



## Banana Farming as a Business: The Role of Tissue Cultured Planting Materials in Kenya

J.N. Mbaka,<sup>1</sup> M. Mwangi<sup>2</sup> and M.N. Mwangi<sup>3</sup>

<sup>1</sup>Kenya Agricultural Research Institute, Thika, Kenya; <sup>2</sup>Previous address: International Institute of Tropical Agriculture, Kampala, Uganda; Current: FaCT BioSciences, P.O. Box 967- Post Code 00217 Kenya; <sup>3</sup> Biochemistry and Biotechnology Department, Kenyatta University, P.O. Box 48344 Nairobi, Kenya.

Corresponding author email: [jnmbaka@yahoo.com](mailto:jnmbaka@yahoo.com)

### ABSTRACT

*Objective:* To assess banana farming and the potential impact of Banana Xanthomonas wilt (BXW) spread to key production areas in Central and Eastern provinces of Kenya.

*Methodology and results:* After the outbreak of banana Xanthomonas wilt (BXW) in Western Kenya in late 2006, a rapid spot check on banana production was conducted in parts of Eastern and Central provinces of Kenya, aiming to assess the potential impact if the disease spread to the area. BXW was not observed in all the surveyed areas. However, potential risk of disease spread was noted since trucks and traders that visit western Kenya, where BXW is present, were also trading in bananas from Central and Eastern provinces. Banana was confirmed to be an important cash and food crop in the surveyed regions, particularly in Mwea and Meru regions, where a good bunch fetches a farm gate price of at least Ksh. 500 (\$7.5). Despite the earlier adoption of the TC banana technology many farmers had reverted to obtaining suckers from their own or neighbours' farms for planting.

*Conclusion and application of findings:* It will be necessary to put in place measures to prevent BXW spread to banana producing areas within the eastern and central provinces as the disease would have a significantly adverse impact on livelihoods. The low uptake of tissue cultured planting materials needs to be investigated to forestall reversion to utilisation of low quality and potentially infected planting materials from existing plantations and other traditional sources. An overview of farmers' perception of tissue culture bananas and possible interventions to ensure sustainable banana farming is discussed.

**Key words:** banana, micro-propagation, sustainability, biotechnology.

Citation: Mbaka JN, Mwangi M. and Mwangi MN, 2008. Banana farming as a business: the role of tissue cultured planting materials in Kenya. *Journal of Applied Biosciences* 9 (1): 354 - 361.

---

### INTRODUCTION

Banana (*Musa* spp. L) is the fourth most about 97 million tones annually (FAO, 2003). Banana is a popular food, providing a good source of carbohydrates, vitamins and minerals. It has for long been regarded as an ideal baby food. Banana occupies 30 % of the cultivated land of the East African highlands (Kenya, Uganda,

Tanzania, Rwanda, Burundi and the Democratic Republic of Congo). About 20 million people in East and Central Africa depend on banana for food and income. Moreover it provides surface cover, reduces soil erosion on steep slopes and is a principal

source of mulch for providing and maintaining soil fertility (Lufafa *et al.*, 2003).

A wide range of genetic diversity of bananas is found in different areas of Kenya. Factors such as local tastes, eating habits, market demand and environmental conditions tend to influence their distribution (Nguthi, 1999). By the end of year 2006, Kenya had an estimated 82,518 hectares under bananas from which 1,058,018 metric tones valued at over 9 billion Kenya shillings (\$ 0.15 billion) were produced (MoA, 2006). The main banana cultivars grown are the East African Highland Bananas (EAHB-AAA), the brewing types (AB, ABB), the cooking types (ABB), and the desert types like the 'Gros Michel' and 'Kampala' (AAA, AAB). Each group has its own disease and pest constraint with Sigatoka (*Mycosphaerella fijiensis* and *Mycosphaerella musicola*), weevils (*Cosmopolites sordidus*) and nematodes (*Platylenchus goodeyi* and *Radophylus similis*) being most serious on the EAHB, while Fusarium wilt (*Fusarium oxysporum* fsp. *Cubense* (Foc)-race 1 and race 2) mostly attacks the desert and beer types. In the mid 1990s, Fusarium wilt was confirmed to be present in all the banana growing areas of Kenya (Kung'u, 1995). The variety 'Gros Michel' and apple banana that by then were grown by small-scale growers mainly for income succumbed to the wilt. The other bananas, mainly the cooking types, succumbed to nematodes and weevils. The situation was made worse by the farmers' practice of planting suckers from their own or neighbours' farms and lack of knowledge on good management practices (Kung'u *et al.*, 1995).

To address these problems, the Kenya Agricultural Research Institute (KARI), in collaboration with the Institute for Tropical and Sub-tropical Crops (ISTC), South Africa, and the International Service for the Acquisition of Agri-biotech Applications (ISAAA) were funded by the Rockefeller Foundation, USA, and the International

Development Research Centre (IDRC), Canada, to undertake intensive research from 1996. The over all objective was to disseminate tissue culture technology to improve banana production (Nguthi, 1999).

Cultivars resistant to *Foc* race 1 and race 2 such as the 'Giant Cavendish', 'Dwarf Cavendish', 'Valery', 'Lacatan' and 'Paz', were multiplied through tissue culture. Cultivars resistant to sigatoka diseases were introduced through the International Network for Banana and Plantain (INIBAP) and evaluated at the KARI National Horticultural Research Centre, Thika. Those found to have superior characteristics were micro-propagated and evaluated on farm (Nguthi, 1999). Distribution of the TC plantlets was accompanied by training on banana production, post harvest handling and value addition through farmers' field schools, field demonstrations and field days.

In general farmers were very enthusiastic about the potential of the TC technology, particularly being motivated by the capacity of the TC banana to generate additional income to compensate for revenue lost from other poorly performing commodities such as coffee (Wambugu & Kiome, 2001). Enormous interest was generated especially in the trial areas, with a corresponding increase in demand for TC planting materials (Kahangi, 2003).

Factors contributing to the farmers' positive reaction were the fast growth rate of plants, high yields (from 10 to about 30 tons/ha) and uniform production. Whereas conventional suckers may take upto 18 months to produce a crop and tend to mature at different times, TC plants produce a crop within a shorter period, and all can be harvested at the same time thus providing a substantial lump sum of money to the farmer. These benefits helped to change farmers perception of banana from a mainly subsistence crop to a viable cash crop (Wambugu & Kiome, 2001). Several TC

laboratories (private and public) were established with hardening nurseries located in different banana growing areas of the country

to reduce the cost of the seedlings. Most nurseries were owned by farmers' groups as commercial enterprises.

#### MATERIALS AND METHODS

The main banana growing areas were identified by the Ministry of Agriculture extension officers in the respective districts. The areas fell under the Upper midland zones 2 (mainly coffee), zone 3 (marginal coffee) and zone 4 (sunflower-maize) of Central and Eastern provinces of Kenya (Jaetzold & Schmidt, 1983). The districts covered were Kirinyaga and Maragwa in Central province and Meru Central district in Eastern Province. A questionnaire was administered through face to face interviews with the farmers to capture data on banana production practices (main banana cultivars, source of planting materials, soil fertility management, crop protection and post harvest handling) and market information (main buyers, market channels and the farm gate price). Farmers

were asked to rate banana production enterprise alongside other cash crops, e.g. tea, coffee, rice and horticultural crops. An activity profile to determine who does what in the banana fields and utilization of income from bananas was also captured. Each field was additionally observed for disease and pest incidences. In total 60 farmers were interviewed across the districts. A private company (Aberdare Technologies in Maragwa district), which trades in horticultural products including bananas and banana seedlings was also visited and the farm manager interviewed. Descriptive data were analysed using the Statistical Program for Social Scientists (SPSS) Version 12.0 for Windows and Microsoft Excel programs.

#### RESULTS AND DISCUSSION

Banana Xanthomonas Wilt was not observed in all the surveyed areas. However, potential risk of BXW spread was noted since trucks and traders that visit western Kenya, where BXW is present, were also trading in bananas from Central and Eastern provinces. Banana was confirmed to be an important cash and food crop in the surveyed regions. Despite the earlier adoption of the TC banana technology many farmers had reverted to obtaining suckers from their own or neighbours' farms for planting. One major seedling supplier indicated that they imported tissue culture banana seedlings from Du Roy Laboratories in South Africa at an average cost of Kshs 40.00 (\$0.6) per seedling, which was then sold to farmers at Kshs 120.00 (\$ 2) after hardening. According to the company the demand for TC seedlings was high with sales of 80,000 - 100,000 seedlings annually. The high demand for the imported TC seedlings was to a large extent linked to the perceived poor performance of the locally produced TC plantlets. Mutations caused by somaclonal variation and incorrect identification of varieties were cited as some of the most common problems. These findings confirmed previous reports from Western Kenya where 300 TC plants in an orchard were found to be mutants (Mbaka *et al.*, 2004).

**Production in Mwea division:** A large part of Mwea division of Kirinyaga district falls under the Mwea irrigation scheme which was set up in the early 1950s by the British colonial government. Until 2001, the scheme produced only irrigated rice under management the National Irrigation Board (NIB). After 2001, due to low returns associated to marketing problems, the rice farmers opted to de-link from NIB management. However, due to inexperience, lack of facilities, and perhaps the missing group synergy, individuals failed to effectively manage their paddy fields which led to further decrease in yields and income. In response farmers started diversifying into other income generating enterprises.

Most of the farmers chose banana due to its suitability for production in the area, high demand in the market, and relative easy of crop management. The water that was previously used to irrigate rice was diverted to banana orchards. Presently, bananas in this area are mainly grown for cash alongside other horticultural crops. The main banana cultivar is the dessert type 'Gros Mitchel' or 'Kampala', preferred due to high yields (75 to 100kg bunch weight) and consumer preference of its keeping quality (long shelf life) and taste. The level of agronomic management

(weeding, pruning, and de-leafing) is high and soil fertility is well maintained by regular application of animal manure. In all cases, banana suckers for expanding plantations or replacing mats that have died out are obtained from the older mats in the same field or from the neighbours farm (at a price or free). Although farmers in this area grow a diversity of horticultural crops, e.g. French beans, tomatoes, onions and Asian vegetables, banana was ranked the top income earner by 50% of the farmers (Table 1).

The main buyers are brokers who sell fruits to urban markets as far as 500 km away in Nairobi, Nakuru, Eldoret and Mombasa. Most farmers indicated that the buyer strongly influenced the price, though in some cases there were contractual arrangements whereby the price remained fixed throughout the year.

On awareness of disease and pest threats to bananas and the use of tissue culture technology as a solution, 50 % of the farmers indicated lack of awareness. The 50 % that were aware had mostly been trained by KARI, and had tried the TC bananas but abandoned them after about four years. The main problem cited for abandoning TC bananas was high susceptibility to nematodes and weevils leading to decreased yields or total mat degeneration within about three years. The TC banana varieties were also perceived to have a short shelf life and did not taste as good as cv. 'Gros Michel', which led to low consumer preference.

Nearly all the interviewed farmers were of the opinion that banana suckers from their existing plantations, if properly managed, would give better mats, with higher yields and of longer life time than TC bananas. Moreover, the conventional suckers would bear fruit at 9 to 12 months, just like the tissue culture bananas.

There was a general feeling that TC banana was a specific variety and farmers seemed not to understand that tissue culture was a propagation method. This could be as a result of the language used during the dissemination of the technology. Most people including scientists refer to the bananas as tissue culture bananas, rather than tissue cultured or tissue culture propagated bananas, which might make one to think of the technology as the product rather than the process that it really is.

As an indicator of the seriousness attached to banana farming one farmer was encountered in Mwea division who had a six acre mono-crop of bananas under irrigation. He indicated that banana farming is an important business that supplements the low wage he gets from his public service job as an animal production specialist. Although he had began farming with production of French beans and Asian vegetables for export to Europe and tomatoes for the local market, the stringent requirements of the European Retailers Good Agricultural Practices (EUREPGAP) and high cost of farm inputs made the enterprises less profitable. After market survey, he identified bananas as a suitable alternative and specifically cv. 'Gros Michel' due to its high demand. The farmer has supplied bananas to two major supermarket chains in the country (Nakumatt and Uchumi) selling at a fixed price of Kshs. 15 per kg, and making a gross income of about Ksh. 60,000 (\$1,000) per week from the six acre plantation. This is much higher than his government job salary of Kshs. 30,000 (\$500) per month. Like other farmers in the area, he got suckers from his existing farms and from neighbours' when establishing the new plantation. Although he is aware of the high susceptibility of cv. Gros Michel (*Kampala*) to *Fusarium* wilt, his experience shows that with good management the plantation will last long and generate more profit than other crops. To offset disease and pest build up the farmer plans a rotation with maize or tomatoes every 4 - 6 years.

**Production in Meru Central district:** Mitunguu is in the Arid and Semi Arid (ASAL) areas of the district. Due to scanty rainfall, no crops were produced in the area for long and the entire population of about one million people were permanently on food relief. However, recently the situation has changed. Farmers joined hands and with facilitation by the Constituency Development Funds from the Government to tap water from Mount Kenya about 100 km away. Availability of water has turned the area into a major banana growing zone, significantly reducing poverty and hunger. Most of the banana farmers in this area are retired or retrenched civil servants who invested their retirement benefits in the area. Most are educated to at least secondary school level

and had been trained on banana management by KARI.

Nearly every household had at least 50 banana stools and on average harvested four bunches from each stool every year. As noted in Mwea division, due to previous frustrations farmers in this area were also not eager to embrace TC bananas. A majority had the experience that banana orchards from conventional suckers would do as well or even better, if given the same attention as the TC bananas.

The demand for banana fruits in the area is high with buyers from as far as Mombasa, Eldoret, Nakuru, Busia and Nairobi. The farmer in this region has more influence on the price and a bunch would only be harvested after an acceptable

offer had been agreed, on average Kshs 500 (\$ 7.5) per bunch and an average annual income of at least 100,000 Kenya shillings (17,000\$) per household. It was clear that bananas are having an impact and have great potential to alleviate poverty and hunger in this region. This impact, for example, is well captured in a case whereby one young man is privately financing his university education through production and marketing of bananas. After failing to raise fees for his education, the parents allocated him a one acre piece of land on which he planted 100 conventional banana suckers of cultivar 'Gros Mitchel'. After just one and a half years he had sold enough bananas and could start paying to study agriculture at the university.

Table 1: Farmers' ranking of top income generating enterprises in Mwea division, Kirinyaga District.

Enterprise (Ranked Top)	% Farmers (n=60)
Banana	50
Rice	18
Tomatoes	12
French beans	10
Asian Vegetables	6
Onions	4
Total	100

**Production in Maragwa district:** This district was the main zone of TC technology dissemination by KARI from the 1990s. This district was included in the survey as it was the centre of banana production in Central Kenya before Fusarium wilt seriously affected production in the early 1990s. Initial enthusiastic adoption of the TC technology led to revitalization of the banana industry in the area. Many farmers were trained on how to carry out farming as a business, group formation and linked with micro-credit and marketing institutions. The introduction of TC bananas succeeded greatly in this region in the early 2000s.

However, during this survey it was observed that the tissue cultured banana orchards had succumbed to nematodes, banana weevils, nutrient stress and physiological degeneration. Comparatively, most of the orchards established using conventional suckers were still thriving though with low yields. Most farmers (individual or groups) who had planted the TC bananas were disillusioned and preferred to plant conventional suckers from the existing plantations, despite soil

infestation with Fusarium, weevils and nematodes. As in the other surveyed districts, income from bananas was used for home improvement, health care, food and education (Fig. 1).

The production of TC bananas is carried out under highly sterile conditions, which is thought to weaken their resistance to pest attack, since the plantlets lack the naturally beneficial micro organisms that would increase resistance. The seedlings are more likely to succumb to attack after transplanting to fields that are heavily laden with soil borne pests and diseases. It seems possible that remarkable banana yield and income increases could be achieved even without biotechnology, but rather by applying more inputs and improving agronomic practices.

Yet the potential of an appropriately introduced technological innovation to modernize institutions or farming systems should not be underestimated. For instance, when connected to a tangible technological product such as TC plantlets, it would be much easier to start a new micro credit scheme or to transfer knowledge



about improved management practices than it would be otherwise, especially in situations where public rural services are under developed (Qaim, 1999). Technology adoption is usually a gradual process with expected behavioural changes among farm groups (Qaim, 1999). It is expected that new technologies like biological enhancement (Sikora & Pocasangre, 2004), and genetic

engineering (Tripathi *et al.*, 2004), will increase banana crop production. However, for any technology or innovation to impact on banana productivity, provision of clean planting materials will remain a key requirement and challenge. Tissue culture offers a suitable solution to this challenge.

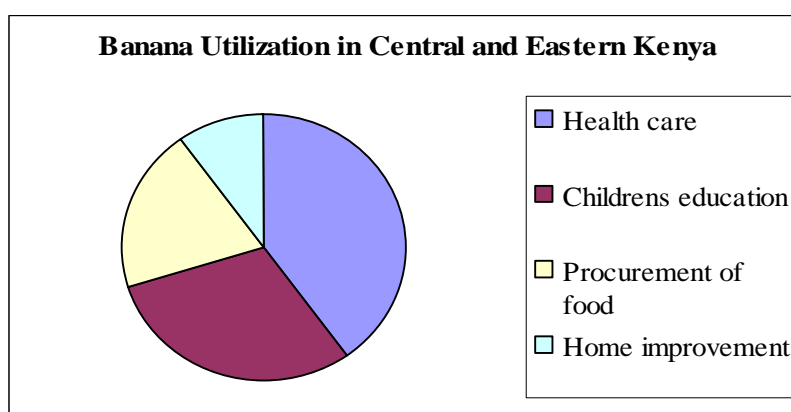


Figure 1: Banana utilization in Central and Eastern Provinces of Kenya.

#### CONCLUSION AND RECOMMENDATIONS

From the survey, it was established that BXW in Kenya was restricted to the western regions of the country and had not spread to the Central and Eastern Provinces. In these areas, banana production is a viable commercial enterprise with the potential to alleviate poverty and hunger as well as improve standards of living for the rural communities. The need for clean planting material is a major challenge that farmers encounter when replacing old or establishing new orchards. The findings of this survey confirm those of Mwangi and Nakato (2007) indicating that when establishing new banana orchards 60% of banana growers in East and Central Africa obtain suckers from their own existing fields.

For the tissue culture banana technology to be adopted in a sustainable manner, the following measures are suggested:

1. Farmers need to be educated to understand and appreciate the benefits of tissue culture technology as a tool for crop propagation. Communication should be intensified to also address other aspects of biotechnology (besides TC),

e.g. crop genetic modification and the attendant benefits and potential risks.

2. More transparency is required when promoting the TC banana technology. While care should be taken not to exaggerate or over-emphasize the benefits, it is imperative that the potential risks or disadvantages associated with this technology be communicated and carefully explained to the farmers. In this case the possibility of encountering mutations should always be made clear. Without proper communication and transparency, the potential of biotechnology to turn around lives of the rural poor can be easily emasculated by negative messages from opposing lobbies or interest groups.

3. There is need to carry out research on the short longevity of tissue cultured banana orchards as compared to orchards established with conventional suckers. Across all the surveyed regions farmers were of the opinion that tissue

cultured plantlets degenerate within 3 – 4 years while those conventional suckers would last even up to 10 years. It is particularly important to follow up on farmers who plant TC plantlets to provide effective extension support and address any issues that might arise post-planting. On the issue of orchard longevity, the possibility of maintaining *highly productive* TC banana orchards for shorter periods (3-4) years could also be considered. In Taiwan, for example, tissue cultured banana are grown for only one and a half years during which production is optimal, and then replaced (T.Y. Feng pers. comm., 2008). However, farmers in Kenya may not consider this viable due to the high cost of the tissue cultured seedling (\$2) compared to a cost of \$ 0.4 in Taiwan.

4. Attention should also be paid on the Besides demonstrating the establishment of orchards locally, stakeholders should consider the possibility of organising study tours for farmers groups to other areas where the technology has been deployed successfully. This would help farmers to make more informed decisions.

5. choice of varieties to be propagated by TC. Ideally all the stake holders (nursery operators, growers, transporters, traders, processors and consumers) should be involved in a participatory manner to enable sustainable adoption.

6. The findings of this survey demonstrate that bananas are an important crop that deserves the same or more attention from the government as is given to other cash crops such as coffee and tea. A more supportive policy environment with stronger and better regulated linkages to markets (local and international) is required to maximise benefits from investments.

7. To enhance the quality of seedlings produced by TC laboratories, there should be a regulatory body to ensure inspection and certification. In Kenya, the regulatory body could be constituted with membership from the Kenya Plant Health Inspectorate Services (KEPHIS), the Horticultural Crops Development Authority (HCDA) and KARI. This would improve farmer confidence in the TC technology and further enhance sustainability of banana production.

8. Possibilities of reducing the cost of production of TC plantlets should be considered. These might consider tax waiver on laboratory materials and consumables, or subsidies from sector specific funding from government.

**ACKNOWLEDGEMENT:** The authors wish to thank the International Institute for Tropical Agriculture, Uganda; the Director KARI and Centre Director KARI-Thika for Logistical support.

#### REFERENCES

- FAOSTAT, 2003. Agriculture data. <http://apps/fao.org>.
- Jaetzold R. and Schmidt H, 1983. Farm management Handbook of Kenya. Ministry of Agriculture in Cooperation with the German Agricultural Team (GAT) and the German Agency for Technical Cooperation (GTZ).
- Kahangi E, 2003. Deployment-Micro propagation/clean planting materials. In: Report of Small Group meeting (SGM) on improved production of bananas and plantains in the Sub-Saharan Africa. 22<sup>nd</sup> August 2003, Hotel Equatoria, Kampala, Uganda.
- Kung'u JN, 1997. Fusarium wilt and other banana diseases in Kenya. *Infomusa*, 4: 14-16
- Kung'u JN, Njuguna LK, Ong'aro JM, Makokha S, 1995. Investigations on Fusarium wilt of banana, nematodes, weevils and other factors associated with banana wilt in Murang'a, Kenya. KARI/ODA Crop protection project Interim report.
- Lufafa A, Tenywe MM, Sabiry MI, Majaliwa MJG, Woomer PL, 2003. Prediction of soil catchments using GIS-based Universal soil Loss Model. *Agricultural Systems* 76: 883-894.

- Mbaka JN, Njuguna JK, Chegeh BK, 2004. Survey of banana diseases in Coast and Western Provinces of Kenya. KARI-Thika Annual report 2004.
- Mbaka JN, Ndungu V, Mwangi M, 2007. Outbreak of *Xanthomonas* wilt (*Xanthomonas campestris* pv. *musacearum*) on banana in Kenya. Proceedings of the ISHS/ProMusa Symposium, Greenway Woods Resort, White River, South Africa, September 10-14 2007.
- Mbaka JN, Mwangi M, Nakato V, Auma J, 2008. An outbreak of banana *Xanthomonas* wilt (*Xanthomonas campestris* pv. *musacearum*) in banana orchards in Western Kenya. Manuscript Accepted for publication in the African Journal of Horticultural Science on 28th May 2008.
- MoA, 2006. Ministry of Agriculture Kenya: Horticulture Division, Annual Report 2006.
- Mwangi M. and Nakato N, 2007. Factors contributing to the spread of banana *Xanthomonas* wilt in East and Central Africa Region. Proceedings of the ISHS/ProMusa Symposium, Greenway Woods Resort, White River, South Africa, September 10-14 2007.
- Nguthi F, 1999. Tissue culture banana seedlings. In: Horticultural News. The official *Journal of the Horticultural Development Authority*, Kenya. No.18. August/September 1998, pp7-9.
- Qaim, M. 1999. Assessing the impact of Banana Biotechnology in Kenya. ISAAA Briefs no. 10. Ithaca, New York, USA. Sikora, RA. and Poscasangre, L.E. 2004. New Technologies to increase root health and crop production. *Infomusa* 13(2) 25-29.
- Tripathi L, Tripathi JN, Tushemereirwe WK, 2004. Strategies for resistance to bacterial wilt disease of bananas through genetic engineering. *African Journal of Biotechnology* 3(12):688-692.
- Wambugu FM. and Kiome RM, 2001. The benefits of Biotechnology for small-scale banana producers in Kenya. ISAAA Briefs No. 22-2001.

