

CHAPTER 12

Banana tissue culture: community nurseries for African farmers

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Abstract

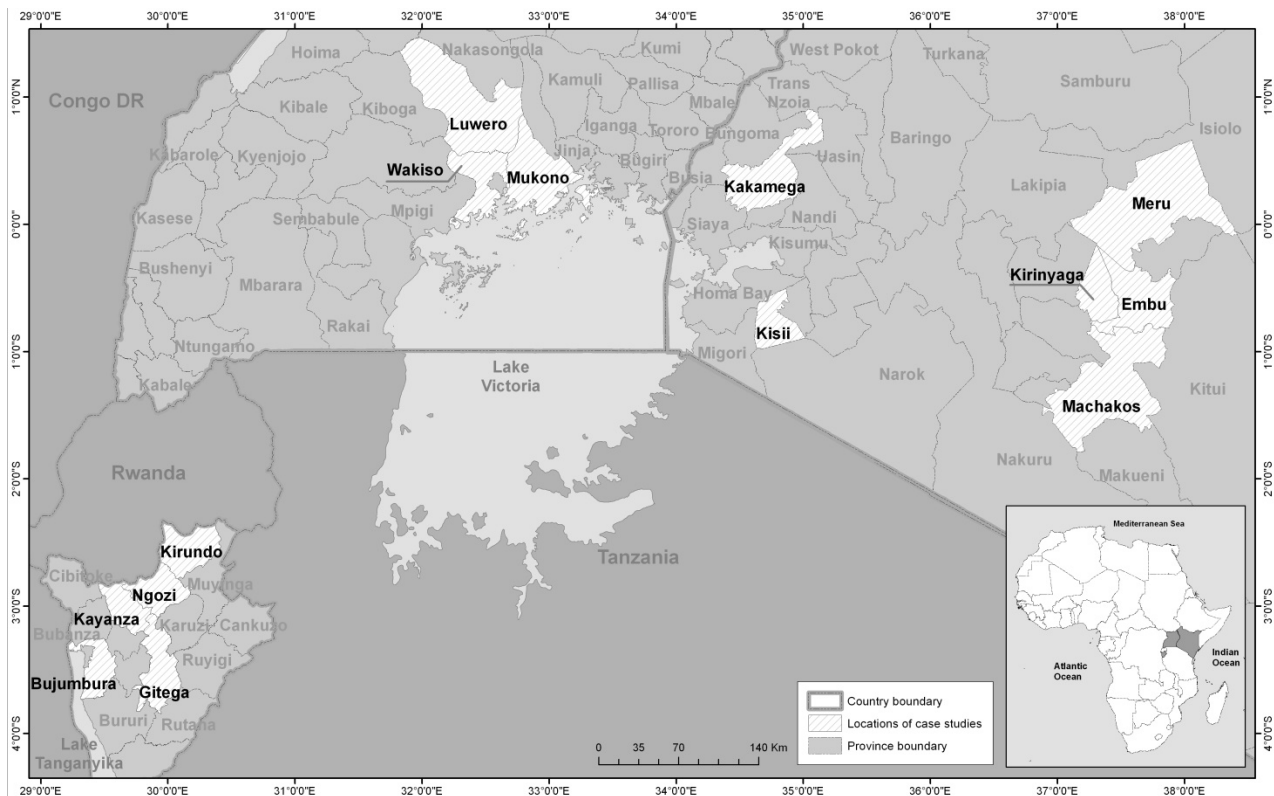
This project was carried out in three countries—Kenya, Uganda, and Burundi—to get disease-free, TC banana plantlets to farmers. Private companies were already producing TC banana plantlets, but there was no channel to distribute them to farmers. The project established community nurseries to receive the in vitro-plantlets, wean them, and harden them (i.e., grow them outside of the flask until the plantlets are big and strong enough to be transplanted to farmers' fields). Eleven new community nurseries were established in Uganda and Kenya to buy the in-vitro plants, harden them, and sell them to farmers. The most successful community nurseries were the ones near their source of TC plantlets and near their farmer customers. About 1,000 farmers were trained to transplant TC bananas to the field and care for them. Although the banana plants are disease free when removed from the flask, they are not disease resistant, and can become infected. The plantlets need extra care when transplanted (e.g., more water and fertilizer). TC was profitable for farmers who were near an urban market, which allowed them to earn higher prices for their harvested bananas. On the other hand, TC plantlets were not profitable for remote farmers.

Rationale

Tissue culture of bananas is a relatively new technology in East Africa. It allows banana planting material to be cleaned of pathogens, especially *Xanthomonas* and other bacteria. BXW is a new and serious pest of bananas in East Africa. When the project started, there was no real pathway for TC plantlets to get from the producers to the farmers.

1. The intervention

Banana is a staple food crop in the East African Great Lakes region (Burundi, Rwanda, northeastern DR Congo, Uganda, Kenya, and Tanzania). Because bananas are perennial and can be harvested year round, the crop is popular with smallholders. However, since the 1970s, banana yields in the region are low and stagnating, largely due to pests and diseases and declining soil fertility (MoA 1994; ISAAA 1996). Most small-scale banana growers plant new gardens with suckers from old plants, exacerbating pests and diseases. Moreover, suckers are bulky, making it slow to disseminate improved varieties.



TC banana planting material is clean and permits rapid dissemination. TC-planted bananas are uniform, harvested early, and the fruit is highly marketable. Specialized private companies can multiply planting material by using TC. And although TC plants are superior to suckers, their success depends on correct management by farmers and demands efficient community pathways to distribute this enhanced planting material.

In January 2008, a new TC banana project aimed to improve the livelihoods of small-scale banana growers in East and Southern Africa by developing improved market pathways to deliver high-quality TC plants based on private partnerships supported by improved institutional policies. Private companies were producing and selling TC plants as a business. All of the TC material distributed to farmers was of the Cavendish varieties, which are the main ones sold in supermarkets. They were old varieties, and not resistant to BXW.

The project had six objectives: (1) produce uniform and high-quality planting materials; (2) supply TC planting material to small-scale farmers through farmer-managed community nurseries; (3) create a training program so smallholders could manage TC planting material in the field; (4) give farmers a new source of clean planting material; (5) establish farmer cooperatives linked to community nurseries; and (6) create new, larger, and dedicated markets for farmer cooperatives. Six countries were targeted: Burundi, Kenya, Mozambique, Rwanda, Tanzania, and Uganda. A three-year study (January 2008–December 2010) for these objectives was conducted in Burundi, Kenya, and Uganda, and is the subject of this chapter.

Theory of change

At the start of the project, TC material was not readily available due to weak dissemination channels. The project proposed research to establish efficient dissemination and distribution, based on community nurseries.

Scaling up

A successful TC satellite nursery model was developed in Kenya and later used in Uganda. TC nursery operators and farmers were trained in TC banana weaning (293 trainees), and about 1,000 farmers were trained in TC banana production in the three countries.

Before they can be planted in the field, the plantlets produced by TC laboratories need to be weaned and hardened. The plantlets are weaned by putting them in a humidity chamber until they are 4–5 cm tall, then placed in large bags and hardened in a shaded nursery until they are 20–50 cm tall. The TC plantlets are free of bacteria and fungi, but they can carry viruses. Intensive testing (by certified indexing centers) is needed to be reasonably confident that the plantlets are virus free (Vézina and Dubois 2015). But once in the field, TC bananas can be easily re-infected with disease. The project produced a training manual for farmers, suggesting weeding, watering, and extra fertilizer to strengthen the plant. The manual also recommended removing the male bud of the plant (to prevent bees and other insects from foraging for pollen in the male flower, which can infect the plant with bacterial wilt) (Lule et al. 2013).

As a result of the project, 11 new nursery businesses were established in Uganda and Kenya. The TC nurseries were successful because they were near their suppliers (the laboratories that produce TC plantlets) and they were in the communities where the farmers bought their plants. A cost-benefit analysis of nurseries in Uganda revealed profits of about \$0.25 per plant, which increased as more plants were sold. The 11 new FGs were able to access credit. The impact of training was assessed on 87 farmers' fields over two crop cycles in Burundi and Uganda, revealing a doubling in yields for farmers who grew TC banana and received training, compared with control farmers. Trained TC farmers who were in groups tripled their revenue, compared with controls.



After the flask: TC bananas are delicate, and must be “hardened” in nurseries before planting in the field. Photo by Jeff Bentley.



A poster in Uganda shows BWX symptoms, and urges farmers to twist off the male flower with a forked stick.

Photo by Jeff Bentley

Framework: Banana tissue culture in East Africa

Stakeholder	Availability/ supply	Accessibility			Quality, variety (incl. biodiversity)	Health, genetic purity, physiological age, & physical quality
		Delivery channel features	Affordability/ profitability issues	Info to create awareness & demand		
Polymakers						Project was allowed by existing policy
National research	NARO provided some TC material in Uganda					
International research		Project trained labs, nurseries, farmers		IITA wrote 2 manuals for farmers	Existing, commercial varieties	TC cleans material of disease
Traders (local markets)						
Private seed sector	TC labs produce in- vitro plantlets	Labs sell TC plantlets to community nurseries				
Farmer organizations	Community nurseries bought plantlets	Nurseries harden the plantlets to sell to farmers	Nurseries are cited near labs & farmers			
NGOs and national extension				Extension trained farmers to use TC bananas		NAADS (Uganda) KARI, JKUAT* (Kenya) trained farmer
Private sector processors				Thriving market in fresh bananas & plantains		
Seed users	Bought plantlets from community nurseries		TC plantlets are profitable for farmers near markets			

*NAADS is the National Agricultural Advisory Services. KARI is the Kenya Agricultural Research Institute and JKUAT is Jomo Kenyatta University of Agriculture and Technology. NARO = National Agricultural Research Organization.

2. General context

Farming systems

Most of the banana varieties grown in the East African highlands are endemic. The region is a secondary center of banana diversity (Smale and Tushemereirwe 2007). There are two types of endemic banana varieties: cooking bananas (matooke) and beer bananas. The region is one of the largest producers and consumers of bananas in the world, and it is dominated by smallholders.

This is low-input, low-output farming, with about 12 banana varieties planted per plot. Bananas are mainly grown to eat, with surplus sold in local markets. Other farming systems include the plantation system, which uses one variety and uniform management, and the backyard system in peri-urban areas, which grows bananas on small plots for food and as a source of leaves for wrapping and cooking.

In **Uganda**, the seven selected intervention sites were based in the central region: three sites in Luwero District, three in Mukono District, and one in Wakiso District. These farming systems have high food and cash crop diversity, with bananas, coffee, maize, cassava, sweetpotato, and beans (Bagamba 2007).

In **Burundi**, there were six intervention sites: three in the north (Kayanza, Ngozi, and Kirundo), two in the center (Gitega), and one in the west (Bujumbura). Farms in Burundi are generally small (under 2 ha) and intensively cropped. They produce little marketed surplus besides bananas and coffee. Bananas are planted at higher densities closer to the homestead, sometimes in association with taro or cassava, where they benefit from wood ash, plant residues, and domestic waste. Further from the homestead, they may be planted farther apart and intercropped with beans, maize, cassava, and sorghum (Rishirumuhirwa and Roose 1998). Smaller farms use more of their land for bananas, whereas larger farms devote more space to beans, forestry, or fallow. Smaller farms have higher land productivity, but larger farms are generally better at exploiting economies of scale (Verschelde et al. 2011).

In **Kenya**, the six intervention sites were located in Embu, Kirinyaga, Meru, Tala, Kakamega, and Kisii. Banana systems in Kenya include subsistence farming and backyard gardening, with few commercial plantations. Where land is scarce, bananas are grown on field edges, as hedges, along paths, and where HH wastewater and garbage are dumped. Banana is the most important horticultural crop and is grown throughout Kenya's eight provinces, although Nyanza, Central, Eastern, and Western provinces account for 90% of national banana production (Qaim 1999). The project sites were in those four provinces, where banana is grown as a subsistence crop, mostly (78%) by women. Roughly 1 in 3 farmers use manure, 1 in 10 use agrochemicals, and cultivation is rain-fed. Recent fluctuations in coffee and tea prices have led to an increased popularity of banana as a cash crop.

Market importance of bananas and plantains for farmers

The growing urban markets are making bananas a more important source of cash for smallholders (Kalyebara et al. 2007). About 26% of the population depends on bananas for food and income in rural areas, and about 65% of city people eat cooked banana every day (Clarke 2003). Most people in Burundi grow their own bananas (80%), both cooking bananas (81%) and beer bananas (69%) (CIALCA 2007).

East Africa has a dynamic cross-border trade in cooking and beer bananas (Jagwe et al. 2008). Burundi is a net importer, bringing in cooking bananas from Rwanda and Tanzania and beer bananas from Tanzania and DR Congo. Kenya imports cooking and dessert banana from Uganda and Tanzania. Kenya also exports some bananas to the Middle East and the European Union. Uganda exports some of its bananas to DR Congo, South Sudan, Kenya, and Rwanda, and to a niche market of East African emigrants in Europe and the USA.

General seed sector characteristics

Banana plants are vegetatively propagated using a sucker, originating from the corm of the mother plant. Most banana-producing HH in the region grow local varieties, which are susceptible to pests and diseases.

Trends, developments, ongoing change

In the past two decades, the East African perennial banana cropping system has been threatened with various new diseases. The recent arrival of BXW is a serious threat to banana production.

Some farmers lost their whole crop if their varieties were very susceptible to BXW (such as beer bananas). The disease started in Ethiopia in the 1960s on both bananas and enset; it was then reported in Uganda and in the North Kivu province of DR Congo in 2001, and it was reported in northwestern Rwanda in 2002. The disease spread further in other banana-growing regions of Uganda, western Kenya, and Burundi between 2002 and 2006 (Tushemereirwe et al. 2003; Mbaka et al. 2009; Carter et al. 2010).

This project had a strong focus on clean planting material, but not on host-plant resistance to BXW. The potential of TC to contribute to productivity growth stimulated different organizations to promote TC in East Africa (Smale and Tushemereirwe 2007). In Kenya, the International Service for the Acquisition of Agri-biotech Applications (ISAAA) started a project in the late 1990s, producing and disseminating TC plantlets to banana farmers. Later, KARI and Jomo Kenyatta University of Agriculture and Technology (JKUAT) also became involved in TC bananas. From 2003 to 2007, Africa Harvest—an international NGO—and other agencies promoted TC in central and eastern provinces. Over 10,000 farmers were trained, and the area under TC banana rose from about 3,200 ha in 2004 to 4,290 ha in 2006 (Njuguna et al. 2010). KARI and JKUAT have spun off laboratories and set up FG-managed TC nurseries in several parts of Kenya, whereas Africa Harvest collaborates with private companies to provide TC plantlets to farmers who are organized in groups.

Before the start of this project, there were four TC banana laboratories in Uganda, where banana TC was started in 1991 by Makerere University as part of a project to mass produce disease-free planting material. In 1995, the National Banana Research Program of NARO, in collaboration with IITA, started to multiply disease-free TC banana planting materials for research, field evaluation, and dissemination. However, as a result of increased demand for TC plantlets, a commercial TC laboratory, Agro-Genetic Technologies Limited, was established in 2002. By 2009 it had distributed about 370,000 TC banana plantlets to farmers (Sonnino et al. 2009).

Two private companies, Agrobiotech and Phytolab, cover most of the banana TC market in Burundi, with some provided by the public Institut de Recherche Agronomique et Zootechnique. Agrobiotech was established in the late 1990s to produce and disseminate clean planting materials. Production of banana

plantlets increased from 80,000 plantlets in 1999 to 330,000 in 2007. Government agencies and NGOs are the main buyers of the TC plantlets, which are distributed to farmers free of charge or subsidized.

During the 36-month (2008–2010) TC banana project coordinated by IITA in Uganda, Kenya, and Burundi, farmers were linked to TC nursery owners to deliver high-quality TC plants to boost banana productivity and to improve the livelihoods of small-scale banana growers. These TC bananas are free of BXW when given to farmers, but can become easily infected in the field (Lule et al. 2013).

3. Seed users

3.1 SEED ACQUISITION AND ACCESSIBILITY OF SEED

3.1.1 *Before the intervention*

What did the interveners know?

Through its collaboration with national and private partners in Uganda and Kenya, IITA had conducted extensive research in banana TC. Substantial progress had been made in identifying problems and solutions using TC banana in Phases I and II of the project “Managing Micro-organisms to Enhance Plant Health for Sustainable Banana Production in East Africa.” The project demonstrated the superiority of TC over conventional banana planting materials among smallholders in Uganda. Research in Uganda showed that distributing planting materials and information to farmers is a key hurdle for TC (AATF 2003), and that fostering links with the private sector demonstrated the benefits so that farmers accepted the new technologies (Dubois et al. 2006).

Research by German partners demonstrated the economic potentials of banana TC and the institutional constraints in its dissemination in Kenya (Qaim 1999). High-quality planting material can be delivered via farmer-managed TC nurseries, followed by training in managing TC material. Farmers in Kenya who accepted these TC plants were able to sell bananas and generate income. Improved TC distribution promoted banana processing and reduced imports of bananas and plantains (AATF 2003). However, while TC plants are superior to suckers, their success is dependent on correct management by farmers in the early stages, and farmers require links with markets. Farmer cooperatives can engage the supplier and the users. Farmers who earn more will be able to spend more on planting material.

In Burundi there were private nurseries of TC banana. No new TC nursery was established because the market was already distorted by NGOs buying TC plantlets and giving them away.

Other information sources

More than 500,000 Kenyan farmers adopted commercial micro-propagation of disease-free bananas (Wambugu 2004). A site study in Uganda reported a 36% adoption rate and a high demand for TC banana plantlets (Sonnino et al. 2009). Nine percent of the farmers in Uganda adopted improved TC bananas. There was a high demand for clean planting materials in the lowlands of central Uganda, greatly affected by disease, though farmers receive most material for free from extension agents and government researchers (Smale and Tushemereirwe 2007).

Farmers' multiplication techniques

Most banana growers plant with suckers, from their own gardens or from other farmers' plots. Most Kenyan farmers (90%) plant suckers, but about 25% use TC plantlets (Asoka et al. 2011); some farmers receive TC materials from projects. Since the mid-1990s, the National Banana Research Program of NARO in Uganda has promoted various ways of multiplication (e.g., community mother gardens, planted with disease-free TC banana plantlets; and a farmer receives TC planting materials from NARO, raises it for evaluation, and later gives two plantlets per plant received to another farmer in the community at no cost, who may then sell other plantlets) (Kikulwe et al. 2007).

Through the C3P project (see Chapter 13), clean planting materials were multiplied using macropropagation and distributed to farmers in East and Central Africa. We note, however, that C3P had little influence on the TC project, as the two projects used different models. The TC project promoted clean TC planting materials (of old varieties—not new disease-resistant ones—but virus indexed), not specifically targeting farmers who had been affected by BXW. Whereas C3P was an emergency program to replace planting material for farmers who had been affected by BXW.

In Uganda, women travel long distances looking for planting materials from their relatives or friends to plant before the rainy season starts (Karamu et al. 2004). In Kenya, banana plots are mostly owned by men, who control earnings from the plots, whereas women are involved in marketing (Qaim 1999). According to ISAAA (2007) women controlled 85% of the income from banana sales. Banana TC has allowed women to exert more control over income as the farming system becomes more market-oriented (Wambugu 2004). TC is attractive to women because it reduces risks (Wamue-Ngari and Mwangi 2008). Female-headed and better-educated HH have higher adoption rates of TC banana (Kabunga et al. 2012a). The main reason farmers do not have access to TC banana plantlets is lack of supply.

3.1.2 What changed as a result of the intervention

A cost-benefit analysis based on a survey of 240 farmers in four districts of Uganda by IITA and Makerere University found that production costs and revenues were higher for TC material than for suckers. The banana prices varied greatly between districts and declined sharply with increasing distance from the main market. Production costs for farms far from Kampala city decreased because of lower pest and disease pressure. A farmer who adopted TC and is closer to the city received more profit than one using suckers. But a farmer far from the market earned higher profits from suckers than from TC plants.

In Kenya, much of the population had heard about TC banana, although only a few had had a chance to fully understand its performance and requirements (Kabunga et al. 2012a). Farmers' education, access to agricultural information, knowledge of a nearby TC nursery, and affiliation with groups increased the likelihood of adopting TC. Farmers with access to credit and female-headed HH were more likely to adopt TC plants.

The project established 11 new TC nurseries in Uganda and Kenya. In Uganda, nurseries were run as businesses, independent of the farmers. Most of the nurseries in Kenya were owned by FGs that acted as the customers for these nurseries. In Burundi, farmers owned and managed the nurseries.

3.2 AFFORDABILITY OF THE TC BANANA

Investing in TC provides significant returns, though it requires more capital than conventional bananas (Qaim 1999; Mbogoh et al. 2002). TC provides higher potential yield and income gains for the poorest farmers (Qaim 1999). Mbogoh et al. (ibid.) estimated average costs for establishing a TC banana orchard to be approximately \$3,300/ha in year one, falling to about \$975/ha/year after that, with an estimated profit of about \$515/ha in year one and increasing to \$6,612/ha/year after that. A profit-margin analysis from KARI (Kenya) and Agro-Genetic Technologies (Uganda) for a hardening nursery (with a capacity of 4,000 TC plantlets) revealed a profit margin of 17% (ISAAA 2007). TC banana is profitable for smallholders (Wambuga 2001; Muyanga 2008; Sonnino et al. 2009; [Kabunga et al. 2012b](#); Kikulwe et al. 2012; Lule et al. 2013).

Opportunity costs or trade-offs

Adoption of TC banana depends on the supply of capital and labor. Farmers with little money do not apply enough inputs (e.g., fertilizer), so productivity is low (Muyanga 2008; [Kabunga et al. 2012a](#)). Banana orchards can be labor intensive, so off-farm jobs lower the adoption of banana technologies as farmers are busy working elsewhere (Bagamba et al. 2007). The adoption of TC banana in Uganda and TC sweetpotatoes in Zimbabwe depended on the capacity of the promoting agencies to reduce the opportunity costs and risks (Sinnoni et al. 2009). The agencies promoted TC to better-off farmers who could take higher risks. Adoption was stimulated by providing free planting materials, training, and technical support and by buying suckers at subsidized prices from adopting farmers.

Differentiation of information

Two training manuals were written, one for banana TC farmers (about 200 pages) and one for TC nursery operators (about 160 pages). The manual for farmers included lessons on working in groups, growing bananas, business skills, and marketing. The nursery manual covered topics like planning and business skills, managing a nursery, and marketing. The project held 226 training sessions in Uganda for 566 farmers (55% females), 49 sessions in Burundi for 165 farmers (45% females), and 75 sessions in Kenya (202 farmers).

3.3 SEED QUALITY

3.3.1 Before the intervention

At the start of the project, suckers were highly infested with pests and diseases. There were few or no quality standards for banana planting material in the region (Karamura, personal communication). The Seeds and Plant Act (2006) was designed to safeguard the quality of planting materials in Uganda, but even for those few farmers who buy seed, the quality does not match the standards stipulated by the law. Black Sigatoka had reduced banana yields in the region by 30-50% while *Xanthomonas wilt* decimated yields by 80-100% (Tushemereirwe et al. 2003). There were small TC banana enterprises in the region, but they lacked universal quality standards, so farmers did not have full access to the benefits of TC.

3.3.1 What changed as a result of the intervention

TC producers were trained to diagnose banana virus with ELISA and DNA-based indexing. The main banana viruses in East Africa include cucumber mosaic virus, banana bunchy top virus, and BSV. At the end of the intervention, TC banana producers were able to provide uniform and high-quality planting materials. During the project, other efforts were made (meetings, publications, and presentations) to sensitize entrepreneurs, policymakers, and regulators to implement standards and certification for TC banana. Nevertheless, East Africa is still far from implementing a certification scheme for TC banana. Efforts are needed at the higher political levels, because the private sector is not very interested in certification.

In Uganda, several nurseries were implemented by private individuals—mostly smallholder farmers—due to the in-depth training. Because of the project, functional and for-profit nurseries were established in Central Uganda. In Kenya, the concept of farmer-managed nurseries was strengthened. In both countries, as a result of the trainings, 11 new nursery businesses were established or strengthened, and nursery proprietors were able to get higher profits. A cost-benefit analysis of three nurseries in Uganda revealed profits of about \$0.25/plant, with higher profits when more plants were sold. However, in Burundi, despite extensive training of prospective TC banana nursery operators and the project's willingness to build nurseries, no agreement was reached with TC banana producers and buyers. Few, if any, farmers in Burundi were willing to pay for TC banana, which is largely given to them free of charge by the government and NGOs; so there was no demand for group-managed nurseries. In Burundi, the project worked only with FGs.

As a result of this intervention, some FGs were able to secure micro-credit, start TC banana nurseries, and expand into activities beyond banana such as renting event equipment, and outside catering.

During the life of the project, researchers measured the training impact by monitoring the agronomic and economic indicators of 1,350 banana plants in 87 farmers' plots for two crop cycles in Burundi and Uganda. Three groups of randomly selected farmers were monitored: non-TC farmers, untrained TC farmers, and trained TC farmers. Trained farmers harvested twice as much as the others, were able to access better markets, and obtained a higher price per kilogram, which tripled their revenue.

4. Seed producers and seed availability

4.1 THE MODEL

A successful TC satellite nursery model was developed and strengthened in Kenya, and later implemented in Uganda (Figure 12.1). In both countries, the model was sustainable because nursery operators, smallholders, and FGs were able to increase their income. However, production of TC plantlets remains largely unregulated.

TC banana satellite nurseries act as distribution hubs connecting TC producers to farmers, and serve as centers for farmer training and input supply. A sustainable TC banana nursery needs (1) to be close to the TC producer (laboratory) and the market (farmers), and (2) access to water, credit, and a

pickup truck to transport the plantlets. The most successful nurseries were in Kenya, owned by formal FGs whose members also buy the material from the nurseries.

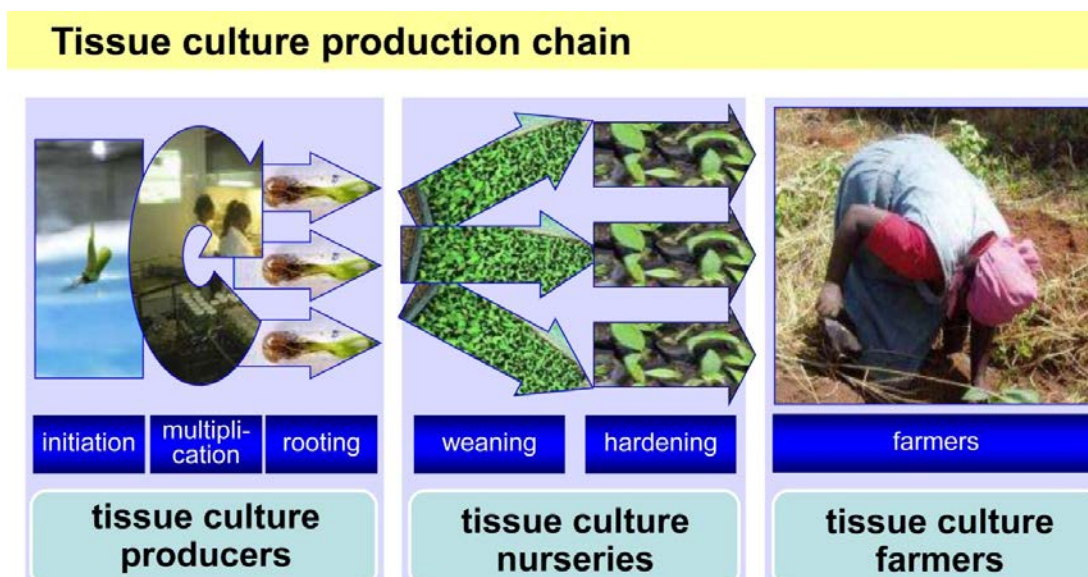


Figure 12.1. TC banana seed system. Source: Dubois et al. n.d.

Scaling up

Plans for scaling up the TC satellite nursery model involved intensive training and distribution of training materials. Several training modules were printed and distributed to extension providers and development organizations. In Uganda, the interveners worked hand in hand with the National Agricultural Advisory Services (NAADS), which was essential for the future of banana TC. In that way the FGs in Uganda were linked to NAADS at the end of the project; NAADS is currently working with them.

Rapid multiplication

This project adapted micro-propagation with TC to produce high-quality planting material for farmers (GTZ 2009). TC banana satellite nurseries were established in strategic locations at a distance from TC production facilities.

Market intelligence

TC plantlets need a lot of care, for which farmer-managed community nurseries were ideally suited, especially in Kenya (AATF 2003; Smith 2004). Nurseries near farmers made it easier to share clean planting material. The community nurseries stimulated farmers to form cooperatives that would allow farmers to access markets, credit, skills, labor, inputs, and tools. These farmers produced high-quality products that conformed to the standards of the market.

It was assumed that there would be sufficient private sector interest in investing in TC, but the private TC laboratories were difficult to include in the project. They were suspicious of outside intervention into quality and certification. Except for the semi-commercial TC laboratory of JKUAT, these producers became less involved over the course of the project, although they were kept abreast of the project findings. The project's work with community nurseries did stimulate demand for TC banana plantlets.

4.2 BENEFITS FOR THE FARMERS

Advantages of the seed

TC seed is often free from pests, including fungi and bacteria. The material can also be free from viruses if it has been properly indexed. TC bananas are true-to-type (they are exactly like their desirable parent), but they grow faster, produce bigger bunches, and flower more uniformly, which makes their harvesting and marketing more predictable. Unlike suckers, TC plantlets can be produced quickly in large quantities.

Disadvantages of the seed

TC plantlets are fragile and need to be hardened before planting, and require appropriate agronomic management when they have been transplanted in the field. Although TC plantlets are pathogen free when they are produced, they are easily infected with pests and diseases if transplanted into infested soils. TC plantlets are more expensive than suckers and generally come in a limited number of varieties. As well, TC has a higher rate of somatic mutations than do suckers (Robinson and Galán Saúco 2010).

4.3 QUALITY ASSURANCE AND REGULATION

Quality assurance mechanisms

The trustworthiness of a nursery operator is important for maintaining quality of planting materials. Most quality aspects can be guaranteed through proper training if nursery operators use good agricultural practices. The project implementers organized hands-on training for TC producers on ELISA and DNA-based indexing, which the participants highly appreciated. Policymakers and regulators were sensitized through meetings, publications, and presentations on how to implement standards and certification for producing TC banana. Uniform, high-quality planting materials were produced, especially in Kenya and Uganda, where the model was sustainable. However, TC bananas are still not certified in East Africa, where the laboratories remain largely unregulated.

New seed regulations

The commercial TC laboratories are supposed to self-regulate the quality and health of their products. Virus certification is urgent, especially as TC plantlets are increasingly traded across borders in Africa. The project communicated several elements that are essential for virus certification in a manual, during training workshops and conferences, and published in peer-reviewed journals (see Section 5.2).

Evaluation of the model

Impact assessments were conducted at the end of the project for Burundi, Kenya, and Uganda. But only the Kenyan data were analyzed (Kabunga et al. 2012a, 2012b, 2014). Education, access to information, and groups and social networks all facilitated the use of TC planting materials.

5. Regulation and policy affecting farmers' use of quality seed

5.1 GENERAL POLICIES AND SEED REGULATION

Seed-related policies

Although there are no TC certification schemes in East Africa, there are seed regulations. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) has been supporting the harmonization of seed policies, laws, regulations, and procedures in East and Central Africa (ASARECA 2011). Burundi, Kenya, and Uganda are members on the East African Phytosanitary Information Committee (EAPIC), which was formed to develop country-specific and regional pest reporting methods and internet-accessible databases that support sanitary and phytosanitary requirements (<http://www.eapic.org>).

Each country also had a seed act (or policy draft) in place. Uganda has the Seeds and Plant Act of 2006. The National Seed Certification Service, under the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF), has the mandate of designing, establishing, and enforcing certification standards, methods, and procedures, following OECD guidelines (MAAIF 2006). MAAIF also drafted the National Seed Policy of 2006.

The seed industry in Kenya is governed by the Seeds and Plant Varieties Act (Cap 327) of 1972. Seed regulations were made in 1977 and revised in 1991, incorporating plant breeders' rights. The Act is currently under review to make seed trade fully liberalized and to incorporate harmonized regional seed certification standards (Sikinyi 2010). KEPHIS, established in 1997, is responsible for certifying seed according to the Seeds and Plant Varieties (Seeds) regulations.

In Burundi, the Seed Act of 1999 was revised after the war (Baramburiye 2010). The Seed Production and Control Program, led by the Institut des Sciences Agronomiques du Burundi, started in 2007. The program follows the seed quality control standards set by the East African Countries (ibid.).

5.2 SEED HEALTH AND QUALITY

It is important for the TC producers to sustainably access virus-free and true-to-type mother plants. This could be provided by establishing certified mother plant gardens as a common resource, either by governmental agencies or a consortium of commercial TC producers (Dubois 2011). TC producers have problems with off-types and accidental mixtures of varieties (only observed after planting in the field), resulting in significant quality variations of the TC plantlets, and giving farmers a negative perception of TC. Seed quality standards must involve the private sector and the government in order to be effective.

Seed health and quarantine

This case has no quarantine issues. Six banana and plantain landraces that are tolerant to drought were identified on the islands of Unguja and Pemba, in Tanzania, and maintained at a central site on Unguja. When screened in farmers' fields on Unguja, the varieties responded differently according to the agro-ecological zones. This screening has stopped on Unguja, and the varieties could not be tested in Uganda, Burundi, or Kenya. The quarantine regulations were inhibiting both the import and the export of the test lines with improved disease tolerance.

6. Seed multiplication tools and techniques

TC plantlets are delicate because they have been growing under artificial conditions, dim light, and high humidity. Thus, they have not hardened and can easily lose water when they are exposed to ambient light and temperatures. Having acclimatized in-vitro plantlets saves a lot of labor and materials and increases their survival rates. Such plants can easily be multiplied. The hardened plants can be quickly prepared for the greenhouse nursery. On the other hand, farmers prefer the fully hardened plantlets, ready to be transplanted to the field. This increases the survival rates in the field.

7. Lessons

Accurate information about the nursery operators and smallholder farmers was essential, but was not available in the public domain. Yet, gathering such information was not included in the planning phase of the proposed project.

TC banana laboratories, largely in the private sector, were difficult to include in the project. These producers were suspicious of outside intervention into quality and certification, and most of their customers were large government organizations and NGOs, dedicated bulk-buyers of TC banana plantlets. Some labs dropped out of the project. But focusing on nurseries and FGs helped to increase the market mix and increased the demand for TC banana.

The project implementers (research organizations and development partners) found it hard to engage with policymakers, particularly those concerned with quarantine and plant health.

Training events need to be tailored to specific situations. Training in Burundi was quite basic, whereas in Kenya farmers were introduced to new methods of compost making, solar



Artificial conditions. TC bananas growing in vitro.
Photo by Jeff Bentley

ripeners, and bookkeeping on computer spreadsheets. Training involved more than just how to grow TC bananas; the business plans developed for the TC nursery operators were useful for establishing nurseries and similar businesses. About 70% of the TC farmers in Uganda stayed in the training, even though the schedule was intense.

Planning with nursery operators and farmers needed to take their needs into account. Some FGs, for instance, were not interested in being trained in marketing. Initially, the large demonstration gardens were meant to be used as training tools and as marketing tools for the TC nurseries. In Uganda, some of the banana TC demonstration gardens were poorly managed or even abandoned. Demonstration gardens should have been planted after the training to ensure proper management of TC banana planting materials.

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