steps to coordinate regional efforts aimed at alleviating the impact of the disease on the livelihoods of the affected communities. In this regard, INIBAP-BARNESA has coordinated a multi-institutional, multi-stakeholder study (funded by the DFID-UK and IDRC-Canada) to assess the impact of BXW on the livelihoods of communities along the production-consumption pipeline, and to understand how the communities are coping with the disease. In addition, INIBAP in collaboration with the FAO is convening a number of regional and international meetings to develop plans for addressing the problem.

This strategy was developed from the recommendations of a regional workshop held in February 2005. It envisages the involvement of international, regional, national and local level actors and interventions to coordinate and bring synergy into research and extension efforts and to support farmers and communities in 'people-focused' activities. Furthermore the strategy underpins the importance of integrating gender, poverty and environmental conservation considerations (ref. Millennium Development Goals).

In the short-term, the strategy aims to generate and disseminate robust diagnostic tools that facilitate disease recognition, management and control. In addition it envisions a programme for spatial surveillance to monitor what is happening where in the region and a regularly-updated portal for information sharing. At all levels of the production-consumption chain, capacity must be strengthened. All activities will need to be coordinated and monitored to ensure that corrective measures are taken in time.

In the medium term, a regional impact tracking mechanism that regularly generates and packages information products for policy makers will be put in place and integrated into the overall regional strategy for integrated pest and disease management. Regional policy dialogue should be strengthened to allow the coordi-

nation and management of transboundary epidemics to food security and household incomes. In the long term, a systems approach should be adopted to boost the health of farming systems, taking full account of genetic diversity, the resource base and biotic stresses. Grass-roots ownership and sustainability should be ensured by deploying a livelihoods approach to improve prospects for marketing bananas and banana products. Indigenous germplasm threatened by the disease must also be effectively conserved in perpetuity to ensure that farmers can replant traditional genotypes once the effects of the epidemic have lessened.

Goal: To ensure the security of food supplies and household incomes in banana-based systems in East and Central Africa

Purpose: To strengthen the capacity of the banana sub-sector to successfully manage the outbreak of Banana *Xanthomonas* wilt

Activities (see also Table 1):

1. Ahead of advancing epidemic

This includes Burundi, Kenya and unaffected regions of DR-Congo, Rwanda and Tanzania.

- a. Establish surveillance and reporting networks
- b. Facilitate the establishment of statutory measures to contain movement of diseased material
- c. Raise awareness of threat among:
 - decision-makers
 - farmers
 - general public
- d. Mount de-budding campaigns
- e. Strengthen capacity of stakeholders
- f. Mobilize resources and initiate research to understand systems.

Estimated budget: to cover Burundi and Kenya and also parts of Uganda, DR-Congo, Rwanda and Tanzania, not yet attacked by the wilt.

2. At the frontline of the epidemic

Parts of Uganda not yet affected; parts of Western Province of Rwanda, parts of Kagera region of Tanzania and parts of North Kivu province of DR-Congo:

- a. Continue sensitization of decision-makers and general public
- b. Motivate and empower stakeholders to:
 - remove male flower buds to interrupt transmission;
 - remove infested plants to reduce contamination between plants and fields.
- c. Strengthen capacity for research and extension support
- d. Adapt and disseminate diagnostic tools
- e. Develop and disseminate appropriate communication packages
- f. Mount and intensify exclusion strategies.

Estimated budget: to cover Uganda, Rwanda, Tanzania and DR-Congo.

3. In the endemic areas

Most of Uganda, Gisenyi province of Rwanda, Masisi region of North Kivu in DR-Congo and the lake shores of Bukoba district of Tanzania:

- a. Strengthen the ownership of the BXW problem by stakeholders:
 - provide management information and tools;
 - strengthen farmer-extension-research linkages;
 - establish FFS and facilitate community learning and action programmes;
 - establish an information portal and a monitor and feed-back system.
- b. Initiate farmer participatory research activities:
 - demonstrate the effectiveness of de-budding;
 - demonstrate the effectiveness of crop hygiene (destruction of infected plant material and use of clean implements);
 - integrate BXW activities into systems health management approaches to contain sporadic epidemics.

Estimated budget: to cover one endemic site in Uganda, Rwanda, DR-Congo and Tanzania.

4. For banana-based systems (medium- to- long term)

- a. Develop and evaluate new varieties
- b. Understand pathogen-vector-crop host systems and associated pathogen survival behaviour.

Estimated budget: to cover two PhD students (1 breeder and 1 pathologist).

5. Coordination at national and regional level (very urgent)

At the national level, coordination is targeting resource (human and financial) mobilization by disseminating and sharing information and developing and imple-

menting national action plans owned by all the stakeholders along the production – consumption pipeline, including policy makers at the local and national levels.

1. Strengthen and coordinate national networks (farmer-extension-research systems)
2. Intensify surveillance in frontline regions (Kenya, Burundi)
3. Coordinate surveys in endemic regions (DR Congo, Uganda, Tanzania, Rwanda)
4. Design and organize awareness campaigns
5. Strengthen capacity of stakeholders
6. Facilitate the formation of national task forces to coordinate activities and link into regional task force
7. Mobilize resources
8. Facilitate the development and implementation of action plans

Coordination at regional level is aimed at promoting synergy, pooling knowledge and optimizing use of resources so that actions in one country are re-enforced by the other countries in the network.

1. Programme regional activities and institute impact-tracking linked to monitoring & evaluation activities
 - a. Monitoring NARS activities – (in a timely manner)
 - b. Budget monitoring – to assure compliance with agreed budgets
2. Initiate national and regional policy dialogue to strengthen trans-boundary pests and disease
3. Capacity building for and back-stopping national technical and management planning
4. Provide peer review support for research proposals
5. Networking
 - a. Regional meetings/workshops
 - a. Establishing and running an internet portal
6. Solicit funds
7. Promote input from external partners, including other INIBAP regions in Asia and Latin America with similar diseases.

Estimated budget: staff time and administrative costs

Implementation strategy

Activities will be implemented and coordinated by national and regional task forces in the framework of BARNESA (Annex 2).

Table 1. Activities for Banana *Xanthomonas* wilt disease management in East and Central Africa.

Mobilize communities in advance of the disease to prepare for pending outbreak	At advancing disease front, equip communities to respond to epidemic	In endemic areas, equip communities to sustain banana production	Response to BXW effectively coordinated
Raising awareness among decision-makers to mobilize resources	Creating an enabling policy environment for national level action (advocacy-awareness)	Policy dialogue continued to sustain resource commitment at national level	Establishing national and regional Coordinating Committees or Working Groups
Raising awareness of actions needed and training of actors	Facilitating policy dialogue at local level (advocacy and awareness raising) for local level action	Policy dialogue continued to sustain resource commitment at local level	Monitoring & evaluation and assessing impact - tools developed, disseminated, harmonized at regional level
Raising general public's awareness of threat and solutions	Strengthening knowledge base on aetiology and epidemiology (infections pathways, dynamics, survival, etc.)	Understanding susceptibility and developing screening methods Strengthen community learning and action programmes Demonstrate the effectiveness of crop hygiene and of de-budding	Monitoring & evaluating and assessing impact: - implemented at national and regional level

<p>Establishing an early warning/surveillance system - stakeholders and actors identified and trained</p>	<p>Evaluating options for introducing alternative varieties (escaping infection) acceptable to farmers and consumers</p>	<p>Breeding resistant varieties identifying promising lines, making crosses, selecting and evaluating promising lines</p>	<p>Information portal established - database, GIS tools, ICT capacity building, and linkages for information exchange strengthened</p>
<p>Diagnostic tests developed (incl. e.g. assessment of variability) and deployed</p>	<p>Validating options for slowing transmission (e.g. de-budding, sanitation, disinfection)</p>	<p>Engineering new varieties: - identify genes, transfer protocols, evaluate lines (incl. biosafety)</p>	<p>Policy dialogue initiated at regional and international level</p>
<p>Information materials developed and disseminated</p>	<p>Developing systems for introducing and disseminating clean 'seed' of new varieties</p>	<p>Evaluating and disseminating new varieties (incl. strengthening of processing-marketing chains)</p>	
<p>Information on BXW mainstreamed in extension curricula</p>	<p>Promoting 'best bet' options for slowing epidemic spread and coping with outbreak in extension campaign</p>	<p>BXW management strategies (incl. new varieties) refined and validated through participatory research</p>	
	<p>Validating and deploying best bet options for slowing epidemic spread and coping with outbreak in FFS</p>	<p>BXW management tactics 'mainstreamed' with other IPM and natural resource management options in FFS and other extension efforts</p>	

References

- Archido J.Q. and T. Mesfin 1996. Disease of enset. Pp. 188-203 *in* Proceedings of the first international workshop of enset.
- Ashagari D. 1985. Studies on bacterial wilt of enset, *E. ventricosum* and prospects for its control. Ethiopian J. Agric. Sci. 1: 1–14.
- Bosch C.H., A. Lorkeers, M.R. Ndile, S.R.B Mgenzi and E. Sentozi. 1996. Diagnostic study: Constraints to banana productivity in Bukoba and Muleba districts, Kagera region, Tanzania. Working paper No. 8, Lake Zone Farming Systems Research Project. Maruku Agricultural Research Institute, Bukoba, Tanzania.
- Dagnachew Y. and J.F. Bradbury. 1968. Bacterial wilt of enset (*Ensete ventricosum* L.) incited by *Xanthomonas musacearum* sp. Phytopathology 59:111-11.
- Dagnachew Y. and J.F. Bradbury. 1974. A note on wilt of banana caused by enset wilt *Xanthomonas musacearum*. East African Agriculture and forest Journal 40:111-114.
- Djatnika I. 2003. Current status of banana R&D in Indonesia. Pp. 93-98 *in* Advancing banana and plantain R&D in Asia and the Pacific, Vol. 11 (A.B. Molina *et al.*, eds). INIBAP, Los Baños, Laguna, Philippines.
- Eshetu W.A. 1982. The role of *Poecilocardia nigrinervis*, *Pentalonia nigronervosa* and *Planococcus ficus* in the transmission of enset wilt pathogen *Xanthomonas musacearum* sp. in Wolayta, Ethiopia. Msc. Thesis, Addis Ababa University.
- Gizachew W/M. 2000. Annual report of the plant pathologist, ARC.
- Karamura D.A. 1999. Numerical taxonomic studies of the East African Highland Bananas (*Musa* AAA-East Africa) in Uganda. INIBAP. 192pp.
- Lassoudière A. 1989. Enquête diagnostique sur la culture bananière en préfecture de Kibungo. Vol. 1. ISAR-IRFA-CIRAD.
- Mgenzi S.R.B, R.A. Mohamed, E. Chambuya and S.I. Mkulila. 2004. Report on farmers training on banana bacteria disease in Kagera region, Tanzania.
- Million T., B. Kidist and W/M. Gizachew. 2003. Enset Bacterial Wilt sanitary control in Gurage zone. Research Report No. 53. EARO. SNNPRS- ARI, Awassa. 23pp.
- MINECOFIN 2004. Agricultural production decline in Rwanda. Ministry of Economics, Finances and Economic Planning. Kigali, Rwanda.
- Mohamed R.A and S.R.B. Mgenzi. 2004. Report on the survey of banana diseases in Kagera region, Tanzania.

- Molina G.C. 1996. Integrated management of "Tibaglon", a bacterial fruit rot disease of cooking bananas. *Philippine Phytopathology* 32:2 83-91.
- Okech S.H.O., S.V. Gaidashova, C.S. Gold, I. Nyagahungu and J.T. Musumbu. 2004. The influence of socio-economic and marketing factors on banana production in Rwanda: Results from a Participatory Rural Appraisal. *International Journal of Sustainable Ecology and World Development (in press)*.
- Opina O.S., A.B. Molina and G.C. Molina. 1999. Improved management system for Saba Banana. Project Report to PCARRD, Los Baños, Philippines.
- Rajab K.A, S.S. Salim and P.R. Speijer. 1999. Plant-parasitic nematodes associated with *Musa* in Zanzibar. *African Plant Protection* 5(2):105-110
- Seifu G.M. 1999. Banana production and utilization in Ethiopia. Research Report No. 35.
- Thwaites R., S.J. Eden-Green and R. Black. 2000. Diseases caused by bacteria. Pp 213-239 *in* Diseases of Banana, Abaca, and Enset (D. Jones, ed.). CABI Publishing, CAB International, UK.

Further reading

- Adhnom N., A. Tsedeke and G. Emanu. 1986. Research on insect pests of root and tuber crops in Ethiopia. Pp. 423-31. *in*: proceedings of the first Ethiopian crop rotation symposium. 4-7 Feb. 1985, Addis Ababa. Ethiopia.
- Archido J.Q. 1992. Annual report of the plant pathologist: July 17, 1991 to July 16, 1992. Enset Team Support Project. Sidama Gamogofa Peasant Agricultural Development Program- PADEP-III. Awassa Research Center (IAR). Awassa, Ethiopia.
- Anon. 2003. CSCC, SNNPR: Statistical Report. Addis Ababa. Ethiopia.
- Anon. 2003. CSCC, FDRE: Statistical Report. Addis Ababa. Ethiopia.
- Dimiyati A., I. Djatnika, C. Hermanto, N. Nasir and A. Hasyim. 2001. Current research activities on banana disease and pests in Indonesia. Pp. 110-122 *in* Advancing banana and plantain R&D in Asia and the Pacific, Vol. 10 (A.B. Molina *et al.*, eds). INIBAP, Los Baños, Laguna, Philippines.
- Gizachew W/M. 2003. Progress report of the plant pathologist. Awassa Research Center. Awassa, Ethiopia.
- Hermanto C. and T. Setyawati. 2002. Distribution of banana bacterial wilt disease in Indonesia. Technical Paper Bulletin. Research Institute for Fruit. Solok, West Sumatra. Indonesia.

- MINECOFIN 2001. Rwanda Development Indicators, MINECOFIN, Kigali, Rwanda.
- Molina A.B. 1999. Fruit rot diseases of cooking banana in Southeast Asia. *InfoMusa* 8(1):29-30.
- Okech S.H., S.V. Gaidashova, C.S. Gold, C. Gatarayihya and P. Ragama. 2002. Banana pests and diseases in Rwanda: a Participatory Rural Appraisal and diagnostic survey observations *in* Proceedings of the IPM symposium held from 8 to 12 September 2002 in Kampala, NARO/ Makerere University, Uganda.
- Raymundo A, M. Orlino, W. Lavina and N.L. Opina. 1977. Comparative genome plasticity of tomato and banana strains of *R. solanacearum* in the Philippines. Project Report. PCARRD, Los Baños, Laguna, Philippines.
- Setyobudi L. and C. Hermanto. 2000. Rehabilitation of cooking banana farms: Baseline status of banana disease bacterium (BDB) distribution in Sumatra. Pp. 117-120 *in* Advancing banana and plantain R&D in Asia and the Pacific, Vol. 9 (A.B. Molina and V. Roa, eds). INIBAP, Los Baños, Laguna, Philippines.
- Soguilon C.E., L.V. Magnaye and M.P. Natural. 1994. Bugtok disease of cooking banana in the Philippines. *InfoMusa* 3(2):21-22.
- Tushemereirwe W, A. Kangire, J. Smith, M. Nakyanzi, D. Kataama and C. Musiitwa. 2001. An outbreak of banana bacterial wilt in Mukono district: a new and devastating disease. KARI Report, Uganda.

List of abbreviations

AFLP	amplified fragment-length polymorphism
APEP	Agricultural Productivity Enhancement Programme, Uganda
ARDI	Agricultural Research Development Institute, Tanzania
ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
ATDT	Agricultural Technology Development and Transfer Project, Rwanda
BARNESA	Banana Research Network for Eastern and Southern Africa, Uganda
BUBAPFA	Bushenyi Banana and Plantain Farmer's Association, Uganda
BXW	Banana <i>Xanthomonas</i> wilt
CABI	CAB International, UK
CBO	community based organization
CFC	Common Fund for Commodities, Netherlands
CGIAR	Consultative Group on International Agricultural Research
CIAT	<i>Centro Internacional de Agricultura Tropical</i> , Colombia
DFID	Department for International Development, UK
DGGE	denaturing gradient gel electrophoresis
DNA	deoxyribonucleic acid
EAHB	East African highland bananas
ELISA	enzyme-linked immuno sorbent assay
FABI	Forestry and Agriculture Biotechnology Institute, South Africa
FAO	United Nations Food and Agriculture Organization
FFS	Farmer Field Schools
FHIA	<i>Fundación Hondureña de Investigación Agrícola</i> , Honduras
GDP	Gross Domestic Product
GUS	beta-glucuronidase
GUS –INT	beta-glucuronidase gene with intron
HIV-AIDS	Human Immunodeficiency Virus- Acquired Immunodeficiency Syndrome

IAR4D	international agricultural research for development
IDRC	International Development Research Centre, Canada
IFRI	Indonesian Fruit Research Institute, Indonesia
IITA	International Institute for Tropical Agriculture, Nigeria
INIBAP	International Network for the Improvement of Bananas and Plantains, France
IPGRI	International Plant Genetic Resources Institute, Italy
ISAR	<i>Institut des Sciences Agronomiques du Rwanda</i>
KARI	Kawanda Agricultural Research Institute, Uganda
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Healthy Inspectorate Service
LRR	leucine-rich repeats
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries, Uganda
MAFS	Ministry of Agriculture and Food Security, Tanzania
MARDI	Maruku Agricultural Research Institute, Tanzania
MDG	Millennium Development Goals
MOA	Ministry of Agriculture, Kenya
MR-PFGE	macro restriction of genomic DNA resolved by pulse field gel electrophoresis
NAADS	National Agricultural Advisory Services, Uganda
NARO	National Agricultural Research Organization, Uganda
NB-LRR	nucleotide-binding site and leucine-rich repeats
NGOs	non-government organizations
PCR	polymerase chain reaction
PDC	Participatory Development Communication
PNG	Papua New Guinea
TRFLP	terminal restriction fragment length polymorphism
USAID	United States Agency for International Development
Xcm	<i>Xanthomonas campestris</i> pv. <i>musacearum</i>
YPGA	yeast extract, peptone, glucose, agar medium
YPSA	yeast extract, peptone, sucrose, agar medium

ANNEXES



Looking at BXW
symptoms, Democratic
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Photo G. Blomme, INIBAP

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