Insect visitors are made to feel unwelcome in banana crops

RIU

Validated RNRRS Output.

Farmers are controlling a major banana disease, Xanthomonas wilt, by preventing the entry of insects that carry a bacterium (Xcm) that causes the disease. Removing male buds from the plants is one solution. Another is the destruction of infected plants to keep them from continuing to attract insects. Finally, by opting for banana varieties in which the male flower cushions have a natural protective covering farmers make their crops inaccessible to the insect vectors. These findings were made possible thanks to the identification of an improved medium for isolating Xcm from insects, soil and plants. The new control techniques are being promoted in Kenya, DR Congo, Rwanda, Tanzania and Uganda using participatory methods.

Project Ref: **CPP18:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **IITA, Uganda**
Source: **Crop Protection Programme**

Document Contents:

Description, Validation, Current Situation, Current Promotion, Impacts On Poverty, Environmental Impact,

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Description

CPP18

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Congo DR, Kenya, Rwanda, Tanzania, Uganda,

Target Audiences for this content:

Crop farmers,

A. Description of the research output(s)

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Identifying Insect vectors and Transmission Mechanisms for Banana *Xanthomonas* Wilt

Suggested working title:

Managing the BXW pandemic in East and Central Africa

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Crop Protection Program (£40,000).
Additional funding from IITA (£ 15,000).

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities.

The research was carried out under project number R8484; ZA0695.

Partners:
Dr. Ranajit Bandyopadhyay (IITA) r.bandyopadhyay@cgiar.org
Dr. Clifford Gold (formerly IITA), c.gold@cgiar.org
Dr. Simon Eden-Green, EG Consulting, UK. egc@eden-green.co.uk
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*4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? **(max. 400 words)**. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

The purpose of the research was to generate information on biology, epidemiology and modes of **transmission** of the **banana *Xanthomonas* wilt** (BXW) pathogen. The disease is caused by a bacterium *Xanthomonas campestris* pv *musacearum* (Xcm). Based on field observations and experience with other similar bacterial diseases of banana e.g. Moko disease (*Ralstonia solanacearum*), Xcm was suspected to be mainly transmitted through insects and secondary infections through roots and contaminated tools. This project aimed to identify the mode of transmission, and follow through by developing or adapting BXW management methods that are applicable on a region wide basis.

The insects that visit banana inflorescence were studied. *Plebeina denoiti* was found to be the most abundant and most frequently visiting insect species and also carried the highest number of Xcm cells. Other visiting insects included fruit flies and grass flies. Male flowers of symptomatic plants were the major source of inoculum for vectors, and insects visited infected flowers more than flowers of healthy plants. Field level inoculation and transmission studies confirmed *P. denoiti* and grass flies could pick Xcm from infected flowers and pass it on to healthy flowers as they visit to collect nectar.

The outputs provided the first experimental evidence for the **insect vectors** involved in Xcm transmission and the sites of inoculum acquisition. These outputs provided the evidence and a scientific rationale to support three key recommendations being promoted for BXW management. These are:

- Removal of **male buds** immediately after the last fruit clusters form so as to remove chance of insects accessing the male cushions.
- Destruction of infected plants, especially those that have flowered, so they do not continue attracting insects to their flowers which are contaminated with Xcm ooze.
- Planting of banana varieties that have persistent bracts that cover male flower cushions making them inaccessible to insect vectors.

An improved semi selective medium for isolating Xcm from insects, soil and plants was developed. This medium is a helpful tool in Xcm diagnostics and is contributing in research for developing sustainable solutions.

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	***Technology***	***Service***	***Process or Methodology***	***Policy***	***Other Please specify***
	x		*x*		

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

The outputs of this research focussed on banana and plantain. The outputs are specific to a disease that attacks only Musa species and thus may not be applicable to other commodities.

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	***High potential***	***Hillsides***	***Forest-Agriculture***	***Peri-urban***	***Land water***	***Tropical moist forest***	***Cross-cutting***
	x	*x*	*x*			*x*	

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	***Irrigated***	***Wetland rice based***	***Smallholder rainfed highland***	***Smallholder rainfed dry/cold***	***Dualistic***	***Coastal artisanal fishing***
x	*x*		*x*			

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**).*

In addition to BXW, the major pest/disease constraints faced by farmers in East and Central Africa include Black Sigatoka, *Fusarium* wilt, nematodes and weevils. Value can be added to BXW management technologies by including other pests/diseases in the technology package. E.g.

- Improved field management e.g. removing infected mats reduces BXW inoculum. The same practice is proven to reduce incidence of banana streak virus and leaf spots.
- Promoting use of clean planting materials for BXW management also reduces spread of nematodes, *Fusarium* wilt and viral diseases. Biological enhancement of planting materials using fungal endophytes for nematode management (project at IITA) presents an opportunity to tackle other pests and pathogens.
- Annual crops, e.g. cassava, sweet potato and maize, that are promoted as substitutes where banana is destroyed by BXW also reduce nematode populations, and also improve soil fertility. These substitute/break crops can be promoted as multi-purpose for BXW management, diversifying the food basket, improving soil fertility and managing nematodes.
- Improved banana varieties can be introduced to address multiple purposes E.g. Cultivars FHIA cultivars which have been selected by farmers in Uganda for being tolerant to *Fusarium* wilt and leafspots, have good juice productivity and hence could be used as replacement for cv Pisang Awak which is grown widely but is highly susceptible to BXW. Rehabilitation/replanting of fields affected by BXW can be used as an opportunity to introduce improved varieties or those with desirable traits, e.g. with persistent inflorescence such as Mbwazirume, Nakitembe, for BXW management.
- Improved marketing of banana for BXW management can be used as an opportunity to improve post-harvest handling. E.g. promoting use of crates for packaging and transporting fruits so as to reduce use of plant residues that could carry BXW will also lead to better improved handling and higher quality of fruits.

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

Other projects that have generated outputs relevant for banana IPM include

- R8342 (Banana IPM - crop management, new cultivars and participatory development communication);
- R6580 (Banana nematode control (break crops etc.),
- R8437 (Assessing the Impact of the Banana Bacterial Wilt, *Xanthomonas campestris* pv. *musacearum* (BXW), on Household Livelihoods in East Africa.

Validation

B. Validation of the research output(s)

*10. **How** were the output(s) validated and **who** validated them?*

*Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation **(max. 500 words)**.*

Farmers have played the highest role in validating the effectiveness of technologies being promoted for BXW management. In South Western Uganda and in the Kagera region of Tanzania over >60 and 75% farmers, respectively, traditionally remove male buds as a measure to ensure good bunch size and uniformity. There is evidence that disease has spread at much lower rates in these areas, and whatever spread there is mostly through contaminated tools. On the contrary in Central Uganda and Eastern DR Congo where debudding is rarely practiced, BXW has spread much faster due to insect transmissions.

In Uganda farmers have been applying a set of cultural measures for BXW control promoted through participatory development communication, farmer field schools (PDC), participatory monitoring and evaluation (PM&E) and community action. These include debudding, removal of infected and disinfection of working tools and using clean planting materials.

Trials to validate effectiveness of debudding were carried out by in Uganda by INIBAP [1]. The study was carried out on both Kayinja and Matooke varieties, in a trial located in Central Uganda where BXW is endemic and compared debudding after 0, 2, 4 and 6 weeks after formation of the last fruit cluster. Results confirmed that debudding has to be done at the earliest opportunity possible, and using forked sticks rather than knives.

The importance of cutting down infected plants to reduce inoculum available to insect vectors has been validated in Tanzania and DR Congo, where there are indications of slowing disease spread after removal of infected mats. In Tanzania, 90% of farmers in affected areas have chopped down over 60,000 infected mats and there is early evidence this is has reduced inoculum available significantly. In DR Congo, an estimated 10% of farmers are debudding while about 40% of farmers in the affected area are cutting down infected mats.

Besides BXW management, technologies for management of banana weevil and nematodes (pairing of roots, hot water treatment, use of wood ash, use of clean planting material) developed by CABI under R8342, R7567, R7529, R7972 were validated by the Kenya Agricultural Research Institute (KARI) on farmers' fields in Central province (Muranga and Maragwa districts) in Kenya. After participatory varietal screening trials, farmers selected Cavedish varieties that are resistant to *Fusarium*, these were multiplied by tissue culture and distributed to farmers to replace the susceptible Gros Michel and the apple banana. This work was funded by USAID and IFAD. The Farmer Field School (FFS) approach that was use in technology validation and transfer would appear to be suitable for future transfer of BXW management technologies in Western and Nyanza provinces of Kenya.

In the different countries farmers actions in validating and applying the recommended disease management measures have been supported by various actors including national research institutions (NARO, KARI, ARDI, INERA), Universities, Ministries of Agriculture, NGOs, FAO, international research institutions (IITA&INIBAP) and various donor agencies, while local governments have helped to put in place enabling policies and regulatory framework.

[1] Blomme, G., Mukasa, H. F. ssekiwoko, Eden-Green, S. 2005. On-farm assessment of banana bacterial wilt control options. African Crop Science Proceedings, Vol. 7: 317-320.

*11. **Where and when** have the output(s) been validated?*

*Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

Outside of Ethiopia where BXW was first reported, outbreaks have been confirmed in Uganda (2001), Rwanda (2005), DR Congo (2005), Tanzania (2006) and Kenya (2006). BXW affects banana and plantain which in East Africa are grown in small holder rainfed production system particularly on highlands where they have an environmental protection role on hillsides.

The INIBAP trials for validating debudding were carried out in 2005 on small holder farms in central Uganda. Generally, in Uganda debudding has been promoted since 2004 especially in the BXW frontline areas. Removal of infected mats to reduce inoculum and reduce mother to sucker transmission have been promoted since 2005, mostly targeting Kayinja (brewing banana) systems where floral infections are much more prevalent. Rouging of whole mats is often the recommended measure in Matooke systems where there is a zero BXW and BSV tolerance policy. Use of break crops for nematode control has been under promotion in Central Uganda since 1998. Use of clean planting material, improved varieties and improving soil nutrition have been promoted in all farm systems for over five years. In Kagera (Tanzania) promotion of debudding for BXW management started in 2005 as a measure to prevent BXW introduction. Removal of infected plants was added to the recommendations once outbreaks were reported and is continuing. In DR Congo, debudding and removal of infected plants has been promoted since 2005 in the Masisi and Rutshuru territory of Nord Kivu province where BXW is present. In Kenya,the IDRC and USAID supported projects between 1999 to 2003 in central province districts of Maragwa and Muranga where over 5,000 farmers were involved in participatory evaluation and validation of different production, IPM and post harvest technologies. Between 2005 -2006 another 600 farmers have been involved in farmer Field Schools in the Eastern province with World Bank support.

Current Situation

C. Current situation

*12. **How and by whom** are the outputs currently being used? Please give a brief description **(max. 250 words**).*

In Uganda, Tanzania, Rwanda, DR Congo and Kenya outputs of R8484 have been and are being used to develop information packages for BXW management. Outputs are being promoted through participatory development communication whereby communities are empowered to take action to control BXW. The outputs have been used to formulate technical bulletins to inform NGOs and extension staff, and also for incorporation into school curricula to reach children, teachers and the farming communities to which they belong. In Uganda an average of 35% of farmers are debudding to manage BXW, though studies show over 80% [2] are already well informed about the practice. In Tanzania and the DR Congo about 60 and 10 % of farmers are debudding, respectively.

Besides BXW management, in Uganda over 700 farmers adopted improved cultivars especially FHIA 17, FHIA 23, which have good acceptance in local and regional urban markets. The cultivars have potential to replace Gros Michel which is threatened by Fusarium wilt across the region. In Kenya, outputs from previous IPM projects have disseminated by KARI, NGOs, CBOs, ministry extension staff through FFS, farmer groups, nursery operators, workshops, and through brochures and crop management guides. Traders have also been trained in banana ripening and packaging methods.

[2] B. Kiiza ; G. Rwomushana, S. Lwasa and G. M. Diiro. AN EVALUATION OF THE BANANA BACTERIAL WILT DISeASE AWARENESS CAMPAIGN IN UGANDA. A report of a study commissioned by United States Agency for International Development (USAID) and and The Danish International Development Agency (DANIDA)/Agricultural Sector Programme Support. August, 2006.

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

In Uganda BXW management technologies targeting to reduce transmission are currently being applied the frontline areas of the pandemic, principally along the Mpigi, Mubende, Kiboga, Kyenjojo, Kabarole, Mityana and Bundibugyo districts and in the endemic areas mainly in the Central, Eastern and Northern regions. The relatively BXW free areas of Kabale, Mbarara, Ntungamo, Isingiro, Bushenyi and Masaka districts are also being targeted. Improved banana cultivars have been adopted in Mbarara and Bushenyi in the south west, and increasingly in the Central region districts especially Luwero. Results from two regional markets i.e. Nairobi (Wakulima Market) and Kigali (Nyamirambo and Kyibisagara) indicated that two introduced dessert varieties (FHIA 17 and FHIA 23) have high demand, implying a ready market.

In Tanzania, BXW management technologies are being promoted in the North western Kagera region that is affected by BXW but will need scaling up/out to Kigoma and Mwanza regions. In the DR Congo BXW management outputs are being used in the Masisi and Rutshuru territories of North Kivu province. In Rwanda BXW management is taking place in the North western Gisenyi province regions. In Kenya, most dissemination of banana technologies has been in Central and Eastern provinces which account for 24 % of the country's banana production. 64% of banana production is from the western region where BXW outbreaks were recently reported, hence there will be need to target these western areas for BXW management.

*14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading **(max 250 words).***

- In Uganda, the recent USAID/DANIDA study by Kiiza et al (2006) showed 85% of farmers are aware of BXW spread and control. However the same survey showed only about 35% are practicing the measures.

The 85% awareness was reached within 3 years but there is potential of achieving this faster. In some villages the number of farmers controlling BXW has risen from 5 to 80 within 3 months following increased use of participatory development communication. Over 700 farmers have adopted/planted 14000 suckers of improved FHIA varieties.

- In Tanzania, an estimated 60% of farmers in Kagera region growing cooking bananas have been debudding as a cultural measure. However most farmers growing brewing bananas do not debud. About 90% of farmers in affected area have uprooted over 60000 mats in less than a year.

- In Rwanda debudding and destruction of infected plantations has been going on in the Gisenyi area since 2005.

In DR Congo 10% of farmers in Masisi regio*n* have been trained and are practicing debudding, and 100 ha of infected plots have been cut down within the last year.

In Kenya, 5000 farmers were trained in banana IPM between 1999-2003 in Central province, almost all adopted/ planted Fusarium-resistant Cavedish variety, 10% adopted modern ripening chambers and 6% adopted use of packaging crates (KARI Annual Report 2004). In 2005-2006, 600 farmers in Eastern Province have been trained in farmer field schools, after which each farmer established an orchard and is training other farmers.

15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? ***(max 350 words).***

Governments within the region have responded quickly to mobilise resources for prevention and management of BXW. The Uganda Government has annually committed funds, todate totalling over 600 million Uganda shillings (325,000USD) in BXW management. The governments of Tanzania, DR Congo, Kenya and Rwanda responded promptly to the BXW threat by mobilising funds for surveys and sensitizing farmers, and also sponsored their staff for training in BXW management in Uganda. The Tanzania government committed USD 70,000 for prevention measures (before the BXW outbreaks) and an additional USD 80,000 after outbreaks were reported. Kenya government committed about 20,000 USD for surveillance before outbreaks. Governments have also collaborated to put in place quarantine measures to reduce BXW spread across borders.

Most countries have functioning institutions and programs e.g. Ministries of Agriculture, Agricultural Research Institutions (NARO, KARI, ARDI, INERA, ISAR) including Universities and effective local government system. Governments have supported establishement/strengthening of new/existing structures to deal with BXW outbreaks. E.g. In Uganda the government accorded BXW national priority status and a taskforce was instituted to formulate an action plan to control BXW. There are generally good linkages between government institutions, NGOs, CBOs and the research fraternity for developing and delivering effective control measures, while leaders have been mobilising farmers for community action and integrating BXW management into local development plans.

Regional institutions involved in banana research (IITA, INIBAP) and the ASARECA network (BARNESA) have been instrumental in spreading information and knowledge regarding BXW management. BARNESA organised an international meeting of experts in 2005 to develop a regional response plan to BXW. In DR Congo FAO and WFP have been instrumental in BXW management initiatives.

- Various donor supported programs have been instrumental in availing resources. DFID through the Crop Protection program, USAID, DANIDA, IDRC, Gatsby have contributed to technology development and transfer, while FAO/WFP have been supportive in helping affected communities to cope with the aftermath of BXW.
- In terms of capacity strengthening the key facts of success would include improving stakeholders' ability to adapt and refine strategies for participatory communication, strengthening extension services and funding research for technology development.

Current Promotion

D. Current promotion/uptake pathways

*16. **Where** is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion **(max 200 words).***

Promotion of BXW management technologies is taking place in six countries in East Africa through the Crop Crisis Control Project (C3P). C3P is an 18 month regional project funded by USAID and being implemented by Catholic Relief Services in partnership with IITA. C3P will improve coordination among actors and increase stakeholders awareness about BXW spread and control measures. Emphasis is on cultural measures (debudding, disinfecting tools, use of clean planting material) and where possible replanting with banana varieties that have persistent bracts to prevent insect transmissions. The table below shows the areas of operation of C3P and target number of beneficiaries. .

Country	Locations	Population in target areas	Target no. of farmers
Uganda	Mukono, Luwero, Nakaseke, Mbale, Kayunga (endemic districts)	481,000	12,500
Tanzania	Bukoba, Muleba, Biharamulo, Ngara, Karagwe, Kibondo, Kasulu, Kigoma districts within Kagera and Kigoma regions	2,100,000	69, 000
DR Congo	Masisi, Rutshuru and Lubero territories of Nord Kivu province	1,996,000	6,000
Rwanda	Cyanzarwe district in Gisenyi region		3, 000
Kenya	Homabay, Suba, Migori, Kuria, Gucha, Teso, Bondo, Busia, Kisii districts in Western and Nyanza provinces	3,580,000	12,000
Burundi	Bubanza, Cibitoke, Kayanza, Kirundo, Muyinga, Ngozi, Ruyigi districts	1,677,000	6000

In addition to the C3P initiative,

- in Uganda FAO has launched Farmer Field Schools for BXW management which is being piloted in 5 districts of Mukono, Kiboga, Kamuli, Lira and Mbarara.
- ASARECA is launching a 3 year regional project ($420,000) in Kenya, Uganda and DR Congo to support research and technology transfer for BXW management. NARO, KARI and DR Congo NARS, IITA and INIBAP are key partners in this project. These initiatives are inadequate and will leave many gaps requiring funding support.

17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. ***(max 200 words)****.*

- Funding has not been sufficient to sustain the campaign against BXW. Effective participatory communication methods are costly to scale out. BXW has joined a long list of crisis competing for attention including old issues such as HIV AIDS and new issues such as bird flu.
- Lack of a streamlined marketing system is contributing to spread of BXW through trade. Traders moving between regions, harvesting with their own knives, packaging dessert banana with residues and lack of quality enforcement will need to be addressed
- Poor coordination between numerous actors in BXW management leading to competition between agencies and duplication of effort.
- Inadequate and slow government response, sometimes delayed enacting or slow enforcement of policies that would slow disease spread. E.g. local governments collect tax from banana trade and hence are unwilling to impose quarantine.
- Poor management and facilitation of extensionists. High ratio of extension workers to farmers (1:15000 in Tanzania), often those controlling extension funds have no supervisory authority over extension staff, poor access to updated information for extension staff.
- Inadequate knowledge/technology due to inadequate research. E.g. Lack of simple diagnostic tools frustrates enforcement of quarantine.
- Cultural measures perceived as time consuming and costly.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues ***(max 200 words).***

- Funding for scaling up/out technologies needs to be increased to sustain technology transfer campaigns taking into consideration the needs of different countries or regions within a country.
- Policy makers need to be sensitised to ensure rapid government responses, through right policy, mobilising resources and advocacy for BXW visibility.
- Capacity for research should be strengthened to ensure technologies are scientifically sound and sustainable e.g. develop resistant cultivars.
- An assessment of information needs and strategies to strengthen information access for extension staff especially in remote areas is required to ensure they access regularly updated information on BXW and similar agricultural crop disasters.
- Strengthen capacity in use of PDC [3] and PM&E [4] strategies as well as assess the inclusiveness of these methods, which are new in most communities threatened by BXW. Explore innovative

communication approaches e.g. integrating BXW management into school curricula.

- Improve coordination between actors and agencies, e.g. harmonising of funding and supervisory functions over extension staff, linkages between government, NGOs, CBOs and research institutions.

[3] Participatory Developement Communication
[4] Participatory Monitoring and Evaluation here implying enabling communities to set own targets and evaluate their own progress in managing BXW.

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? ***(max 300 words).***

- BXW is a severe disease that spreads rapidly and rapid action is required when outbreak or threat is declared.
- The disease should be addressed as a community rather as an individual farmer's issue, hence requiring concerted efforts from the community for its effective control.
- Smooth running of community driven initiatives need laws/rules to guide them.
- Poor people are more receptive when they are involved in decision making, setting goals and evaluating their own progress. PDC and PM&E strategies are useful in this instance.
- BXW control need not be isolated; it should be integrated into ongoing activities and programs.
- BXW is a regional issue, currently affecting six countries, but all countries are not equally able to mobilise resources for management. Regional initiatives improve coordination and equity in distribution of resources.
- Government (all levels) need to be more closely involved in BXW management initiatives. The goodwill and support of local administration and leadership is essential for success.
- Communicating about BXW and crop issues is a complex and dynamic process. Each category of stakeholders has a unique way of accessing information which should be well understood by the communicator.

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.

A study on the impacts of BXW was commissioned by the International Development Research Centre (Project 102860-001) [5]. Another study was commissioned by DFIDs Crop protection Program (Project R8437, ZA0661) [6].

The studies were carried out in Central Uganda districts that have been drastically affected by the BXW

pandemic. Both were carried out in 2005 and obtained data from Mukono, Kayunga, Masaka and Sironko districts, covering a combined study sample size of over 450 respondents. Based on these studies projections suggest that, in the absence of resolute action, cumulative losses of banana production could mount to over US $4 billion by 2010, emphasizing the need for an investment of resources commensurate with the scale of the BXW threat. Some key findings were that since 2001:

- 40% reduction has occurred in the area under banana cultivation;
- 97% of respondents report a reduction in production of 65- 80%;
- 70% or more respondents observed reductions in production of Matooke and Kayinja, while other cultivars have also been affected;
- Labour needs to produce bananas has reduced by 70%;
- Number of Matooke traders in local markets have declined by >50%.
- Volumes of banana being marketed have reduced by 75% while the price has increased 50%;
- Changes in uses of banana have been reported in 90% of households, many socio-cultural uses of banana having declined sharply;
- The use of Kayinja bananas for making juice, beer or spirits has declined by more than 60% and cultivars previously used for brewing are now being used for eating;
- Weekly incomes of banana juice and alcohol processors has reduced by more than 50%.
- The study revealed that marketing of bananas and banana products in Mukono is dominated by women.

Another study completed recently was commissioned to evaluate the effectiveness of BXW management awareness campaign (see Kiiza et al, 2006 for USAID/DANIDA). The cross-sectional study involved collection of primary data from 405 farmers and 45 traders from 11 in-depth study districts, and 8 Focus Group Discussions from 4 districts. Empirical findings revealed that BBW is still a big threat across all regions and by gender. The majority of traders (83%) expressed the view that their sales volume had decreased since 2004 and BBW could be one of the factors.

[5] L. Aliguma and E. Karamura. Community Coping Mechanisms in Response to the Banana Bacterial Wilt: Effects in Mukono District. April 2006.
[6] Crop protection Program (Project R8437, ZA0661). Assessing the Impact of the Banana Bacterial Wilt, *Xanthomonas campestris* pv. *musacearum* (BXW), on Household Livelihoods in East Africa, 1 February 2005 – 31 December 2005.

21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) ***(max. 500 words):***

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*
- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*
- *Indicate the number of people who have realised a positive impact on their livelihood;*
- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

The USAID/DANIDA study has documented evidence of successful containment of the BXW outbreaks in most parts of South Western Uganda, specifically citing success in three out of the five sub-counties that were initially affected in Mbarara district; and in two of the four sub-counties in Bushenyi district. Isolated success stories are emerging in Mukono and Kayunga districts where BXW was first reported. Although the report does not provide empirical data it is expected these successes will lead to improved livelihoods through increased productivity of plantations and increased income. The IDRC and CPP studies documented household coping strategies including reduced food intake, reduced external expenditures on education, health and clothing, changing crop production (especially to annual crops), switching goods for transportation or marketing, abandoning and selling processing businesses, and migration to other areas. The studies found that implementation of cultural BXW management measures have reduced disease incidence to 3-8% and 1-28% in Mukono and Kayunga districts, respectively. The Uganda National Banana Program assessments reports indicate BXW is being successfully managed in Bukomero, Kiboga, Kimenyedde, parts of Mukono and Bamunanika, Luwero and Myanzi sub-counties and Mubende District. The success achieved is attributed to community action approach and peer pressure. In some cases, more than 60 farmers have recorded no disease from up to 80% BXW incidence within a year.

As progress is made towards reducing the impact of BXW it is expected household food security will increase and income restored to farmers. In Zirobwe subcounty of Uganda, one farmer who adopted strict debudding of his Kayinja plantation was able to increase his beer production ten fold within six months of strictly enforcing the practice.

In the DR Congo two studies by FAO [7] and INERA/UCG [8] found that BXW reduced production from an average of 20 tons per ha per year to zero; with income loss of 1600$ per year in the endemic zone while in the epidemic zone production and income was reduced by 50%. The loss of income from banana has caused a shift to sawing timber for wood production which has a negative effect on the environment. The impact has been felt widely, with school attendance falling.

Besides BXW management, in Kenya, adoption of improved *Fusarium* resistant varieties and IPM practices benefited 5000 farmers with banana yields increasing from an average of 8 to 30 tons /ha, 500 adopted modern ripening chambers that reduces post harvest losses by 30%, while 300 farmers adopted use of packaging crates and formed marketing groups which improves bargaining power and quality of marketed produce (KARI-Thika annual report 2004). 600 farmers trained through Farmer field schools are presently training more farmers and helping to further transfer IPM technologies.

[7] BAKELANA, K. and NDUNGO, V. (2004), La maladie de Bwere: une bactériose dévastatrice de la culture de la banane dans la province du Nord- Kivu en République Démocratique du Congo. Rapport de mission FAO 11pp
[8] NDUNGO. V., BAKELANA, K., EDEN- GREEN, S. and BLOMME, G. (2004), Un foyer de flétrissement causé par *Xanthomonas campestris pv.musacearum* en RDC, Infomusa, vol 13 n°2 p 43-44.

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

Banana *Xanthomonas* wilt outbreaks have led to significant reduction in incomes forcing people to look into alternative livelihoods. Some of the practices that are detrimental to the environment include:

- Felling trees for timber and charcoal production. In the DR Congo region of Masisi the increasing loss of banana acreage has been associated with a declining population of eucalyptus trees that have been felled and turned into timber for sale in Goma town. Transporters who were previously occupied with banana and banana beer transport have now turned to transporting timber. This scenario is replicated almost in all countries affected by BXW.
- Loss of income from banana has forced many farmers to turn to cultivation of vegetables, which in Uganda is associated with destruction of wetlands that are close to water sources and hence suitable for vegetable production. Production of most vegetables requires regular use of pesticides which could lead to pollution of water sources and soils. Some farmers, especially youth, have turned into brick making which is associated with significant mining of soils. Other farmers have turned
- Where banana have been lost to BXW farmers have turned to cultivating annual crops. These crops are not well suited for preventing soil erosion particularly on hillsides during rainy seasons and could lead to rapid soil exhaustion.

Successful management of BXW would support profitable banana based farming systems, which are necessary for an enduring and sustainably managed natural resource base.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

Banana flowers provide a habitat for various kinds of insects, which collect nectar and pollen, for their survival. It has been feared that massive debudding (removal of banana flowers) could destabilize the ecological niches of these insects and possibly lead to loss of biodiversity. However, most insects do not only visit banana flowers, and can gain the same benefits from other plants that are intercropped or grown in the neighbourhood of banana farms.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 200 words)***

The effects of climate change are already suspected to be unfolding in East and Central Africa. Increased incidence of banana bunchy top virus (BBTV) in Ruzizi valley (between DR Congo, Rwanda and Burundi) has been associated with prolonged dry periods in the last decade, suspected to favour increased populations and ecological adaptability of insects vectoring BBTV. BBTV was previously restricted to low altitudes (1000m),

but is now devastating bananas up to 1600-1700masl. Promotion of clean planting material and improved field management for BXW would contribute to management of BBTV.

Insect vectors of BXW are known to be more in the mid altitudes (900-1600masl) and less important in the high altitudes (>1800masl), e.g. eastern DRC, Rwanda and Western Uganda. It is however thought that changing climate can cause shifts in vector adaptability to the higher altitude agroecologies, leading to more insect transmitted infections. In the event that climate change results in the predicted shifts, the practice of debudding being promoted would find the vulnerable communities prepared to cope. Another effect likely to result in climate change is increased drought. Development and evaluation of BXW (and other pest/disease) tolerant varieties could consider drought tolerance traits.