C3P

Crop Crisis Control Project

REDUCING FOOD INSECURITY THROUGH TECHNOLOGY TRANSFER: MACROPROPAGATION

Experience in BXW Worst Hit Areas of Uganda

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Brief 7

Background

Uganda is among the world's leading countries in terms of banana production and consumption. Bananas occupy the largest cultivated area among staple food crops in Uganda and are primarily grown on small subsistence farms (plots of less than 0.5 ha). Over seven million Ugandans, including about 65% of urban dwellers, depend on the crop as a staple. It is estimated that 75% of Ugandan farming households grow the crop on about 1.5 million hectares, which accounts for over 38% of the arable land that is utilized. Major banana production in Uganda occurs in the central and western regions (91% of total banana production).

In addition to being a major food staple, bananas are an important source of income, with excess production sold in local markets. Average per capita annual consumption of bananas in Uganda is the highest in the world, estimated at close to 1 kg per person per day. Bananas are consumed as fruit; prepared by cooking, roasting, or drying; and fermented for the production of banana juice and alcoholic beverages (beer, wine, and gin) (Edmeades et al. 2006). Unfortunately, production has been on the decline in the central region, which is one of the traditional banana-growing areas (Gold et al. 1999). The most drastic reduction in production has been attributed to the Banana Xanthomonas wilt (BXW) pandemic.

BXW was detected for the first time in central Uganda in Mukono district (Tushemereirwe et al. 2003) and Kayunga in August 2001. The disease spread rapidly within three years of its emergence in central Uganda, developing into a full blown epidemic spreading throughout the eastern,

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central and southwestern districts of the country. The BXW outbreak presents a considerable threat to banana production in Uganda, endangering the livelihoods of about 3.5 million Ugandan farming households. The disease has been found to be very destructive with incidence of 70–80% in many plantations (Kizza et al. 2006).

Eden-Green (2003), in Kizza et al. 2006, reported that BXW reduced banana output from 36 to 3 bunches per month per farmer in Ntunda subcounty, Mukono district, in central Uganda. In terms of value, the loss was estimated at 495 USD per annum per farmer based on a price of 1.25 USD per bunch. Similarly, he also found that the epidemic reduced a farmer's harvest by 19 bunches per week in Budadiri (Mbale district) leading to a loss of 555 USD per annum per farmer. This shows that the epidemic can lead to yield losses of about 90%.

Following the BXW outbreak in 2001, the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) constituted a task force to formulate a strategy to eradicate the disease. An action plan emphasized cutting and burying infected banana stools, restricted movement of banana materials, decapitation of male flower buds, disinfection of tools, and creation of awareness. The efforts to contain the disease focused initially on the affected villages in the two districts of Kayunga and Mukono.

In 2003, the disease was found to be more widespread than previously thought, requiring the formulation of a new strategy. This new strategy emphasized the need for national surveys, research on the disease and its control measures, and for large scale information and sensitization efforts to increase farmers' awareness of the disease, and their capacity to manage it. The main responsibility for carrying out control measures lay with farmers and the role of the Government of Uganda was seen as facilitating and coordinating. The response tactics to be used included: protecting unaffected areas by halting disease in frontline areas, promoting the exchange of clean planting material, and using participatory development communication tools (brochures, videos, posters, calendars), particularly in the endemic zones.

In 2005, the International Institute of Tropical Agriculture (IITA) introduced and demonstrated a new macropropagation technology for multiplication of banana plants at Namulonge Agricultural Research Institute (NARI). Trials were being carried out using local varieties to improve macropropagation as an alternative method for producing clean planting material that would be affordable to small-scale farmers. The

Picture 1: *Participants of regional training prepare corms for the macropropagator*

Picture 2: *Participants prepare for potting of plantlets from the macropropagator*

technology was first developed and established in Nigeria (2000) and Cameroon (2002) with the support of IITA, USAID, and the Ministry of Agriculture of Cameroon. Owing to its success in the two West African countries, coupled with the trials done by IITA at NARI, the technology was scaled out to farming communities within the Great Lakes Region via C3P.

Macropropagation is viewed as better than tissue culture, considering it is highly unlikely that farmers will develop the capacity to do in vitro micropropagation (tissue culture) which is more expensive and requires specialized facilities that are not readily available. Micropropagation (i.e. meristem/tissue culture) assures more rapid production of planting materials but also requires more sophisticated techniques, skills and care to handle the material (Vuylsteke and Talengera 1998).

Initially, CRS-Uganda and the project partners advocated the use of micropropagation (tissue culture) for rapid multiplication of clean suckers to replace the banana plantations which had been destroyed by BXW. However, while tissue culture as a method of generating planting materials has the advantage of a higher rate of multiplication, producing plantlets with greater uniformity, giving faster establishment and vigor (Vulysteke 1998), it is still poorly developed in Uganda with only one practicing laboratory, Agro-Genetics. Also, micropropagation is expensive and highly inaccessible to the subsistence farmers who are the major stakeholders in the production of bananas.

Macropropagation on the other hand, offered a much better option which was relatively simple and required minimum investment, making it user friendly to the small-scale farmers and easily adaptable by the entire farming community.

The Crop Crisis Control Project (C3P), in partnership with international organizations (IITA, World Vision) and local development organizations like Caritas Kasana-Luwero, and Caritas Lugazi, favored the transfer of the macropropagation technology to farming communities who needed many healthy suckers within a relatively short period of time to re-establish their plantations previously destroyed by BXW such as in Mukono, Kayunga, Luwero and Mbale Districts. In these locations, farmers still use the traditional propagating method, which depends on natural regeneration of plants for the supply of planting material, a process that is slow and produces only a small number of suckers. This is inadequate in meeting the current farmers' demand for planting material to replace the massive loss of banana plantations to BXW.

METHODOLOGY

Targeting the intervention

In 2006, the Crop Crisis Control Project, managed by Catholic Relief Services (CRS), teamed up with the National Banana Research Program (NBRP) to develop a strategy for responding to the BXW pandemic in the endemic areas of Luwero, Nakaseke, Mukono, Kayunga and Mbale districts which were worst hit by BXW and where the food security of households were most threatened. Technical backstopping was provided by IITA and Bioversity International.

The districts of Mukono, Kayunga, Luwero and Mbale were chosen as target areas for C3P. This was also in line with MAAIF's criteria for prioritization of action on BXW where the districts were characterized as severely endemic[1] (Verbal communication, Dr. Caroline Nankinga, NBRP, 2006).

Most interventions had been focused in threatened and frontline areas due to funding limitations. More effort was still required in the endemic areas to strengthen ongoing efforts by scaling out. The strategies that C3P employed included: community sensitization using Participatory Development Communication (PDC) tools, training on control and management of the disease, dissemination of clean planting material, and intensive de-budding and removal of affected plants.

Training of partner extension staff

Training on banana macropropagation was carried out at three tiers. The first tier training was at the regional level with three extension staff members drawn from partner organizations within the six C3P countries of Uganda, Rwanda, Tanzania, Burundi, Kenya and the DRC. The aim was to equip extension staff with skills on rapid multiplication of healthy banana seedlings. The training was organized by CIALCA (Consortium for Improved Agriculture-based Livelihoods in Central Africa), IITA and CRS; it was hosted at NARI and facilitated by trainers from IITA Uganda and Cameroon.

The major objective of the training workshop was to train partner extension staff on different techniques of producing low cost clean planting materials as one of the control measures to combat BXW. Participants were given both theoretical and practical training on the different stages in banana seed production. A manual was given explaining the field techniques of complete or partial decapitation, and detached corm techniques. These techniques involve stimulating lateral bud production by destroying the active growing point (meristem) in the pseudostem. They increase sprouting and sucker multiplication in the field and are simple to understand. With minimum investment germination chambers (macropropagation chambers) and weaning facilities (nurseries) can be established at farm level.

The second tier training in Uganda was done by the partner extension staff in their different districts (see Table 1). This training was carried out at district level and participants were community based trainers (CBTs) drawn from 16 subcounties in five districts where BXW had been experienced. In total 164 extension workers and CBTs were trained in macropropagation and BXW control. A locally translated macropropagation manual was used in these trainings. However, it remains to be officially recognized and published for use by the wider community.

Table 1: *Farmers and extension workers trained in macropropagation skills*

District	Extension workers / CBTs trained				Farmers trained			
	Target	Actual number trained			Target	Actual number trained		
		Female	Male	Total		Female	Male	Total
Luwero and Nakaseke	45	32	62	94	1500	353	407	760
Mukono and Kayunga	30	8	25	33	600	1020	1082	2102
Mbale	30	7	30	37	400	450	395	845
Total	**105**	**47**	**117**	**164**	**2500**	**1823**	**1884**	**3707**

1 Mukono/ Kayunga: BXW prevalence in cooking bananas 24%, in Kayinja bananas 66%.
Luwero: BXW prevalence in cooking bananas 18%, in Kayinja bananas 32%.
Mbale: BXW prevalence in cooking bananas 12%, in Kayinja bananas 22%.

Picture 3: *Mbale CBTs in a participatory monitoring event*

CBTs performed the third tier training, with the participants being farmers (picture 3). In total 3707 farmers were trained on macropropagation techniques at the macropropagation chamber sites and mother gardens that have been established at subcounty level. During the farmer trainings, emphasis was placed on the use of the false and complete decapitation techniques The false decapitation method involves cutting a small hole in the pseudostem, the "trunk", of a six-month old plant to destroy the actively growing point, "meristem". The plant is left to stand for at least one month to allow sprouting. After sprouting of the suckers, they are detached immediately once they attain three to four leaves (at a height of 20 to 30 cm), and transferred directly to the field. This method enables farmers to get suckers from a plant in the field without necessarily having a macropropagation chamber. It has been especially beneficial where farmers are reluctant to detach corms or where they live far from where macropropagators are located. On the other hand, complete decapitation involves cutting off the pseudostem and destroying the apical meristem by drilling to break apical dominance.

Farmer utilization of macropropagation technology

The turn-up for trainings and the response to the macropropagation technology by farmers has been overwhelming. Actual numbers trained have so far exceeded targeted numbers due to the interest that has been shown by the farmer communities (see Table 1). Farmers from Mbale World Vision and Mukono Farmers association have even gone ahead to carry out demonstrations. The technology was exhibited by C3P at an agriculture trade show in Jinja (16–21 July 2007). Dr. Caroline Nankinga Kukiriza, one of the people who visited the show, wrote: "I was impressed to see farmers demonstrating the technology after such a short time of exposure since the C3P project had just started. This shows excitement and indicates probably that farmers are expecting a lot from this technology."

Though the C3P project was only in existence for 18 months, spillover of the macropropagation technology from targeted areas to neighboring areas has been seen. For instance, Caritas Uganda, though not part of the C3P project, after visiting the Caritas Lugazi macropropagation sites, has constructed a macropropagator in Buwama subcounty in Mpigi district. Also, the District Agriculture Officer in Mbale, after receiving training on macropropagation through the World Vision C3P staff, has established a macropropagation farmer site in Bukonde subcounty, which was not one of the C3P intervention areas. He is positive that this technology will be effective and plans on expanding to another four subcounties in Mbale district.

Establishment of macropropagation sites

Sites have been established in 16 subcounties in Uganda. Each macropropagation site consists of a a mother garden (picture 4), a hardening shade or nursery (picture 5) and a macropropagation chamber (pictures 7, 8, and 9). Suckers for the mother gardens were derived from tissue culture to ensure that there is a clean source for corms to feed the propagators in the future. However, to start off the project it was necessary to identify clean sources of corms to feed the macropropagators. This means that proper identification and certification of farmer fields to supply corms for propagation had to be carried out before the banana corms could be transplanted to the farmers' fields or be fed into the propagators. A certification protocol was developed by IITA and used to certify 19 farms as clean sources of corms.

Farmers selected to host macropropagation sites were identified through a situational analysis exercise. The criterion for selection of farmers was that the farmer had:

1. to show a progressive attitude towards new techniques,
2. to be willing to implement new management practices recommended,
3. to be a member of an existing farmer group and be selected and proposed by the group,
4. to be ready to train other farmers and to host other farmers at the site for training,
5. to possess at least one acre of farm land.

Picture 4: *Mother garden in Busaana subcounty*

Picture 5: *Nursery shade for hardening plantlets*

Table 2: *Location of macropropagation sites and mother gardens*

District	Subcounty	Village
1. Mukono (shaded light blue)	Naama	Kikikwa
	Nabaale	Nagalalama parish
	Nyenga	Nyenga
2. Kayunga (shaded light blue)	Nazigo	Bugiri
	Busaana	Namkuma
	Kangulumira	Kangulumira parish
3. Luwero (shaded grey)	Kikyusa	Kikyusa
	Makulubita	Bakijulula
	Luwero	Bweya
	Butuntumula	Kasaala
4. Nakaseke (shaded grey)	Kapeeka	Kapeeka
	Semuto	Kasaana
	Nakaseke	Kiziba
5. Mbale (shaded green)	Namanyonyi	Kilulu
	Bukonde	Buleweta
	Nakaloke	Namunsi

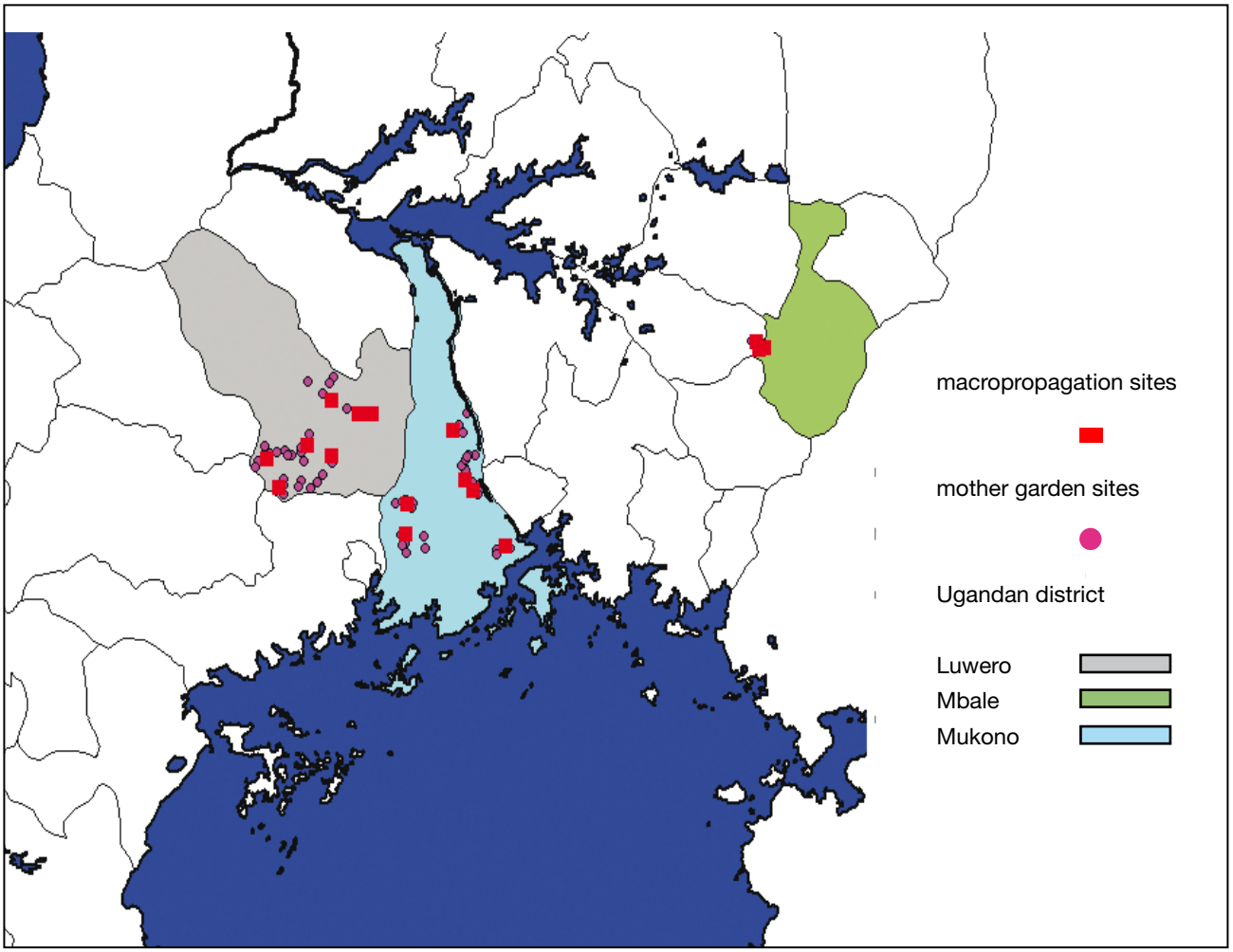

Figure 1: *Map of the location of macropropagation sites and mother gardens in Uganda.*

Figure 1 and Table 2, show the location of different macropropagation sites and mother gardens. Sites are made up of a macropropagation chamber, a nursery shade and a mother garden. The aim of having a great number of sites was to ensure accessibility for many farmers in the targeted areas to clean material. In total, 87 mother gardens (each 0.3–0.5 acre) have been established with the purpose of feeding the macropropagation chambers.

Macropropagators were constructed with cheap, locally available materials. Field visits to the different sites have revealed the variability in designs and adaptations that were made by the partners. It is interesting to note that although all the extension officers trained during the regional training used the same facilities during training, there was variation in the final designs by different partners (see picture 6, 7, 8, 9). Some of the partners have also realized ways of improving the efficiency of the macropropagators as well as increasing their capacity by reducing the height of the poles and making side extensions as can be observed in macropropagators in Luwero (picture 9).

Inside the macropropagators, the chambers are kept under controlled humidity and controlled temperature (60–70% humidity and 32°C). The chambers typically consist of a framework covered by transparent plastic sheets (picture 6, 7, 8, and 9). The framework that covers the bed is built of concrete or wood. The beds are ¾ filled with a steam-sterilized substrate where the corms are planted (picture 10, 11 and 12).

Filling of chambers

The whole process of filling and planting of corms in the macropropagators was performed by farmers during farmer trainings on macropropagation. The groups participated in sterilizing the soil and sawdust, fetching firewood, and watering. A certification protocol formulated by IITA was used to certify farmers' fields in the districts of Wakiso, Mubende, Sembabule and Luwero from which the clean corms were obtained to feed the propagators.

Memorandums of understanding (MOU) – to specifically address issues on ownership, related to plantlets emerging from the sites – were drawn up between the partner organizations, farmer groups and farmer hosts to avoid any misunderstandings that could arise during the distribution process of plantlets produced from the propagators.

Picture 6: *The standard design demonstration macropropagator at IITA Namulonge.*

Picture 7: *Macropropagator in Mbale*

Picture 8: *Macropropagator in Mukono*

Picture 9: *Macropropagator in Luwero*

Picture 10: *Beds for planting corms.*

Economics of macropropagation vs. tissue culture

A comparison of the costs involved in macropropagation and tissue culture has shown that macropropagation is a more cost-effective method of multiplying clean planting material among farmers.

An analysis of costs involved in macropropagation and tissue culture was derived from actual costs incurred by two partners, Caritas Lugazi and Caritas Kasana Luwero. Based on thes partners' costs it was projected if a macropropagator were to operate for one year, the average cost of a plantlet emerging from the propagator would be USD 0.25 in the first year of operation compared to the average cost of one tissue-culture plantlet of USD 0.9. This confirms that macropropagation is more cost-effective than tissue culture.

Lessons learned

1. Macropropagation technology can be adapted to different situations as can be seen from the various chamber designs; farmers can help modify technologies to suit their situation. The use of inexpensive materials can encourage farmers to replicate technologies.

2. NGOs can be very effective in passing technologies from research institutions to farming communities. Promoting synergy between NGOs (CRS, Caritas, World Vision) and research institutions (IITA, Bioversity, NBRP) can be beneficial to the farming communities and also to achieving the objectives of each of the institutions.

3. Certification of farms for corm procurement and a good validation process before material goes out to

Picture 11: *Plantlets in macropropagator.*

a field/farmer is critical for the success of producing clean material from macropropagators and for avoiding re-infection once the plantlets are in the fields. The process needs to be emphasized and needs considerable preparation and strict guidelines to ensure the spread of clean material to new sites.

4. Trainee selection is very important if information and skills are to be passed on to farmers. The trainees selected at the extension officer level should be those that actually interface with the farmers and speak and understand the local languages.

5. Macropropagation sites should be located near water sources to continue to have sufficient access to water in case of drought and farmers should be taught innovative ways of irrigating plants.

6. Sites at farmer/household level are more easily managed than those at institutional level. Farmers tend to fully own sites at farmer level and even offer to weed and water plants without being subsidized.

7. Memorandums of understanding should be formulated early in the project to avoid misunderstandings. The MOUs should clearly spell out roles and responsibilities of different actors. They should be formulated in consultation with the farmers who will use them in the local languages so that they are fully understood.

8. The approach of using groups ensures that there is both collective responsibilitiy and division of duties. Group ownership increases the sustainability of the activities.

9. It is much cheaper to produce plantlets through macropropagation than by the procurement of tissue-culture plantlets. Other methods of macropropagation such as complete and false decapitation need to be emphasized as well, as they can be executed by the farmers themselves in their fields; they are cheap and do not necessitate the use of a macropropagator.

Conclusion

Experience with C3P macropropragation technology in Uganda has shown that it is a very promising method for rapid production of clean banana suckers to re-establish healthy banana plantations in BXW-affected areas. To continue this effort, an intensive program of follow-up and continued training and support is urgently needed.

Picture 12: *A farmer sterilizing sawdust and soil.*

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