Socio-economic Impact of Biotechnology Applications: Some Lessons from the Pilot Tissue-Culture (tc) Banana Production Promotion Project in Kenya, 1997-2002

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1.0 Abstract

This article is based on a socio-economic impact study of the introduction and adoption of tissue-culture (tc) technology in banana production in Kenya. It attempts to demonstrate that a prudent introduction and promotion of a new biotechnological innovation in farming can make a positive contribution to the socio-economic status of resource poor farmers in a developing country, such as Kenya. Adoption of tc technology in banana production in Kenya is considered a good example of biotechnological applications in agriculture. Hence the article hopes to make a contribution to recent debates at international levels as to whether biotechnology can make a difference in uplifting the living standards of people in the third world (Qaim, 1999; Graff, et al 2002; Qaim, et al 2002) by showing that it actually does so, using experiences from Kenya. The study utilizes both primary and secondary data sources. The results show that tc-banana production is relatively more capital intensive than non-tc banana production (re: about 70% fixed costs for tc banana versus about 49% fixed costs for non-tc banana). However, tc-banana production is found to offer relatively much higher financial returns than non-tc banana production.

The high profitability of tc-banana production relative to traditional (non-tc) banana production and other farm enterprises in the pilot tc-banana project area in Kenya demonstrates the importance of biotechnological applications in rural development and shows that biotechnology can make a difference in uplifting the living standards of people in the third world. Therefore, efforts to promote tc-banana production in Kenya are justifiable from both food security and economic criteria.

KEY WORDS: Biotechnology and Tissue-Culture (tc) Banana, Adoption, Socio-economic Impact, Rural Development, Third World, Kenya.

1.1 Background

There has been a lot of debate at international levels in recent times as to whether biotechnology can make a difference in uplifting the living standards of people in the third world (Qaim, 1999; Graff, et al 2002; Qaim, et al 2002). This article attempts to demonstrate that a prudent introduction and promotion of a new biotechnological innovation in farming can make a positive contribution to the socio-economic status of resource poor farmers in a developing country, such as Kenya. The article is based on the results of the socio-economic evaluation of the impact of the introduction and adoption of tissue-culture (tc) technology in banana production in Kenya, a project that is considered a good example of biotechnological applications in agriculture.

Banana is one of the best-known food crops in Africa. Women in particular use banana to diversify the types of foods consumed in the household. Apart from its value as a food crop in Kenya, sales from banana output provide the much-needed household income for small-scale farmers. A succinct background to the Banana Sector in Kenya can be found in Qaim (1999). Qaim (1999) also reviews the introduction of tissue-culture (tc) biotechnology in banana production in Kenya and focuses on ex-ante analysis and discussion of the potential effects of such technology at the farm level, including the market effects of biotechnological progress.

1.2 Rationale for the tc-Banana Production Promotion Project in Kenya

Production of bananas in Kenya is basically a small-scale farm activity, with a national average of 0.32 ha of bananas per farm. However, banana production in the country has been on the decline

over the last decade due to a number of problems, the major one being the crop infestations with pests and diseases, particularly Panama disease, sigatoka, weevils and nematode complexes, and environmental degradation (Qaim, 1999). Following this rapid decline in banana production in Kenya, food, employment and income security in the banana producing areas of the country has been threatened since the late 1980s. Traditional cultural practices in banana production have been a major cause of the problems in banana production in Kenya in the recent past. Through such traditional cultural practices, the farmers transmit unknowingly most of the banana pests and diseases through banana suckers as these farmers search for and procure suckers as planting material from one farm to another. The spread of pests and disease through this practice can reduce banana yields by up to 90%. Therefore, there is need to encourage the farmers to improve their cultural practices and use clean, disease-and-insect-free planting materials. Tissue-culture (tc) propagation techniques can provide such planting materials.

Given the high incidence of hunger, malnutrition and poverty in Kenya, where nearly 60% of the country's population earns less than US$ 1 per person per day (ROK/CBS, 2000), any projects that address the problems of food and income generation must be accorded great significance in Kenya. Since the superior performance of the tc-banana technology in the farmers' fields had actually been demonstrated by Kenyan scientists during the early 1990s, especially by those working under the auspices of the Kenya Agricultural Research Institute (KARI), which is mandated to undertake agricultural research and development work in Kenya, the International Service for the Acquisition of Agri-biotech Applications Afri-Centre (hereafter referred to as ISAAA Afri-Centre, or simply the ISAAA) felt that the small-scale farmers could be assisted to reclaim their banana orchards through the introduction and promotion of tissue-culture (tc) technology in banana production. It is within this context that the "Biotechnology to Benefit Small-Scale Banana Producers in Kenya" Project, a tc-based banana project, was initiated in 1997. The broad goal of the project was to make available to farmers in Kenya, particularly the resource poor and small-scale farmers, improved banana plantlets for increased production and productivity in order to improve their nutrition and also enhance income generation.

1.3 Project Implementation and Related Technology Adoption Issues: The Need for the Tc-Banana Micro-Credit Revolving Fund Project

The tc-banana technology transfer project was founded and facilitated by the ISAAA, with KARI as the host institute, working closely with other strategic partners, such as the Genetic Technology Laboratory (GTL) in Kenya for the production of tc-banana plantlets, the Institute of Tropical and Sub-tropical Crops (ITSC) of South Africa in the provision of technical backstopping services, amongst others.

The implementation process started in July 1997. Financial support for the project activities was obtained from the Rockefeller Foundation of the United States of America and the International Development Research Centre (IDRC) of Canada.

Diffusion of a new technology, such as the use of tc-banana plantlets, within an area as measured by the acreage of land planted with the improved seed(lings) and the percentage of farmers who use the improved seed(lings)--tc-banana plantlets in this case--does not occur instantaneously, but rather gradually. According to Graff, et al (2000), we can assume that the individuals will select technologies that maximize expected returns, adjusted for the cost of risk. Following this line of argument, we can suppose that a farmer compares the current variety to the improved variety and will adopt the use of the improved variety only if the expected net return from the use of that variety after adjustment for associated risk is greater than zero. Graff, et al (2000) show that in the case of agriculture, a new variety will be adopted only if the extra cost of the seed is smaller than the sum of

the benefits. Promotion of the use of the tc-banana plantlets in Kenya can be justified from this consideration, given the past experiences with the devastating effect of pests and diseases on banana production using the traditional cultural practices in the country.

Literature suggests that when it comes to poor farmers, especially in the developing countries, adoption of new technologies may be affected by credit constraints. Graff et al (2000) argue that when a farmer can obtain only M units of currency (such as dollars) as net returns to a farm enterprise that employs the new technology, adoption might not be feasible unless $M > W + C_1$, where C_1 is the production cost associated with the new technology and W is the extra seed cost, even if the new technology is more desirable. Therefore, in many instances, adoption may be facilitated by the provision of credit to constrained farmers.

In order to promote the use of tc-banana plantlets in banana production in Kenya, it became obvious that the farmers were constrained by lack of capital, and that this factor was going to drastically limit diffusion. Field trials had established that the minimum feasible size of a commercial unit of tc-banana plantlets that the farmers aspiring for credit should maintain, taking into consideration such critical variables as inputs, management, cost of tissue-culture (tc) plantlets and land preparation, would be about 80 plantlets. This required an initial investment of about US$ 200 per farm household, which was beyond the reach of the resource poor farmers. At this threshold credit level, a potential return of at least US$ 230 per household per annum could be expected. This level of return would be fair enough for the farmer to be able to repay the required credit of about US$ 200 within the first harvest cycle (about 15 months), and with the tc-banana plants covering at least an eighth of an acre. This farm size is actually the size of land that the majority of the farmers in the project area are able to free for bananas. Given the perceived farmers' limitation in the acquisition of credit from elsewhere, the ISAAA initiated a $15,000 pilot tc-banana micro-credit revolving fund, primarily to enable the participating farmers acquire planting material and other inputs for tc-banana production. BEAM Business Options Ltd, a private company with expertise on community mobilization, group organization and capacity building, as well as in the design and management of rural financial services, was commissioned to implement the pilot micro-credit revolving fund project. This micro-credit project used a group approach in its implementation, and it targeted about 450 farmers.

1.4 Justification for the Baseline Socio-economic Study of the tc-Banana Promotion Project

For any project, a baseline socio-economic study is necessary in order to determine the socio-economic conditions facing the project target beneficiaries and the benefits of the project in relation to the existing conditions. As far as impact assessment of tissue-culture (tc) banana production in Kenya is concerned, Qaim (1999) is the only study that has been undertaken in the past. However, Qaim (1999) is basically an ex-ante evaluation of the potential effects of the introduction of tissue-culture (tc) technique as a biotechnology in the propagation and production of bananas in Kenya. Therefore, an ex-post economic evaluation of the tissue-culture (tc) banana project in Kenya in order to determine the kind of impact the project is having on the participating rural households was considered to be important.

2. Methodology

This baseline socio-economic study was primarily designed to evaluate the economic worth of the tc-banana project in Kenya. There are many approaches in the evaluation of the economic worth of a given project, including the determination of payback period, average proceeds per unit of outlay, average income on the book value of the investment, net present worth or value, net benefit investment ratio, benefit – cost ratio and the internal rate of return—see Gittinger (1982), pages

299–408. In the evaluation of the economic worth of the tc-banana project in Kenya, determination of discounted benefit – cost ratios was considered to be a sufficient analytic approach. Characterization and evaluation of commodity demand factors was also considered to be important because such factors critically influence the profitability of any enterprise. Therefore, this baseline socio-economic study of the tc-banana project in Kenya involved the economic assessment of both production and marketing aspects of the project, and made use of both primary and secondary data sources. Secondary data came from the review and evaluation of past relevant studies. The primary data was generated through the survey of a stratified random sample of 72 banana producers in the Maragua/Muranga region of Central Kenya, which is the main tc-banana project area in Kenya. The 72 banana producers were selected and interviewed during the September – November 2001 and the May- June 2002 period using a structured questionnaire. Data was collected and analysed using appropriate computer packages.

3. Study Findings

3.3.1 Project Membership and Group Dynamics

All the farmers that were participating in the tc-banana production project were advanced some credit to enable them purchase tc-banana plantlets and some other basic production inputs. These farmers have been repaying their credit as a group and have recorded an impressive loan repayment performance of over 75% for the first round of the loan. Currently, the ratio of men to women in the membership of the project is approximately 1:1. The project has also exceeded its membership target of 450 farmers: the formation of farmers' groups with over 500 members who have purchased over 6,000 tc-banana plantlets over the last 5-years is an indicator of the farmers' confidence in the value of the tc-banana technology. Many of the farmers have participated in training workshops, especially those focusing on the challenges that face smallholder farmers in a liberalized economy.

The majority of the project farmers had an average income of about Kshs 3,000 ($40) per family per month before the tc-banana production. This income derives from diverse farming enterprises, bananas included. With the collapse of the marketing system for what used to be the major cash-earning enterprises in the project areas, particularly coffee and dairy, banana orchards have now become an important cash earner. Most of the sample survey farmers consider income from bananas to be higher than that from any of the other farm enterprises despite the fact that banana is regarded as a subsistence food crop. Of the respondents with coffee on their farms, 84% consider bananas to provide higher income than the coffee crop. About 68% of those with a dairy enterprise consider bananas to provide higher income than small-scale dairy farming. Income from bananas is also higher than that from maize and beans. Maize and beans, however, are the staple food crops in the area and are not often sold. The projected additional net income to the family per month after the adoption of the tc-banana production technology is expected to be over Kshs 1,875 ($25) per month, reflecting an increase of over 62.5 % in disposable income per family per month.

A substantial proportion of the income from the sale of bananas was found to go into expenses on food purchases, and this may be an indication of the food consumption preferences in the area. Increased banana production may thus improve the nutritional value of the household diets and hence improve the general health and productivity of the households.

3.3.2: Previous Economic and Marketing Studies of Issues Related to Tc-Banana Production in Kenya

A general evaluation of the Phase I of the tc-Banana Project, the phase which started in July 1997 and came to an end in June 2000, gave the following as the major benefits of the project: (i)

availability of large quantities of clean and superior planting material that has enabled the project participating farmers to reclaim their banana orchards; (ii) substantial reductions in the banana yield losses from pests and diseases through the promotion of good field hygiene practices and proper management for the banana crop; (iii) additional advantages accruing from the superiority of the planting material in terms of its early fruiting and maturing period (12-16 months, compared to 18-24 months for the traditional banana), bigger bunch weights (at least 20 kg, compared to 10-15 kg for the traditional banana), and a higher annual yield per unit of land (yields of up to 50 tonnes per hectare per annum, against yields of about 30 tonnes per hectare per annum for the traditional banana); and (iv) easy coordination of marketing due to more uniform and simultaneous plantation development.

An economic survey of the tc-banana farmers who had made some banana harvests and sales by the end of the Phase I of the tc-Banana Project (see Mbogoh, 2001) gave the following estimates of the benefit-cost ratios for the discounted streams of the costs and benefits for both tc and non-tc banana production at 20% and 30% rates of interest, based on a ten years life cycle:

- At 20% Rate of Interest, Over a 10 Years Period:
    - (i) The Benefit – Cost Ratio for tc-Bananas at the 20% rate of interest = 2.8
    - (ii) The Benefit – Cost Ratio for non-tc-Bananas at the 20% rate of interest = 3.2

- At 30% Rate of Interest, Over a 10 Years Period:
    - (i) The Benefit – Cost Ratio for tc-Bananas at the 30% rate of interest = 2.5
    - (ii) The Benefit – Cost Ratio for non-tc-Bananas at the 30% rate of interest = 3.0

Even though it is generally believed that the tc-banana productivity life cycle in the sub-tropical areas is about 5 years, there are some indications that this cycle could extend up to 10 years under tropical conditions. Hence a 10-years life cycle was used in the analysis. The 20% and 30% interest rates were assumed to be the ceiling rates for capital rental, given the current capital market situation in Kenya. The results of the benefit-cost analysis show that the production of both tc and non-tc bananas in Kenya is economically worthwhile, but a detailed evaluation of the data showed that the tc-banana production had a much higher stream of benefits, with a net present worth that was about 3.4 times greater than that for the non-tc bananas. These findings indicate that tc-banana production is considerably more financially remunerative as an enterprise than non-tc banana production.

Past marketing studies show that demand for bananas in Kenya is generally supply dependent and highly price elastic. Potatoes are the major competitor for cooking bananas and mangoes are the major competitor for the dessert/fruit bananas. Many factors interact to determine demand for bananas, but prices, quality and customer preferences were found to be critically important as the major factors that influence the institutional demand for bananas. Learning institutions and hospitals were found to be important as consumers of ripe bananas (Beam Business Options Ltd, 2001).

3.3.3: The Project Phase II Baseline Socio-Economic Study

3.3.3.1 Introduction

The Phase II of the tc-Banana Project started in July, 2000. We undertook the baseline socio-economic survey in the tc-banana project area as part of the Phase II activities in order to be able to generate data that could be used in the evaluation of the Project after it ends by 30th June, 2003. This section of the paper presents and discusses the results of the Phase II baseline socio-economic study.

3.3.2 Demographic and Gender Issues in Banana Production

The baseline survey showed that 58% of the farmers interviewed were men while the rest (42%) were women. The survey further revealed that only 32 of out of the 72 sample survey farmers had harvested and sold some tc bananas over the last one year prior to the date of the field survey. The following were the significant demographic features of the sample survey farmers:

(i) The **percentage (%) distribution of the education, age and gender differentiation of the sample survey farmers** is given in Table 1.

Table 1: The percentage (%) distribution of the education, age and gender differentiation for the sample survey farmers

Education	Age	% Respondent M/F		
		M	**F**	**Total**
No Formal Education	Above 50 Years	9.1		5.3
Primary Level	Below 25 Years		12.5	5.3
	Between 35 & 45 years	9.1	12.5	10.5
	Between 45 & 50 years	18.2		10.5
	Above 50 Years	36.3	25.0	31.5
Secondary level	Below 25 Years			
	Between 35 & 45 years		12.5	5.3
	Between 45 & 50 years	9.1		5.3
	Above 50 Years	9.1	12.5	10.5
College and Above	Below 25 Years			
	Between 35 & 45 years		12.5	5.3
	Between 45 & 50 years			
	Above 50 Years	9.1	12.5	10.5
Total		**100.0**	**100.0**	**100.0**

(ii) An evaluation of **labour contribution in banana production on gender basis** showed that women contribute only about 25% to the total labour requirements for land preparation and planting, while the contribution from children in this regard is negligible. A further evaluation showed that the women's contribution to banana management labour as far as banana weeding, watering, desuckering (i.e. the banana pseudo-stem management), harvesting and marketing labour is concerned is about 40%, while the children's contribution in this regard is about 8%. The overall picture from the evaluation of labour contribution on gender basis is that women, with a minor input from the children, only contribute about 33% to the total labour requirements in banana production; the rest of the total labour requirements in banana production is provided by men.

(iii) The analysis of the **household gender empowerment** in the access and control over banana for home consumption, sales and income for the sample survey farmers showed that the access and control of bananas for home consumption and sales are substantially in the hands of women (average access and control are over 85%). However, when it comes to access and control over income from banana sales, these appear to be shared responsibilities between man and wife, but women have a slight upper edge of about 2 percentage points. These

results suggest that improved banana production is likely to contribute significantly to household welfare, especially for women and children.

3.3.3 Cultural Practices and Economic Parameters: Banana Yields, Costs and Returns

(a) Cultural Practices in Banana Production, Plot Size and tc-Banana Holdings

The cultural practices in small-scale banana production in Kenya are adequately reviewed in Qaim (1999) and need not be repeated in this article. However, the main activities in tc-banana production will be summarized in the presentation of average costs of production in Table 2. According to Qaim (1999, p.7), banana producers in Kenya can be classified into three categories:

(i) Small-scale farmer: one who grows bananas on an area of land less than 0.5 acre;
(ii) Medium-scale farmer: one who grows bananas on an area of land between 0.5 acre and 2.0 acres;
(iii) Large-scale farmer: one who grows bananas on an area of land greater than 2 acres.

The majority of the sample survey farmers in the current study could be described as being small-scale farmers. The tc-banana producers in the survey sample were found to be having an average tc-banana plot measuring about 0.3 of an acre (approximately 0.1 of a hectare (ha), thus giving a tc-banana holding of about 180 stools per farmer.

(b) Tc-Banana Establishment and Operating Costs

The tc-banana crop requires frequent watering and sufficiently fertile soils. Despite the drought conditions that had inflicted the country (Kenya) during most of the 1999/2000 period (see section (c) below), the majority of the farmers interviewed were satisfied with the results they were getting in terms of the yields of their tc-bananas. In fact, most of them intend to expand banana production.

Production costs are normally classified into fixed costs (FC) and variable costs (VC), depending on whether they are incurred only once during the establishment of a project (hence establishment costs) or whether they recur even after the project is established (hence operating costs). In this study, the costs of land preparation, digging of holes, planting material and planting labour are classified as fixed costs (FC) since they are incurred only once during the establishment of the tc-banana crop, while the costs of the various types of inputs, including the labour for their application, weeding, deleafing and desuckering are classified as variable costs (VC) since they recur even after the crop is established.

According to this study, the estimated average total cost (ATC) of production for tc-bananas for the survey households is KShs. 229,500 per hectare per annum, this being the sum of an average fixed cost (AFC) about KShs. 161,300 per hectare per annum and an average variable cost (AVC) of about KShs. 68,200 per hectare per annum. This analysis thus shows that the establishment and operating cost in tc-banana production is about KShs. 229,500 per hectare in year 1, and that the cost reduces to an operating cost of about KShs. 68,200 in year 2 and subsequent years after the establishment of the orchard. (Note: approximate exchange rate in June 2002 is about KShs. 78.0 per US$ 1). Table 2 gives a summary/breakdown of the various components of costs in tc-banana production on an acre basis (Note: 1 hectare (ha) equals about 2.47 acres).

Table 2: Annual Average Total Production Costs for Tc-Bananas(KShs/Acre)*

Details: Production Activity per Acre	Quantity (Units) Employed per Acre (Actual Farmers' Practices)	Unit cost (Kshs)	Total Cost per Acre (Kshs)
Land preparation	30 man-days of labour	80 per man-day	2,400
Digging holes	600holes; 18 man-days of labour	80 per man-day	1,440
Sowing/Planting	600 plantlets; 14 man-days of labour	80 per man-day	1,120
Cost of seedlings	600 seedlings (tc-banana plantlets)	100 per seedling	60,000
Manure	6 tonnes (10 kg of manure per hole)	1,000 per tonne	6,000
Fertilizers (DAP)	150 g of DAP per hole for 600 holes	30 per kg	2,400
Furadan (nematicide)	50 g of Furadan per hole; 600 holes	350 per kg	10,500
Waterings	3 man-days of labour per watering; twice a week, for 3 months in a year.	80 per man-day	5,760
Weeding	6 man-days of labour per weeding; two weedings per year.	80 per man-day	960
Desuckering	3 man-days per occasion; thrice per year.	80 per man-day	720
Miscellaneous	Provisional Cost Item**	600	600
Total Costs	**All Inputs per Acre**	**Kshs**	**91,800**

***Conversion factor: Approximately 2.5 acres per hectare (ha).**
****Miscellaneous item (provisional cost item) is basically a residual after the allocation of the average total production cost estimates to the various production activities as per the field survey.**
Source: Field Survey, 2001/2002.

Qaim (1999, pp. 16-17) had estimated the average fixed costs (AFC) and the average variable costs (AVC) for small-scale tc-banana producers at KShs 44,439 and KShs 8,049 respectively in 1998 KShs (when the exchange rate was about KShs 59.7 per US$ 1). This estimate gives a total production cost of KShs 52,488 per acre of tc-banana plot. However, Qaim (1999) had assumed a tc-banana plantlets population of 450, while the current study assumes a tc-banana plantlets population of 600. Therefore, if we took care of the differences in the Kenya shilling value (exchange rate) and tc-banana plant populations, the Qaim (1999) estimate of the small-scale average total cost of production for tc-bananas would actually translate into KShs 91,436 in year 2002 Kenya shillings (KShs). This estimate by Qaim (1999) is surprisingly close to the estimate from the current study, which is about KShs 91,800 per acre as shown in Table 2 and presented in various sections of this study. However, it should be noted that the current study does not incorporate the cost of land (rental value) and banana harvesting and handling costs into the estimate of the annual recurrent (i.e. operating) costs, as was done by Qaim (1999). However, the inclusion of these costs in our estimate would raise the estimate of the average total production cost of tc-bananas only by a relatively small proportion, thus leaving the estimates from the two studies comparatively similar.

(c) Banana Yields, Marketing, Prices and Returns

Banana yield is very sensitive to moisture stress. Yet many of the farmers participating in the tc-banana project planted most of their tc bananas during the 1999/2000 period when the weather conditions became less favourable for banana establishment and growth than expected. Given this scenario, it would be reasonable to assume that the farmers could easily double their observed yields in a favourable year (i.e. during a wet year with normal rainfall). If this actually happened, the

profitability of tc-banana production would even double as the tc-banana establishment costs become fully recovered after the year 2 following the establishment of the banana orchard. Therefore, banana yields reported in this study are much lower than anticipated for most farmers, except for those who were able to sustain their banana crop through some form of irrigation or watering in general. The mean harvest from the tc-banana orchards for the sample survey farmers was found to be about 966.4 bunches of bananas per hectare per year, out of which about 5% (i.e. 48.3 Bunches) were consumed at home and the rest marketed. For marketing, many of the banana producers depended on sales of bananas to market intermediaries at the farm-gate.

The prices at which the farmers sold their bananas depended on the type of buyer and the perceived quality of the banana bunch and were determined through "eye-balling" and negotiations. No weight measures were used in price negotiations. However, prices were found to vary with perceived size and quality on the part of the buyers, the main quality determinants being the shape and the size of the banana bunch and lack of blemishes on the banana fingers. A focus group study carried out during the baseline survey showed that the farmers primarily sell their bananas in the green (i.e. unripened) form to traders and other marketing intermediaries (popularly referred to as BROKERS), either at farm gate or at their local trading centers. Many of the produce buyers (brokers) come from major urban market centres, from about 100 – 200 km away from the project area. For the farmers who take their bananas for sale at the local trading centers, bicycles and/or the local commuter transport (popularly referred to as "matatu") are used to ferry the produce.

Depending on the distance from the farm to the nearest trading center, farmers pay between KShs.10/= and KShs. 30/= per bunch of bananas plus between KShs. 20/= and KShs. 50/= each way as commuter fare. In addition, KShs. 10/= per bunch of bananas is charged as cess by the local authority for selling at the local trading center. Hence it will cost between KShs. 50/= and KShs. 100/= to deliver and sell a bunch of bananas at the local trading centers. During the field survey, an average bunch of tc-bananas was found to be weighing anything between 20 and 30 kg. However, an average bunch of the local non-tc bananas was found to be weighing anything between 12 and 16 kg. These weight differentials certainly make it more attractive to produce tc-bananas relative to non-tc banana production.

Even though the farmers reported wide farm-gate price variations, depending on their location from the nearest local trading centers, they could expect to get between KShs. 200/= and KShs. 400/= per bunch of their bananas if they were to deliver and sell it at the local trading centers. Considering the cost of delivering and selling at the local trading centers and the inconveniences of transport and the time element, the average return per bunch of bananas sold at farm gate at about KShs. 150/= is seen to be much more attractive than the KShs. 250/= per bunch of bananas realizable at the local trading centers before deducting the transportation and local authority charges. Generally, tc-banana bunches were found to fetch up to 40% premium prices over the non-tc banana bunches. This explains why prices can vary from a low of KShs. 100/= to a high of KShs. 400/= per bunch of bananas in the same region at a given time.

Evidently, the prices the farmers are getting for their bananas are relatively low (being around or less than KShs. 200/= per bunch ex-farm gate) when compared with an estimated price of from KShs. 400/= to KShs. 600/= per bunch, depending on its size, that is realizable from the major urban markets, such as the Nairobi markets. One obvious question that arises is why the farmers appear to be permissive to apparent exploitation by the brokers. The answer is that the farmers are not well organized for the purposes of marketing their bananas collectively. Each of the farmers only produces small amounts of bananas at any given time, and the farmers' markets tend to be characterized by costly transport and few buyers. In any case, the farmers lack market know-how,

and this further discourages them from trying to deliver their bananas for sale in markets outside their district.

The evaluation of the costs and benefits for tc-banana production over a 10-years period gives a benefit-cost ratio of about 4.8, which reflects a fairly attractive rate of return on investment. The main factors that contribute to high levels of benefits in tc-banana production include better crop establishment and higher yields. This study has established that the average total cost of tc-banana production per farm household is about KShs. 229,500 per hectare in year 1, and that the cost reduces to an operating cost of about KShs. 68,200 in year 2 and subsequent years after the establishment of the orchard. This study found that the tc-banana yield by the end of year 1 of the crop establishment is only about 966.4 bunches per hectare. However, the yield level is expected to rise and literally double up by the end of year 2 after the establishment of the orchard. Therefore, the gross value of tc-banana production is expected to be about KShs. 265,500 per hectare in year 1, and about KShs. 531,000 in Year 2 and subsequent years after the establishment of the orchard. This analysis suggests that the farmer can expect to make a profit of about KShs. 36,000 per hectare by the end of the year 1 of the establishment of the orchard. This profit level by the end of year 1 reflects a rate of return of about 15.7 % to the initial capital investment during that year. However, the profit level in Year 2 and subsequent years after the establishment of the orchard actually rises to about KShs. 462,800 per hectare per annum, thus reflecting over 100 % rate of return on the initial capital investment. The positive net return or incremental benefit by the end of the year 1 of the project suggests that the tc-banana production project is characterized by an infinitely large internal rate of return.

(d) Break-even Analysis

The average tc-banana yield for the survey farmers was found to be about 966.4 bunches of bananas per hectare per annum, the estimated mean weight per bunch of the tc-bananas being about 22 kg. These findings are fairly favourable, when compared with the estimated average non-tc banana yield of about 579.8 bunches of bananas per hectare per annum, each bunch weighing about 14 kg. Given that the annual production cost of tc-bananas drops from about KShs. 229,500 per hectare to about KShs. 61,800 in Year 2 and subsequent years after the establishment of the orchard, the average annual cost of tc-banana production can be pegged at about KShs. 145,650 per hectare. Since the average 22 kg banana bunch fetched an average price of about KShs. 274.72 at farm gate for the survey farmers, then the break-even output level for tc-banana production can be estimated to be about 530.2 bunches of bananas per hectare per annum. This is the level of output at which the farmers are just able to recover their average total cost of production and is lower than the level of production that was actually observed for the sample survey farmers. Since many of the farmers were found to have planted their crop during the year 2000, a year that had experienced severe drought conditions that persisted into the year 2001, the general level of output would have been even better than what was recorded during the time of the field survey had the weather conditions at the time of the establishment of the tc-banana crop been more favourable. Hence the break-even output level further confirms the high profitability of tc-banana production.

(e) Functional Income Distribution: Returns to Labour, Capital and Market Intermediaries

Functionally, labour was found to contribute about 24% to the total cost of tc banana production; the rest of the cost relates to capital inputs, taking land as given. From the results of this study, the average annual gross value of tc-bananas production, based on years 1 and 2 of the project, can be pegged at about KShs. 398,250 against an expected average annual gross production cost pegged at about KShs. 145,650 for years 1 and 2 of the project. Thus the average gross margin for tc-banana production is about KShs. 252,600 per hectare per annum. Hence the returns to labour can be

estimated at a minimum of KShs. 60,624 (24%) per hectare per annum, of which about KShs. 20,006 (33%) per hectare per annum is attributable to women labour returns. Similarly, the returns to capital can be estimated at KShs. 191,976 (76%) per hectare per annum.

Our marketing surveys show that average wholesale prices for ripe bananas sold to supermarkets in Nairobi, the main metropolitan market in Kenya, have been around KShs. 16 per kg. Taking the average of 22 kg per bunch of the bananas harvested by the tc-banana project farmers so far, the average wholesale price for ripe bananas in the Nairobi market is about KShs. 352.00. This figure gives a 28.3 % marketing margin for ripening and trading in bananas, which appears to be a reasonable marketing margin.

4: Summary and Conclusions

The 72 sample survey farmers who had sold some tc bananas over the last one year prior to the date of the survey also produced non-tc bananas. For these farmers, the average household plot size was 0.3 acre for tc bananas and 1.0 acre for non-tc bananas, while the average fixed cost as a proportion of the average total cost in banana production was 70.4% for tc bananas and 49.1% for non-tc bananas, with the capital contribution to the average total production cost being 76.1% and 52.6% for tc and non-tc bananas respectively, the respective balances being the contribution from labour. However, the yield from non-tc banana production is only about 60% of that from tc-banana production.

Banana yield is very sensitive to moisture stress. Yet many of the farmers participating in the tc-banana project planted most of their tc bananas during the 1999/2000 period, a period when the weather conditions became less favourable for banana establishment and growth than expected. Rains completely failed during the first season of the year 2000, and drought conditions persisted into a good part of the year 2001. This affected not only the growth rate of the tc-banana plants but also the other farming activities and productivity of farm labour. Therefore, it is not surprising that the banana yields reported during the socio-economic survey are much lower than anticipated for most farmers, except for those who were able to sustain their banana crop through some form of irrigation or watering in general.

Prices influence profitability, and as noted elsewhere, banana prices in the tc-banana project area were being determined through “eye-balling” and negotiations, and no weight measures came into play. However, prices did vary with the perceived quality on the part of the buyers, the main quality determinants being the shape and the size of the banana bunch and lack of blemishes on the banana fingers. Generally, the tc-banana bunches were found to be fetching up to 40% premium prices over the non-tc banana bunches. This explains why the prices could vary from a low of KShs 100/= to a high of KShs 400/= per bunch of bananas in the same region at a given time.

Past evaluation of the economic worth of banana production in Kenya show that the production of both tc and non-tc bananas is economically worthwhile. The benefit-cost ratios for tc and non-tc banana production were found to be about 2.8 and 3.2 at 20% rate of interest and 2.5 and 3.0 at 30% rate of interest respectively. The past study also shows that the tc banana production has a much higher stream of benefits, with a net present worth which is about 3.4 times greater than that for the non-tc bananas--see Mbogoh (2001). These findings indicate that tc banana production is considerably more financially remunerative as an enterprise than non-tc banana production. The current baseline socio-economic study supports this conclusion, based on the results of profitability analysis. The study now estimates the benefit – cost ratio of tc-banana production at 20% rate of interest to be about 4.8, a figure that generally reflects improved banana yields since the Mbogoh (2001) study. The analysis of profitability indices shows that the annual rate of return to capital

invested in tc-banana production improves drastically as the banana establishment costs are recovered towards the end of the year 1 of the tc-banana crop establishment and thereafter. Apart from the income generation perspective, bananas also provide food for household consumption.

Functional distribution of income from banana production is 76% for capital and 24% for labour, of which 33% of the labour contribution is from women. Banana ripening and trading margin is about 28.3 % of the average realizable wholesale price for ripe bananas in Nairobi supermarkets, and this margin appears to be reasonable.

Evidently, tc-banana production is relatively more capital intensive than non-tc banana production. Comparisons of inputs, yields and returns show that non-tc banana production is basically a low-input, low-output type of activity for small-scale farmers, and this makes it conceptually less demanding on their efforts. On the other hand, tc-banana production is basically a high-input, high-output type of activity. Hence the production of tc-bananas is relatively more profitable than that of non-tc bananas, and the production of tc-bananas in the project area can be said to be making a significant and positive contribution to the livelihoods of the involved rural households. As noted from the evaluation of the results in Table 2, the findings from the current study are fairly comparable to those of Qaim (1999) when time factor, exchange rate fluctuations and differences in plant populations are taken into account. Therefore, the small-scale farmers should be encouraged to switch from non-tc banana production to the production of the tc bananas. However, they would have to be educated and encouraged to adopt better management practices because the production of tc bananas requires higher husbandry standards. The higher financial returns per unit area of land associated with the tc-banana production should make the small-scale farmers appreciate the need for the proposed switch.

The tc-banana producers appear to be constrained by capital for investments in irrigation facilities (to make banana watering easy) and acquisition of fertilizers or organic manures to produce good banana crop. This situation justifies the case for continued efforts to provide some form of micro-credit to tc-banana farmers to enable them overcome capital-related constraints. Lack of organized marketing makes exploitation of the banana producers by traders/brokers fairly easy. Therefore, the efforts that are being made to promote tc-banana production by the tc-Banana Project for small-scale farmers in Kenya through the technical and financial support from KARI and ISAAA are commendable since they can be justified from both food security and income-generation criteria.

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