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STATUS OF BANANA BACTERIAL WILT IN UGANDA

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ABSTRACT

Banana bacterial wilt caused by *Xanthomonas campestris* pv. *Musacearum* (Xcm) was first reported in Ethiopia on *Ensete ventricosum* in 1968 and on bananas in 1974. A similar disease, confirmed to be caused by Xcm was then reported in Uganda in 2001 on bananas in Mukono and Kayunga. The disease (now locally called Kiwotoka) is very destructive and attacks most of the banana cultivars grown in Uganda. In 2005 it was estimated to have caused yield loss of about US$ 34 million at a time when it was well established in only about 30% of the banana producing areas. This paper describes the current status of the disease distribution and control in Uganda.

Key Words: *Musa* sp., *Xanthomonas campestris* pv. *Musacearum*

RÉSUMÉ

Le virus de flétrissement bactérien de la banane causé par *Xanthomonas compestris* pv. *Musacearum* (Xcm) était d'abord signalé en Ethiopie sur *Ensete ventricosum* en 1968 et sur la banane en 1974. Une maladie similaire causant Xcm était signalé en Ouganda en 2001 sur les bananes à Kayunga dans le district de Mukono. La maladie maintenant appelée localement Kiwotoka est très destructive et attaque la plupart des variétés des bananes plantées en Ouganda. En 2005, il a été estimé qu'il avait causée une perte en rendement d'à peu près 34 millions des dollars américains au moment ou il était bien établi seulement dans 30% des régions produisant la banane. Cet article décrit l'état actuel de la distribution de la maladie et son contrôle en Ouganda.

Mots Clés: *Musa* sp., *Xanthomonas campestris* pv. *Musacearum*

INTRODUCTION

Bananas and plantains (*Musa* spp.) are the fourth most important global food commodity. They are cultivated in over 100 countries covering about 10 million hectares, with annual production of 88 million tonnes (Sharrock and Frison, 1999). In Africa, bananas and plantains provide more than 25% of food energy requirements for about 70 million people of whom 20 million are from East Africa alone (Sharrock and Frison, 1999). Uganda ranks second after India in the world in banana production with an annual output of 9.84 million tones, accounting for 11.18% of the world's total production (INIBAP, 1999).

Despite its importance, the crop is threatened by various production constraints including: declining soil fertility, socioeconomic problems (marketing, high crop management costs, post-harvest handling/utilization), pests (banana weevil, nematodes), and diseases (black Sigatoka, Fusarium wilt and banana streak virus disease) (Tushemereirwe *et al.*, 2001). In 2001, a banana bacterial wilt disease (locally called kiwotoka)

caused by *Xanthomonas campestris pv musacearum*, was reported as a new threat to the banana especially in Mukono and Kayunga districts (Tushemereirwe *et al.*, 2001; 2003).

Worldwide the disease was first reported in Ethiopia on Enset cultivars (*Ensete ventricosum*), a relative of banana, in 1968 (Yirgou and Bradbury, 1968). It was later reported on bananas in the Keffa, Shoa and Sidamo, Harerge and Game-Goffa regions of Ethiopia, on the Hybrid Casse (Yirgou and Bradbury, 1974), with incidence between 70 to 80% (Korobko *et al.*, 1987).

Globally, bacterial wilt diseases of bananas are considered less important than black Sigatoka and fusarium wilt disease as evidenced by absence of an international working on bacterial wilts of banana in the PROMUSA Programme of the International Network for Improvement of Banana and Plantain (INIBAP, 1997). However, the banana wilt in Uganda has overtaken the other banana diseases in importance largely because most farmers are not yet sensitized about measures for its effective control.

Various surveys conducted since 2001 indicated that in all the affected districts, all banana types (Pisang awak ABB (syn Kayinja), Blugoe, Highland bananas (AAA-EA), Gros Michael (syn. Bogoya), and Neypoovan (syn. Sukari-Ndizi) were affected. The disease was spreading rapidly. In Mukono District, it covered 10 villages in one year from the banana field where it was first seen in October 2000 and 18 villages by July 2002 despite efforts to stop it. Incidence of 70-80% in one year was reported for many affected plantations. This paper describes the methods adopted to fight the disease and the status of the disease as captured in studies undertaken by mid 2006.

DEVELOPMENT AND IMPLEMENTATION OF CONTROL STRATEGY

The strategy. In response to the outbreak of banana bacterial wilt, the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) Government of Uganda, constituted a task force in December 2001 to develop a strategy and Action Plan, to eradicate the disease. The strategy emphasised massive creation of awareness, cutting and burying infected banana stools, quarantine, decapitation of male buds, and disinfection of farm tools used in the affected fields.

This quick measure reduced disease incidence below 10% per year, but could not be sustained due to high implementation costs. It was during this time too that the full extent of the disease became known. The disease was reported in 13 more districts and was spreading fast necessitating a change of strategy from eradication to "contain and manage".

The National Agricultural Research Organisation (NARO) was directed to develop a comprehensive research and development strategy to contain the disease. The strategy emphasised surveillance of the disease, generating information and technologies for management of the disease, utilising the information/technologies to contain and control the disease, improving policies appropriate for control of the disease and monitoring impact of implementing these activities (NARO and MAAIF, 2003). Furthermore, the strategy provides recommendations to guide implementation of the formulated action plan.

The development partners who were supporting banana based research and development activities were approached to support government efforts to implement the strategy. The Gatsby Charitable Foundation and the Danish International Development Agency (DANIDA) through the Agricultural Sector Programme Support (ASPS) and United States Agency for International Development (USAID) through Agricultural Productivity Enhancement Programme (APEP) provided funds to start the activities for control of the disease. Other Development partners (the Rockefeller Foundation, Department of International Development-UK through the Crop Protection Programme (CPP) and International Development Research Centre (IDRC) agreed to stretch their resources for ongoing banana research activities to cover related BBW activities.

Establishment and coordination of the Banana Bacterial Wilt Control Initiative (BBWCI). The first action towards implementation of the formulated strategy and action plan for control of BBW involved putting in place a mechanism for coordinating the action plan. This involved a Steering Committee (also serving as a National

Task Force), a Technical Committee and a national coordination office. The Steering Committee composed of personnel from MAAIF, NARO, Ministry of Finance Planning and Economic Development, Local Governments, Makerere University and Farmers (Uganda National Farmers Federation) was tasked to oversee implementation of the strategy.

A technical committee comprising of scientists from MAAIF, NARO, Makerere University, local government and International Collaborating Institutions (International Network for Improvement of Banana and Plantain and International Institute of Tropical Agriculture) was appointed and charged with the task of guiding implementation of the activities for control of the disease. A National Coordinator to spearhead the efforts to control the disease was appointed on 1 April 2004 and tasked to coordinate all activities on BBW control in the country as one entity known as the national Banana Bacterial Wilt Control Initiative (BBWCI).

The BBWCI was charged with the responsibility to ensure that all institutions, that have banana in their activity portfolio, integrate BBW control in their action plans. To strengthen coordination and monitoring of BBW control activities as defined in the national action plan, a system of task forces was provided for at various local government levels. It was envisaged that the National Coordination system, with the national Steering Committee (National Task Force) as its apex, would link to the farming communities in villages through district task forces, sub-county task forces, parish task forces and finally village task forces. This arrangement would ensure participation of all stakeholders in control of the disease. The activities of the BBWCI at district, subcounty, parish and village levels would be coordinated by public extension staff with task forces at the different levels playing the monitoring and overseeing roles at their respective levels.

The initial activity in every area where an outbreak would be reported would be mobilisation of stakeholders to form task forces at the various levels for ensuring implementation of disease control measures. In affected areas where farmers accord banana production high priority, the Task Forces were formed from village to district. With the BBWCI structure in place, teams simultaneously embarked on activities aimed at containing and controlling the disease as well as monitoring the impact of the efforts.

National sensitisation campaign for control of the disease. The BBWCI set sensitisation priorities to enable most effective use the little resources available to it. Highest priority was accorded to the disease free/threatened zone where plantations needed protection from the disease. Pockets of disease outbreak were anticipated. The goal of the initiative in these areas was to eradicate disease outbreaks.

Second in priority was halting further advance of the disease frontline zone (the advancing edge of the disease endemics). Priority was given to the frontline towards South Western Uganda, the main banana producing region of the country. The goal of the initiative was to push the endemic zone backwards by eradicating the disease in affected plantations in the frontline.

Third in priority ranking were zones where the disease was considered endemic. In these areas, the short term objective of the initiative was to enable farmers to cope with disease. However, the ultimate goal was to progressively eradicate the disease from farmers' fields.

The initiative deployed both convetional communication methods ideal for reaching wide audiences and participatory communication methods ideal for initiating action at community level. The sensitisation campaign involved raising stakeholders' awareness about the disease and its control through trained trainers and multiple communication channels. The BBW control recommendation package propagated is summarised in Table 1. In all cases the communication was aimed at pursuading farmers to implement these disease control recommendations.

Conventionalcommunication approach deployed. The channels through which information was delivered massively and rapidly to farmers included the following:

Multiple communication channels. The BBWCI produced and distributed 40,000 posters in 2004 as well as 67,000 brochures, 100,000 newspaper-inserts (in New Vision, Orumuri, Rupiny, Bukedde

and Etop) and 6,000 calender posters in 2005. Radio spot messages and talk shows (in five languages; English, Luganda, Ateso, Luo and the Runyakitara (Runyankole, Rukiga, Runyoro and Rutoro)) were done. The campaign was scaled up in the first half of 2006 with production of 100,000 refined posters, radio spot messages and talk shows in ten languages (English, Luganda, Rukiga/ Runyankole, Runyoro/Rutooro, Rufumbira, Lugbara, Luo, Ateso, Kuksabiny and Lumasaba) on 18 local radio stations and 10,000 brochures targeting extension workers. The use of bill boards and school poster package were also piloted.

Trained trainers. Two hundred and ninety six extension workers drawn from all the three zones were trained on identification and control of BBW in preparation for deployment as trainers in 2004. Additionally, 148 service providers drawn from the Uganda National Farmers' Federation were trained in 2005 to support the trained extension workers.

Seminars and workshops. Several seminars and workshops at district and grass root levels were conducted by trained trainers. These enabled the many local leaders, opinion leaders, NGOs, and interested farmers to join the expanding pool of trainers.

Public gatherings. Going public at social gatherings (religious occasions, funerals gatherings, political rallies and markets etc) was found instrumental in spreading information about BBW and tracking down its progress.The technique was mostly used in the unaffected areas to track the disease outbreaks.

Information on the whereabouts of disease "fronts" and the presence of new outbreaks was progressively tracked down and targeted with sensitisation of affected communities about control measures. The information from farmers and task forces in affected areas was channelled to the coordination office through their Local Government extension workers. The BBW control team made on-spot checks for each of the new areas where the disease was reported and mobilised the local leaders to set up task forces for containing and controlling the disease using a participatory approach.

Participatory BBW control: Deployment of a Participatory Development Communication (PDC) approach. Whereas the conventional top-down approach was instrumental in swiftly raising awareness of stakeholders about the disease across the whole country, it was not effective in triggering actions aimed at controlling the disease. To address this shortcoming, a participatory communication approach was formulated and deployed in pilot areas. The implementing team chose to use the Participatory Development Communication (PDC) approach previously developed from the International Development

TABLE 1. Set of recommendations that were found effective in containing BBW and eradicating it from affected banana plantations in Uganda

1. Avoid introducing the disease into your area, garden or unaffected plants by observing: not using cutting tools in your plantation until you have eliminated all infected mats or sterilise the tools before using them on every other mat. This prevents stool to stool spread of the disease through the tools; restricting entry of infected bananas or banana parts into your area/garden.

2. Break male buds from all banana plants at about two weeks after flowering with a forked stick. This prevents disease transmission by insects which visit the flower while using a stick prevents transmission that would otherwise be caused by cutting tools.

3. Clear all disease plants by uprooting and heaping or using 'Round-up' (glyphosate) herbicide as recommended by the BBWCI (1ml of herbicide/banana mat). This eliminates source of inoculum.

4. Clean tools used to clear infected plants by briefly heating them with a fire flame or dipping them in a 'JIK' (sodium hypochlorite) solution (1:5 water to JIK ratio)

5. If for three to six months you do not see fresh plants getting diseased, resume use of tools in your banana plantation. However, remain vigilant as fresh infection is highly likely.

Research Centre of Canada (Bessette, 2004). This approach centres on action plans developed by communities to address specific problems facing them. A development worker trained in this approach facilitates the community to develop the action plan.

The strategy of using PDC as a tool for mobilising communities to fight BBW was initially piloted in Kimenyedde sub-county of Mukono district. Community action plans were developed as follows: 1) The approach was introduced to community leaders to get buy-in as foundation for full implementation and scaling out. 2) Community members, their leaders, development workers and researchers were brought together to share information on the BBW and other banana management problems. This step ended with farmers identifying strategies they wished to try to solve the BBW problem (prevention if farmer had unaffected plantation or eradication measures if affected). 3) Community members were grouped on the basis of the strategies applicable to their BBW situation (protecting unaffected gardens or aradicating the disease). 4) Each group identified actions required to implement the solution to be tried, resources required, technical needs, partnerships required and who would do what. 5) Each group developed a communication plan to eventually enable them share lessons learned with the wider community if their efforts paid off. 6) Finally, the community developed a monitoring and evaluation plan, a schedule of activities and agreed on how to source for required resources. The plan was then implemented. The success story created at this site was shared with the wider community through various communication channels released at a massively attended open day presided over by the minister of Agriculture Animal Industry and Fisheries.

The community action plan strategy was scaled out to new areas through a training of trainers approach as is done in conventional extension approaches. Community development workers were trained in the approach and charged with the task of facilitating development and overseeing implementation of the action plans.

Scaling up the approach was piloted in the selected districts of Kiboga, Mpigi and Mbarara. The disease control action plan centred on deployment of the recommended control measures (Table 1).

DISEASE STATUS

Disease distribution. A system involving radio messages and posters urging everyone to report new outbreaks of the disease to the National Banana Research Programme, Kawanda (National Coordination office) was put in place. The same system was also used to report controlled outbreaks/disease pockets. The system involved 1) farmers who reported to the nearest local government agent when they suspected they had the disease in their area, 2) sub-county agricultural extension agents who verified farmer reports and informed the district authorities 3) district agricultural extension officers who also verified and forwarded information to the central Government offices handling BBW, 4) National coordination office (Banana Research Programme) of the BBWCI which arranged final verification (if necessary, say for reports from new districts) and entered the information in a national data base on BBW. This system of reporting was backed by disease surveillance surveys based on the 'going public' model (sensitizing gatherings in public places and asking if they have seen such a disease). From the two complementary disease surveillance methods, the disease was effectively tracked down as it spread across the country and targeted with sensitization and mobilization of the affected communities to control it.

By May 2006, the disease was confirmed in 319 sub-counties spread across 35 districts including Mukono, Mubende, Nebi, Kabarole, Kayunga, Wakiso, Kibaale, Soroti, Luwero, Nakasongola, Masindi, Hoima, Apac, Lira, Kaberamaido, Kumi, Sironko, Mbale, Pallisa, Iganga, Mayuge, Bugiri, Kamuli, Jinja, Kampala, Kiboga, Mpigi, Gulu, Bushenyi, Ntungamo, Masaka, Mbarara, Kabale, Isingiro and Soroti (Fig. 1). Information about new outbreaks of the disease was continuously collected and centrally stored in a data base at Kawanda. The same was done for eradicated disease pockets.

The disease distribution was characterised by a large area where the disease was intense and other

areas which had the disease in scattered pockets or were free. The disease was fully established in all sub-counties in about 15 districts lying in central Uganda between lakes Victoria and Albert (Fig. 1). This area where all monitored units (sub-counties) were affected was defined as an endemic zone. Within an endemic zone, there were many isolated areas free of the disease which were called disease free pockets. The advancing edge of the endemic zone was defined as a frontline. For instance the frontline to the west was made of the districts of Mpigi, Mityana, Mubende, Kiboga, Kyenjojo, Kibale, Kabarole and Bundibugyo.

Areas where the disease was not known to occur but which were close to the endemic zone and therefore presenting a high risk (endangered areas) were described as disease free but threatened. Areas where disease was not known to occur and which were distant from the endemic zone and therefore presenting low risk of occurrence of the disease were defined as disease free. By May 2006, these areas could only be found in south western Uganda. Any new occurrence of disease in a previously disease free area was defined as an outbreak

Prevalence and severity of the disease. In addition to the surveillance studies described earlier, a survey to establish the prevalence and severity of the disease was carried out in April 2005 as described in Kagezi *et al.*, 2006 (this special issue). The information on the number of disease affected farms in the sampled districts suggested that in the areas where the disease was fully established at the time of sampling, 76-95% of the fields were affected (Table 2).

Estimate of economic importance of the disease. The data on disease incidence, disease distribution,

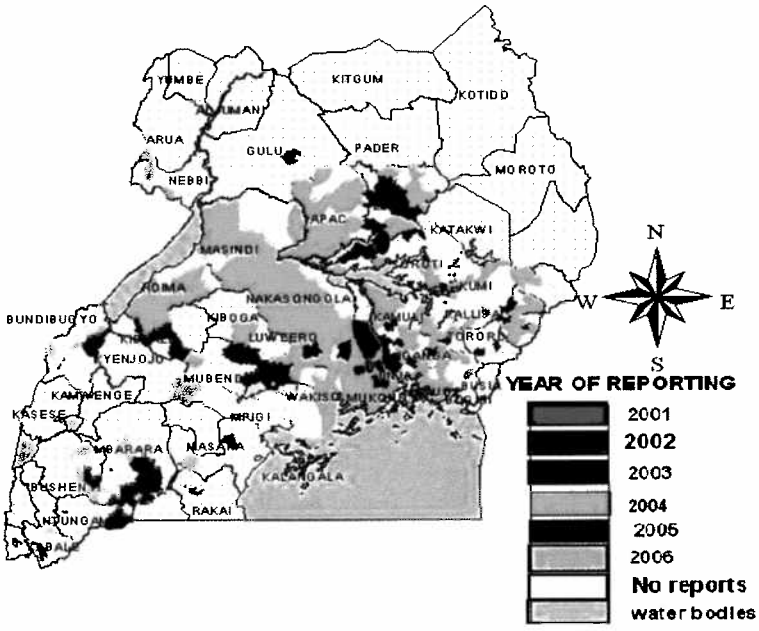

Figure 1. BBW distribution by sub county: May 2006.

banana production and banana prices was used to compute the loss due BBW by the sampling time (April 2005). The total loss of national banana output due to BBW for year t (Y_{it}), was estimated as a product of the total banana acreage (A), the share of the area affected by BBW as estimated based on disease incidence in plantations (I), the yield loss per hectare (γ), the average district yield (x), and the farm gate price (p)

$$Y_{it} = A_{it} I_{it} \gamma_{it} X_t P_t \quad (1)$$

Using UBOS 10 year banana production data (1992-2001), production figures were extrapolated up to 2010 at the annual growth rate of 3.04%. It was also assumed that the ratio of matooke to kayinja as reported (Kagezi *et al.*, 2006) would remain the same for the same period. BBW incidence survey data (Kagezi, et al 2006) was extraporated for 2006 up to 2010 following a logistic function model of the form (2).

$$X(t) = \frac{1}{1 + (\frac{1}{XO} - 1)e^{-rt}} \quad (2)$$

Where x(t) is the BBW incidence at time t, rate of BBW incidence increase is r=0.05, and XO is BBW incidence in 2005.

The yield losses in the subsequent years were obtained as in equation (1) with projected BBW incidence (equation (2)) and extrapolated banana production figures.

This analysis revealed that the disease caused a loss of 34.3 million US dollars in 2005 (Table 3). It was estimated that the loss would rise to 75.6 million US dollars in 2006 and would shoot up to US dollars 229 million by 2010. These loss estimates make BBW a big threat to the banana industry and the country's food security. Fortunately, the disease started in a region where banana production is low (central and eastern Uganda). The losses would have been much higher if it had started in the major banana production areas of western Uganda. It will be disastrous if it manages to get established in these major banana growing areas.

TABLE 2. BBW affected fields in sampled districts of Uganda by April 2005

District	%BBW affected fields
Bushenyi	1.1
Kamuli	90.4
Kayunga	95.3
Luwero	76.8
Masindi	92.0
Mbale	48.9
Mubende	6.7
Ntungamo	5.5

Effects of the sensitization and control programme on the disease status. In the areas to the west of the western frontline where BBW outbreaks were recent, the mobilized and sensitized communities managed to eradicate outbreaks from whole sub-counties. All in all, the disease was effectively controlled in 15 out of the 319 sub-counties affected by May 2006 (Table 4). The advancing front of the endemic zone (where the disease was getting endemic as defined in this paper) was slowed down as evidenced by the reduced number of new sub-counties getting affected. Only limited pockets of outbreaks were detected ahead of the frontline and these were targeted with eradication measures and controlled. Overall, the rate at which sub-counties were getting affected was considerably reduced from 2005 (Fig. 2). It is believed that the sensitization and disease control programme was among the possible reasons for this reduction in disease spread.

These results suggest that the mounted disease control programme was quite effective in areas where it was implemented. This could be attributed to the pathogen's limited ability to survive outside the host and the manner in which farmers were engaged to own the problem.

The disease is reported persist in soil and debris for only a short time (Mwebaze *et al.*, 2006). Additionally, it appears not to have a wide host range and is unable to survive in the absence of a host. These attributes make it easy for farmers to deny it means of survival thereby clearing it from their fields. Furthermore, the approach of engaging the community to own the problem contributed to the success of the control program. Upon realising that the disease was extremely devastating but controllable, farmers felt encouraged to aggressively fight the disease. Those not convinced

TABLE 3. Estimated Banana losses (USD) due to BBW at the current rate of infection if control measures were not adopted: April, 2005

Year	Matooke	Kayinja	Total
2002	975,149	241,837	1,216,986
2003	5,406,792	1,222,701	6,629,493
2004	16,461,201	2,316,637	18,777,838
2005	29,825,900	4,507,569	34,333,469
2006	69,747,965	5,804,659	75,552,624
2007	112,740,679	8,770,663	121,511,342
2008	146,794,281	10,479,530	157,273,811
2009	183,186,865	11,861,699	195,048,564
2010	215,824,043	13,192,416	229,016,459

TABLE 4. BBW control situation by sub counties: May 2006

Status of disease	No. of sub counties
Controlled	15
Nearly controlled	25
Spread contained	35
Endemic	244
Subtotal	319
No disease reports	667
Total sub counties	986

were forced to join the adopters by the bye-laws passed by the community to rid their villages of the pathogen.

The activities in the pilot areas provided lessons that will guide the scaling up of the participatory approachs for BBW control. These include:

(i) Implementing of participatory BBW controls requires placement of an effective extension worker to mobilise the communities and their leaders for action; supportive local authorities; participation of all relevant development agencies; and sensitised farmers.

(ii) Partnerships: Various stakeholders and their resources were brought on board to manage the epidemics. This covered transaction costs and improved impact and effectiveness.

(iii) The taskforces set up through the technical personnel were not as effective as those initiated through political leaders. It was realised that the taskforces had to be embraced and supported by political leaders to function effectively. Political leaders already have established networks for mobilising the community, controlled allocation of resources and had power to coarse uncoorperative members of the community.

(iv) The few farmers who adopted recommended disease control measures successfully prevented infection or eradicated the disease. However, farmers appeared reluctant to apply the male bud decapitation recommendation to the banana beer variety (Kayinja) because either they believed the practice would lower the strength of juice/ alcohol from it or felt it was an unusual requirement since Kayinja is grown as a semi-cultivated (unmanaged) crop. Intensive sensitization targeting Kayinja was needed since this banana type served as a disease spreader.

(v) Uprooting, chopping and heaping as a modified method of rouging diseased plants was still labotorius and thus it was recommended to evaluate use of herbicides to poison the plants as the roguing method.

This PDC approach of tackling problems rolls out slowly but is extremely effective in triggering problem-solving actions at community level. It is important to note that getting right the method of mobilizing the community for action is as important as getting right the technical

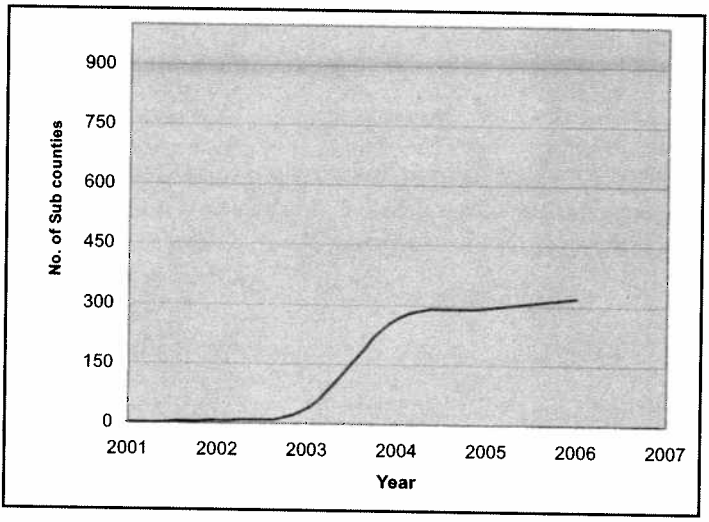

Figure 2. Graph showing the number of sub-counties that got affected by BBW each year since detection of the disease in Uganda.

recommendations. In all areas where both were correctly handled the disease has been effectively controlled.

Generation of information and technologies to back up disease control efforts. Research effort aimed at generating information on disease status, etiology and epidemiology as well as technologies for refining the disease control programme has been going on since 2002. Tangible progress has been made for some of the research activities that were identified and included in the strategy and action plan for control of the disease. Some activities where information is already available include: Impact of the disease on the banana industry; impact of deployed control efforts; some alternate hosts; means of disease transmission; pathogen survival; disease entry points; use of herbicides to destroy diseased banana plants; and searching for sources of resistance and details on these will be found in papers that follow in this volume.

CONCLUSION

Analysis of the status of BBW in Uganda revealed that the disease poses a serious threat to food security and incomes of rural communities in banana based systems. The disease caused a loss of about US$ 34 million in 2005 when it was established in only less than 30% of the banana growing areas.

The formulated control measures proved effective in all areas where they were fully and accurately deployed. A participatory approach emerged as an effective strategy for mobilising communities and their local leadership to deploy the measures. This was largely because it enabled the BBWCI to engage them in discussions that led to their ownership of the problem. It was demonstrated that the disease can be eradicated from affected plantations if farmers implement the eradication measures so far recommended. This implies that the disease can be prevented from getting established in the zone currently described as unaffected or little affected (largely in the south west of Uganda). The future disease control activities should focus on rapidly eradicating the pockets of disease outbreak in the largely unaffected areas and progressively targeting the current heavily affected areas with an eradication campaign starting from the frontline zone. Effective control of the disease without first resorting to change of varieties as is the case for most diseases appears possible for this disease.

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