Tissue culture removes obstacle to control of banana nematodes

RIU

Validated RNRRS Output.

To get rid of banana nematodes without using chemicals, farmers in East Africa had to uproot all infected plants, grow a break crop, and then replant with pest-free bananas. But, they couldn't be sure that the new banana plants were free of nematodes. Now, low-cost tissue culture removes this obstacle and makes mass plantings of disease-free bananas possible. The break crop plus tissue-culture plantlet method was proven by farmers in Kayunga and Kayanamukaka, Uganda. Their soils were badly infested with nematodes but they didn't want to use harmful pesticides. Now, a laboratory in Uganda produces 10 million plantlets a year by tissue culture. So, this technology has major potential for banana production in East Africa and for poor producers.

Project Ref: **CPP73:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **University of Reading, UK**
Source: **Crop Protection Programme**

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Geographical regions included:

Kenya, Tanzania, Uganda,

Target Audiences for this content:

Crop farmers,

Document Contents:

Description

CPP73

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.

Non-chemical control of banana nematodes in East Africa

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

Crop Protection Programme

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.

R6580 (1996 – 2000) Non-chemical control of banana nematodes in East Africa

The University of Reading S R Gowen), Kawanda Agricultural Research Institute (W K Tushemereirwe, J Namaganda, I N Kashaija, F Bagamba), National Resources Institute (R I Lamboll), Mukono District Extension Service

Related projects
R7567
R7972

*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 concept of planting disease-free bananas in land free of the principal **nematode** pest (***Radopholus similis***) was first suggested about 35 years ago. The method involves uprooting of all infected banana material from a plot, cultivation of a **non-host break-crop** for a period that will clear the nematodes specific to bananas, followed by re-cultivation with pest-free banana planting material. The technology for achieving this has become feasible with the increased availability of mass-produced disease-free plants (**micro-propagation**). The uncertainty of acquiring 100% **clean planting-material** was hitherto seen as the only serious obstacle preventing the removal of banana nematodes from farmers' fields.

The concept was validated by 40 farmer-participatory trials/demonstrations in Kayunga, Mukono District and in Kayanamukaka, Masaka District. Sites were selected on the basis of farmer interest in the non-chemical control technology and on very high nematode population levels in the soil. The socio-economic baseline survey showed that 93% of farmers had experienced declines in production from 15Kg to 6Kg per bunch, with the number of harvested bunches falling from 140 to 29 in a good year. At this early stage, farmers were very aware and

concerned about the decline in yield, but could only partially interpret the complex of causes, particularly the effect of nematodes.

Cassava (ACMV resistant) and **sweet potato** were the non-host crops chosen for use as the break crops.

On-farm and on-station technical outputs (field):
Banana nematode populations: Soil and root samples from on-farm field trials conducted with cassava and sweet potato break crops showed that the main banana nematodes (***Pratylenchus goodeyi*** and *R. similis*) could be cleared or significantly reduced. Screen-house bioassays with soil from re-planted bananas at 30 Kayunga trial sites (116 plots) following break crops, showed that 97% of plots were clear of these nematodes.

Training and dissemination:
Three project technicians were trained and were deployed in laboratory and field.

In excess of 300 farmers and other stakeholders were trained by the project in the non-chemical control of nematode technologies, with an estimated similar number being trained in or exposed to the methods or component technologies by project farmers and other trained stakeholders.

In previous work (CRBP Annual Report, 1994), the use of tissue-cultured Cavendish banana plants in re-plantings in Cameroon reduced the need to apply nematicides for the first 2 years of the crop, after which *R. similis* eventually returned, possibly from nearby banana plantations. Preceded by a non-host break-crop, it is likely that such soil might have remained free of these nematodes for much longer.

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

Bananas
The approach may be suitable for other higher value crops eg passion fruit, coffee
The use of a clean seed bed could also be applicable to lower value crops eg yam

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

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***					

*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**).*

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.

Management of nematode pests falls within the overall IPM package that banana farmers are recommended to adopt. Mulching and use of newly introduced disease-resistant varieties (R7567) and weevil management (R7972) and strategies for restricting the spread of banana bacterial wilt (R8484) and banana streak virus (R7529) through an improved understanding of their epidemiology and management.
The project should also be linked to other projects such as the regional IPM work managed by INIBAP

Clustering with **Linking demand for and supply of agricultural information in Uganda (R8281)** should be explored. This would provide a link with NAADS private sector service providers in Uganda.

Approaches to improving farmers access to information, training and new products (eg R8422). This includes novel learning and communication approaches and tools to improve farmers' understanding of important, but difficult to observe pests and diseases such as nematodes (eg participatory video with cocoa farmers R8448).

Links should be established with other initiatives making use of tissue culture/ micro-propagation (such as tree crops, fruits and flowers). Tissue culture is a relatively new technology that is relatively easy to establish. It is estimated that a laboratory could be established for US$ 50,000. Staff do not require to be highly trained; laboratories elsewhere employ secondary school graduates. There are commercial opportunities for such enterprises such as AGT in Uganda in other countries of the region

Within the poverty grouping as defined in the RUIP guideline, successful banana production in East Africa is most likely to be achieved by the " **moderate poor**". Benefits to the more deprived groupings will be dependent upon the regular supply of affordable fruit on local markets (though adoption of the recommended technologies). RNRRS and non-RNRRS outputs have highlighted the contemporary factors that farmers must consider

- Mulching- this once time-honoured practice has been neglected in certain districts (such as east and central Uganda). Productivity is best in mulched bananas as demonstrated in R 7567
- Use disease-resistant varieties; black Sigatoka is a recent arrival in east Africa. This disease slows

plant development and increases vulnerability to nematodes (and weevils). The FHIA varieties have demonstrated good disease resistance and tolerance to nematodes.

- Use in-vitro produced plants in new plantations, preferably in land where there has been a cassava/ sweet potato break-crop or where bananas have not previously been cultivated.
- Removal of the male flower from plants to lessen the incidence of bacterial wilt disease

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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)**.*

Project assessments and validations:
There were four assessments. A Baseline survey (Bagamba, 1997), an Intermediate socio-economic survey (Bagamba, 1999), an End of project socio-economic impact assessment report (Bagamba, 2000) and a Final report on socio-economic and uptake aspects (Lamboll, 2000). These summarised the overall impact of the project, highlighting positive achievements, together with uptake and adoption constraints.

Farmers took longer than scientists expected to internalise the break-crop concept and to learn about nematodes and their role in banana decline, although they were enthusiastic in promoting the benefits ie higher yields. The outputs have shown that even partial application the individual components of the technology (growing preferred non-host crops and replanting with tissue-cultured or non-infected planting material) can permit better yields because the pest-free young plants have the opportunity to become more hardy before pest populations can have a significant effect on growth and vigour.

Over 70% of farmers understood the main nematode problem by March 2000, but it had taken longer to reach this point than expected by the scientific team. A key reason was the invisible nature of the pest. There was general consensus that the quality, taste and density of the bananas was good, although the bunch and finger sizes were generally not exceptionally large. This was due to (i) exceptionally dry conditions at key times in the growth cycle; (ii) growing varieties in the trials which were not particularly high-yielding but were preferred and had been chosen by farmers mainly for post-harvest attributes and (iii) the crop was held back by adverse conditionsother pproblems including Sigatoka disease, drought and (iv) because banana re-planting was held back by dry conditions, the project came to an end before it was possible to achieve the higher-yielding harvests with 1st and subsequent ratoon crops (i.e., 2nd crop onwards). Shortage of CPP funds precluded an extension of the production-monitoring and nematode sampling component under the Benchmark Sites Project.

Demonstration plots of tissue-cultured banana planting material were established by the District Extension Service in Mukono. This is a good indicator of the interest (and uptake) in this technology and of a commitment to continued banana production in the district.

Most farmers accepted the principle of growing disease-free tissue-cultured planting material, but of their preferred local banana varieties. Unfortunately, these did not show significant increases in yield in these trials because of the adverse growing conditions (drought). By the end of the trials, it was found that farmers were prepared to grow higher-yielding bananas such as FHIA varieties developed by the National Programme. These should be evaluated in future adaptive research programmes.

These Improved cultivars were evaluated with farmers for resistance to Fusarium wilt and leafspots, yield and farmer acceptability. Cultivars e.g. FHIA 17, FHIA 23, FHIA 1 AND FHIA 5 were selected by farmers for use as dessert and juice/gin production respectively. The large numbers (14629) of planting materials of these cultivars distributed to 715 beneficiaries (12% of the local community at one of the sites) reflects the value attached to them by these farmers. Also the on farm gate prices for these cultivars have been increasing significantly for example, an average bunch of FHIA 17 increased from Ug sh 2000= to 5000= (109.7) increase implying an increasing demand.

The arrival of BXW disease has had implications for the implementation of nematode control through the removal and destruction of BXW infected plants and the parallel recommendation for planting break crops such as cassava and sweet potato which have not been found to be hosts of BXW either. In cases where BXW is very severe, complete removal of banana plants and replanting with a non-host crop has been recommended. Use of clean planting material for re-establishment of the banana plot should be a component of the **total banana IPM package**

Who

In Uganda NARO, IITA, MAAIF, INIBAP, NRI, farmers, Universities (both local and international) are responsible for generating technologies. Although the research/MAAIF teams in many cases initiate these trials/ demonstration plots, farmers are facilitated to record, analyse and report what they observe in their fields as they control pests and diseases. This encourages them to put in more effort in pest and disease control. The MAAIF, Extension staff, NAADS NGOs and research teams are responsible for delivering technical information to the farmers. The local governments are responsible for mobilising the farming communities, incorporating pest and disease control activities in district, sub-county workplans and also supervision of technical staff. MAAIF, NARO, Local governments are also responsible for instituting the enabling policies and regulatory framework to support the pest and disease control programmes.

In Kenya technologies will be validated by KARI with the supervising scientists coming from the National Research Centre, Thika which has the national mandate for conducting research in horticultural crops. IPM banana technologies for management of banana weevil and nematodes developed under R8342, R7567, R7529, R7972 was validated by the Kenya Agricultural Research Institute (KARI) on farmers' fields in Central province (Muranga and Maragwa districts), Kenya. Cultivars were screened for resistance to Fusarium wilt, those found resistant were multiplied through tissue culture and distributed to farmers to replace the susceptible Gros Michel and the apple banana. This was done by KARI in Central and Eastern provinces with funding from USAID and

IFAD. Farmers were taken through farmer field schools (FFS).

*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)**.*

Beyond Uganda, there have been programmes of importation, validation, mass propagation and dissemination of clean planting material of superior banana cultivars in Kagera, Tanzania, through the Kagera Community Development Program (KCDP). These included a number of the FHIA varieties and Yangambi Km5 investigated and disseminated under R7567, R7972 and R8482. Varieties were validated on-station and on-farm by researchers from ARDI Maruku and farmers supported by KCDP staff, with non-governmental organizations (NGOs), primary, schools, district departments of agriculture and progressive farmers facilitating dissemination by establishing nurseries and multiplication plots. The International Network for the Improvement of Banana and Plantain (INIBAP) International Transit Centre (ITC), Belgium, provided *in vitro* plants. By 2002 it was estimated that one million suckers had been provided to farmers in the region.

In Kenya IPM of banana and distribution of clean planting material (tissue culture) is currently going on in dry parts of Eastern Province under irrigation (Meru south, Tharaka and Machakos districts) where there are moderate poor, extreme dependent poor and extreme vulnerable poor. Six hundred farmers in 20 farmer groups have so far been trained.(Funding agency :IFAD-$0.3M)

Current Situation

C. Current situation

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

Attempts have been made to link farmers with improved banana cultivars to both local and regional markets. The new cultivars (FHIA 17, FHIA 23) were tested on local markets (Kampala) and regional markets (Kenya, Rwanda). Results show that these two cultivars have acceptable attributes as dessert and are better replacements of Gros Michel, currently a commercial variety threatened by fusarium wilt. These cultivars are already being sold on roadsides of roads from Mbarara, Bushenyi and Luwero and in Kampala markets. There is need to organise farmers to produce in large volumes for the huge market potential that exists especially on the regional markets and increase on their promotion.

Awareness has been created about IPM technologies using mass media (electronic and print), posters, brochures, billboards and going public. Participatory methods such as participatory monitoring and evaluation, participatory development communication and community action have been used to get communities to control diseases such as BXW. NGOs, Extension staff and Research staff are mainly concerned with delivery of

technical information; local leaders are better placed for mobilisation of the farmers for community action. The farmers are at the centre of all these processes including implementing control, mobilising or communicating to fellow farmers.

AGT is the first Commercial agro biotech laboratory in Uganda and is the biggest tissue culture laboratory in East and Central Africa, with the capacity to produce up to 10 million plantlets per year. http://www.agtafrica.com

Technology dissemination through trainings (farmer groups, training of trainers, individual farmers, nursery operators (TC banana hardening nurseries), distribution of banana production brochures, technical backstopping in farmer (individual or group) banana production enterprises, Field days, Agricultural shows (Trade fares), Farmer field schools, training on banana processing and value addition to interested parties, on station and on farm banana demonstration plots, visits to the research centres by farmers, traders, politicians, local leaders, school children and academic attachments for university students.

Whom: NARs, MOA, NGOs, CBOs, Politicians, individual farmers, farmer groups, banana traders.

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).***

Improved banana cultivars are being used in Luwero, Mbarara and Bushenyi as dessert, juice and food. Mostly these cultivars have revived the opportunity of central Uganda to supplying dessert bananas not only to its urban markets but also to the regional markets. Results from two regional markets i.e. Nairobi (Wakulima Market) and Kigali (Nyamirambo and Kyibisagara) indicated that the two introduced dessert bananas (FHIA 17 and FHIA 23) had market acceptable dessert banana quality attributes and fetched relatively high prices. For example, in Wakulima market in Kenya, an average cluster of 16.6 fingers of FHIA 17 was sold at ug sh 1660, while cluster of 18.7 fingers of FHIA 23 was sold at ug sh 1875 respectively implying an existing market potential.

The large numbers (14629) of planting materials of these cultivars distributed to 715 beneficiaries and the increasing prices of improved bananas on farm and the positive response from the local and regional markets indicates a great success. However, production capacity of the farmers is still low to satisfy the existing market potential on the local and regional markets. Much work needs to be done on creating awareness among the urban consumers and promoting them to the regional markets.

In Kenya, most of the developed banana production technologies have been disseminated and adopted in the Central and Eastern parts of the country although not all the areas are covered. This region only accounts for 24 % of the banana production. 64% of banana production is from the western region where BXW has now been reported. Banana management in the region is poor as no technology dissemination has been undertaken in the region.

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

See above

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).***

The Kenya Agricultural Research Institute (KARI) and the Ministry of Agriculture under the Agricultural Technology Intake and Resource Initiative (ATIRI) have funded 2 banana growing groups (500 farmers) in Central and Eastern Kenya to promote banana as a commercial enterprise through technology dissemination. This programme is currently funded by the World Bank through the Kenya Agricultural Productivity Project (KAPP). The coordinating institution is KARI. Farmer groups identify the technology, write proposals through their respective MOA offices, the proposals are accessed by a regional and national a steering committee. Those that qualify receive funding directly to the group account. The backstopping scientists are facilitated by the farmers as need arises (timing 2005-2010).Under IFAD, distribution of pest and disease free planting material (tissue culture) has been promoted.

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).***

In Kenya, through the C3P project, technologies developed in Uganda for control of BXW will be validated and used in Western Kenya. Awareness creation (posters, brochures, going public, media) will be undertaken in the disease free areas of the country. It is anticipated that the C3P initiative will widen to include all recommended technologies.

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)****.*

In Kenya:

- Poor coordination between extension and community or community-based groups
- Knowledge among service providers is lacking
- Ratio of Extension workers to farmers very low (1:15,000 on average)
- Lack of funds to mobilise them
- Lack of early warning and response system for diseases
- Political interference

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).***

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).

This will be particularly relevant for Uganda and also for Tanzania.

- Mobilisation
- Community action
- Community by laws and ordinances
- Participatory methods
- Coordination structure at national level
- Integration of IPM strategies into ongoing activities (IFAD, ATIRI, KAPP-Districts) for cost effectiveness.
- Sharing experiences between countries
- Mobilising resources at regional and country level

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.

The importance of bananas among other food and cash crops is represented in Table 1.

Table 1. Ranking of food and cash crops in selected banana/coffee farming systems of Tanzania

Rank	Kagera (Karagwe)	Arusha (Alumeru)	Kilimanjaro (Hai)	Mbeya (Rungwe)
Food crop				
1.	Bananas	Bananas	Bananas	Bananas
2.	Beans	Maize	Maize	Maize
3.	Maize	Beans	Beans	Round potatoes
4.	Round potatoes	-	-	-
Cash crop				
1.	Coffee	Maize	Maize	Tea
2.	Bananas	Bananas	Tomatoes	Bananas
3.	Beans	Coffee	Bananas	Coffee
4.	Maize	-	Beans	
5.	Round potatoes	-	Coffee	-

Source: Nkuba, et al., 2003

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*

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.

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

No

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)***
