AN ECONOMIC ASSESSMENT OF TISSUE CULTURE BANANA PRODUCTION TECHONOLOGY; A CASE OF CENTRAL KISII DISTRICT

BY

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DECLARATION

DECLARATION BY THE STUDENT

This research is my original work and has not been presented for award of degree in any other university. No part of this thesis shall be produced without the prior permission of the author and or Moi University.

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DEDICATION

I dedicate this thesis to my beloved parents the late Mr Elisha Lisa and Grace Anyangu Lisa for instilling in me the virtues of diligence, discipline and honesty, my son Eric and daughters, Naomi and Betty who missed my loving care and company during my period of study.

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ABBREVIATIONS AND ACRONYMS

EU	European Union
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
IDRC	International Development Research Center
INIBAP	International Institute for Bananas and Plantains
IRR	Internal Rate of Return
ISAAA	International Service for the Acquisition of Agri-Biotech Applications
KAPP	Kenya Agricultural Productivity Project
KARI	Kenya Agricultural Research Institute
LIC	Low income countries
MoA	Ministry of Agriculture
NPV	Net Present Value
PRA	Participatory Rural Appraisal
R&D	Research and Development
RF	Rockefeller Foundation
tc	Tissue Culture

ABSTRACT

Agriculture technology is known to be a catalyst for agricultural development and rural poverty reduction through increases in food production and/or reduction in production costs. Inception of tissue culture banana technology was thus perceived as having the potential to reduce the vulnerability of households to production losses from banana pests and diseases. In turn, this would lead to higher or more consistent incomes at farm household levels. The study was set to investigate the impact of tissue culture banana technology on the incomes of the farmers in Central Kisii District. The objectives of the study were; to determine the profitability of investment in tissue culture compared to conventional banana production at farm household level, and to analyze socio- economic and management factors that influence the yields of tissue culture banana technology in the study area. Two hypotheses were postulated that; (a) farmers income from using tissue culture technology does not significantly differ from that achieved from using conventional banana technology and (b) Socio – economic and management factors do not significantly influence the yields of tissue culture banana technology. The study was carried out in Mosocho and Marani Divisions of Central Kisii District. Both primary and secondary data were used. Primary data was collected from 200 small scale farmers engaged in tissue culture and conventional banana production. The study sample was chosen using cluster, purposive and simple random sampling techniques. Secondary data comprised of published data from district survey reports, district development plans, district and divisional reports on tissue cultured and conventional banana production, sessional papers, books, journals and articles. Three methods of analysis were employed these were: Descriptive Statistics Analysis, Benefit Cost Analysis using Net Present Value, Benefit Cost Ratio, Internal Rate of Return and Cobb-Douglas production function model. OLS estimation of the production model was done using statistical package for social sciences (SPSS) version 13.0. The R^2 and adjusted R^2 were obtained to explain the variation in the dependent variable. This was followed by testing of significance of the identified variables investigated at $p < 0.05$ significance level. The findings showed that the socio-economic and management factors analyzed had significant impact on the total output produced. It was established that farming experience (t= 6.642) and quantity of fertilizer applied (t=5.055) were the most significant and potent contributors followed by manure application. NPV of tissue culture banana and conventional banana technologies were Ksh. 64,383.56 and Ksh.64,884.42 respectively revealing that conventional banana technology was slightly more viable than the tc technology. BCR and an IRR of 1.866 and 16.031% for tc technology and 2.569, 20.95% for conventional technology indicated that costs incurred in the production process of bananas were recovered and profits made but there were more profits in conventional technology. tc had statistically significant lower average net income compared to conventional bananas. It was recommended that, technology promoting institutions need to intensify and facilitate flow of information and exchange of research findings on banana yields and the recommended management practices for increased productivity. Collaboration between farmers and credit providers should be enhanced to improve tc banana management. On farm preparation of farm yard manure and compost should be encouraged amongst the farmers. Farmers need to be enlightened on proper farm records through field days, exhibitions and workshops at local levels.

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CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Agriculture has been described as the cornerstone of human life and the backbone of many economies in the developing world particularly in Sub-Sahara Africa. Strong agricultural growth has been a feature of countries that have successfully reduced poverty such as India, Bangladesh, Indonesia and China. Thirtle *et al.* (2003) reporting on observations drawn from 48 developing countries, show that one percent increase in agricultural productivity reduced the proportion of people living on less than US$1 per day by between 0.6 and 1.2 percent. According to Lipton (2001) no other sector offers the same possibilities to create employment and lift people out of poverty.

Agriculture is the lifeline of the 61 percent of Kenya's population who live in rural areas. It is the root of economic growth, employment, and foreign exchange. Kenya's agricultural sector directly influences overall economic performance through its contribution to GDP. The sector contributes to 30 percent of the GDP, 80 percent of the national employment, 60 percent of the total export earnings and provides for most of the country's food requirements. Furthermore, agricultural growth has the potential to catalyse growth in other sectors, with an estimated multiplier effect of 1.6, compared to 1.2 in non- agricultural sectors (Republic of Kenya, 1999).

Bananas grow in more than 120 countries on almost 10 million hectares, with an annual production of 98 million metric tons. Bananas are easy to grow and do not need to be replanted each season. They are well suited to intercropping systems and to mixed farming with livestock. They thrive in a range of environments and produce fruits all year-round, thus providing a continual source of food, even during the "hungry- period" between other crop harvests (Musa, 2004; INIBAP, 2004).Indeed, the importance of bananas throughout the world, and in Kenya cannot be over-emphasized. The crop is the world's third important starchy staple after cassava and sweet potato (FAO, 1997). Its world production estimates are placed at 49.63 million ton, of which 6.44 million is grown in Africa, 20.31 million in Asia, 13.31 million in South America, 1.5 million in Oceania, 7.66 million in Central America and 0.42 million in Europe (INIBAP, 1991; Robinson, 2001). It is mainly consumed domestically, with an annual per capita consumption of 220-460 Kg, providing more than 25% of the total calories consumed (INIBAP, 1991). In Africa, bananas and plantains provide more than 25% of food energy requirements for around 70 million people.

Banana is an important staple food and cash crop in many parts of East Africa, particularly Kenya, Uganda and Tanzania (ISAAA, 1995). In East Africa highlands, bananas provide staple food for around 20 million people, and this region alone produces nearly 15 million tones annually (Musa, 2003, INIBAP, 2004). It is the most economically efficient crop to produce compared to other starchy crops (Anon, 1999). The East Africa region i.e. Kenya, Uganda and Tanzania produce about 49 percent, providing income and food for 20 million people (Anon, 1999).

In Kenya, and to a larger extent, the East African region, the crop is mainly grown and managed by smallholder farmers, predominantly peasant women. Besides being a source of carbohydrates, essential vitamins and minerals, banana is attractive to smallholder farmers because it is appropriate for inter-cropping. Production begins within 16 months from planting and may last up to ten years thus providing reliable family income. Over the last decades however, banana production in Kenya and the Eastern Africa region has been on the decline (MOA, 1994). This decline has been brought about by the infestation with Panama disease, Black and Yellow Sigatoka, weevils and nematodes. As a result, bananas have become increasingly costly and no longer serve as a ready supply of highly nutritious food and cash for rural populations, particularly women and children. The situation threatens food, employment and income security in banana producing areas.

Kenyans obtain most of their food, livelihoods, employment and foreign exchange earnings from the agricultural sector, even though only 20% of the country's territory is arable land (CBS, 1996; Sombrock, *et al.* 2002). In addition, the population growth rate of over three percent per year registered in Kenya in recent years has placed an increasing strain on the food production, income and employment potential of the agricultural sector and its natural resources in the country. As a result, hunger and poverty levels have been on the increase. Dependence on cash crops, such as coffee and tea, further restricts the availability of land for food production. At the same time, low levels of farm inputs and management, inadequate land for crop rotation among smallholder farmers, who make up to 80% of the population and lack of disease-free planting materials, have recently resulted to higher pathogen pressure on farming systems than in the past years (Nyangito, *et al.*, 1999). Pests and pathogens become endemic in the soil while land scarcity limits the opportunity for rotational production so that many crops are planted into infected soils, perpetuating the problems. The intensification of agriculture has also implied accelerated depletion of soil as a natural resource or resulted to reduced productive capacity. All these factors compound the problems and exacerbate the need for improvements in food productivity in the short term while maintaining the productivity of the agricultural natural resource-base for future generations.

The total area under banana in Kenya is estimated to be 85000 hectares producing 900000 metric tones per annum (Anon,1996).This gives an average yield of 9 tones per ha as opposed to the potential of over 40 tones per ha. Banana are grown from sea level to 1800 m above sea level where there is adequate rainfall, although in some dry areas like Machakos, Homabay and Baringo districts, irrigation is practiced (Nyangito *et al*.,1996).

Banana farming in Kisii Kenya has continued to play an important role in the economy of the region. Kisii District in Nyanza Province has the favorable climatic conditions for banana cultivation. The region produces 40 percent of the total banana production in Kenya (Onyango *et al*., 1999). The region has 24,600 ha of the crop and produces 441,000 tones annually and yields up to 17 tones per ha. (Anon, 1994, MOA, 2005) this figure is far much below the potential of 40 to 50 tones per ha. The cooking type of banana, the East African highland banana a *matoke* is most common. However dessert bananas also contribute to the economy of the region. The main dessert banana grown is the “kisukari” (AB) or the apple banana, which is highly susceptible to panama disease and its production, has been declining. This cultivar is also low yielding even under favorable climatic conditions. New superior dessert banana cultivars resistant to panama disease have been identified and introduced in the region.

The introduction of tissue culture (tc) techniques for banana propagation was thus perceived as having the potential to help reverse the situation since it would ensure timely availability of clean planting material. The basis of the technology is the ability of many plant species to regenerate a whole plant from a shoot tip (Wambugu and Kiome, 2001).

Since inception of tissue culture banana technology, farmer groups have increased, the number of participants along the banana sub sector or value chain in the region has increased and the benefit of the technology to farmers has not been analyzed and documented. This study is therefore designed to asses the impact of tc technology on farmers income, and identify socio economic and management factors that influence the yields of tissue culture tc banana in the District.

1.2 Problem Statement

A participatory rural appraisal (PRA) exercise carried out in Kisii in1997 revealed that there was a rapid and steady decline in banana production. The decline was caused by constraints which came about because of use of conventional method in banana plantation establishment.

The common farmer practice of using infected sword suckers has continuously perpetuated the spread of banana diseases and pests, which are estimated to reduce yields by up to 90% (MOA, 1994) thus worsening the food security situation. Limited access to clean planting materials for banana growers in Kenya and East Africa constitutes a priority problem since banana contributes to the livelihoods of many as well as the nutritional needs, employment and income for nearly 20 million people in the region. Since the 1960s several exotic cultivars had been introduced by farmers into the region from other banana growing areas within and outside the country.

Table 1.1: Average Banana Production Statistics for the Provinces of Kenya (1996-1997)

Province	Area (ha)	Production (t)	Yield t/ha	Production /share
Central	16,913	169,316	10.0	16.5
Coast	5,743	55,341	9.6	5.4
Eastern	9,669	97,144	10.0	9.5
Nairobi	48	409	8.5	0.0
North eastern	271	1,522	5.6	0.1
Nyanza	30,234	574,740	19.0	56.1
Rift valley	2,688	39,781	14.8	3.9
Western	7,800	86,107	11.0	8.5
Total	**73,366**	**1,024,360**	**14.0**	**100.0**

Source: Ministry of Agriculture, 1998

Banana growers, national and international research institutions sought to formulate strategies to mitigate production decreases. One of these strategies was the introduction of tissue culture banana technology by which clean planting material of superior varieties were introduced to farmers.

The formal introduction of tissue culture banana technology into Kisii Kenya began in 1997. The objective of the technology was to acquire, multiply, and disseminate new banana cultivars to farmers.

The immediate purpose of introducing tissue culture banana technology was to reduce the vulnerability of households to production losses from banana pests and diseases. In turn, reducing production vulnerability was to have important ramification for consumption and income vulnerability. Reducing production vulnerability was to lead to higher or more consistent incomes and consumption levels, either directly through meeting subsistence needs or indirectly through more regular or increased sales and market purchases. Over time, smoother banana production and improved income can accumulate contributing to changes in status in the community.

Apart from ex-ante impact assessment (IA) study in 1999 to evaluate the potential impact of tissue culture technology in Kenyan banana production and some on- going ex-post impact assessment work on improved banana varieties in Tanzania, nothing has been done to assess the impact of improved banana varieties on farmer’s income compared to the conventional varieties in Kisii, Kenya. The research aimed at determining the costs and benefits of the investment in tc banana production after the improved varieties have been developed and adopted by farmers.

It is against this background that this study was designed to investigate the impact of tissue cultured banana technology on farmer’s incomes, and the socio-economic characteristics and management practices that influence the yields of tissue culture banana production in Central Kisii.

1.3 Research Objectives

1.3.1 Broad objective

The broad objective of the study was to describe tissue culture banana production in Central Kisii District, compare its profitability with conventional banana production technology, identify farm level problems facing the small scale tissue culture banana farmers and explore measures that could be employed to curb them.

1.3.2 The Specific Objectives

i. To assess the profitability of investment in tissue culture banana production compared to conventional banana production at farm household level.

ii. To identify and analyze some of the socio- economic characteristics and management factors that influences the yields of tissue culture banana technology.

1.4 Research Hypotheses

The following hypotheses were formulated and tested in relation to the objectives of this study:

Ho_1; There is no statistically significant profitability difference between tissue culture and conventional banana production technologies.

Ho_2; Socio –economic characteristics and management factors identified have no significant influence on the yields of tissue culture banana technology.

1.5 Justification for the Study

Banana is a crop that seem to be doing well both in the local and international market. Tissue culture banana technology was introduced with a target of increasing productivity and farmers' income. The research was designed to evaluate the incomes achieved from tc farming compared to conventional banana production. An analysis of socio economic and management factors was expected to reveal their significance on tc production and to shed light on income generation and profitability of the enterprise to farmers and households.

According to Echeverria, (1990), there are three main reasons for evaluating agricultural technologies or research. These are to take a look at the future, i.e. to assist in effective research planning, both at the project and program level to take a look at the past i.e. to estimate a research payoff, usually for the purpose of justifying financial support for future research, and to look at the present i.e. to help guide the development of effective research and technology policies.

Impact is the value of research benefit to the individual recipients, communities and the country at large (Anandajayasekeram, 1990). It shows the usefulness of research results to policy makers, farm communities and organizations, donors and other interested groups. Impact studies are in one way to provide convincing evidence that agricultural research has been a good investment in the past and in the future. Impact studies are done in order to evaluate the effects of agricultural research. It is a way of assessing user satisfaction with research results whereas evaluation is judging, appraising, determining the worth, value or quality of research, whether it is proposed (ex-ante), on-going, or completed (ex-post) aspects considered during the evaluation are the relevance, effectiveness, efficiency and impact.

Agricultural research is viewed as a long-term investment. The benefits of research will be forthcoming long after the initial research activity is conducted. The three main research time lags are, 1) the research for new knowledge i.e. the research process itself takes time, 2) the adoption lag; this is the time between when a particular technology is developed and when it is applied, and 3) the aggregate impact of new technology on productivity. There is just a small impact when a few innovative farmers use new technologies but this impact increases with the number of farmers who adopt the new technologies.

The researcher seeks to support areas of scientific research and policy affecting banana production. By evaluating the effects of tissue culture banana technology on farmers' income and identifying problems facing its production, participating organizations will be able to target their work more appropriately towards income improvement and livelihood needs.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents information on importance of economic assessment, theoretical and empirical literature on what is tissue culture technology, importance and impact of the technology on banana production, studies on feasibility of investment in banana cultivation, costs and returns in banana production. Finally, it gives information on various economic assessment studies and tissue culture banana studies that have been done before.

2.2 Theoretical Literature

Banana is one of the crops that have received increased research attention over the last ten years in Kenya. The tissue culture technique (micro-propagation) refers to the production of large numbers of plants from small pieces of the stock plant in relatively short periods of time. Depending on the species in question, the original tissue piece may be taken from a shoot tip, leaf, lateral bud, stem or root tissue (Nguthi, 2008). Micro propagation offers several distinct advantages compared to conventional propagation techniques. A single ex-plant can be multiplied into several thousand plants in less than one year. Using the technique, it is possible to rapidly introduce selected superior clones of plants in sufficient quantities to have an impact at the farm level.

The technique also allows mass multiplication of species that are difficult to regenerate by conventional methods of propagation and where conventional methods of propagation are inadequate to meet the demand of planting material, which is the case with the banana in Kenya (Nguthi, 2008). Conventionally one banana plant produces about ten suckers in a year while over five hundred plantlets can be produced using the tissue culture technique. Another purpose for which plant tissue culture is uniquely suited is in the obtaining of specific pathogen –free plants. Tissue culture plants thus exhibit significantly increased vigour, yield, and early maturity and are disease and pest free.

Micro propagation has been developed over many decades, and can now be considered a ‘mature’ plant biotechnology. It is already widely used in developing countries, particularly Asia as a result of the immense market in China for plants generated in this way. It is relatively cheap, and has been shown in general to increase productivity especially of root and tuber crops, such as sweet potatoes.

2.2.1 Impact of Biotechnology on Yields

Biotechnology has great potential to develop crop technologies with favorable attributes such as higher yields, higher nutrient content, and resistance to pests and diseases. The adoption of genetically engineered crops has resulted in agricultural productivity growth and ensured an abundance of food in countries like the USA, where they have been adopted (Fernandez-cornejo and McBride, 2002). However, biotechnology needs to be directed towards addressing the crops and areas that will benefit the poor people. Currently biotechnology is being developed by the private sector and is directed towards areas and crops that have promising returns (Tripp, 2001_b).

According to FAO (2001), tissue culture has revolutionized banana cultivation and has replaced the use of conventional vegetative suckers in many of the intensive banana growing regions. FAO estimates that up to 50 million tissue cultured plants are produced annually making banana the most widely *in vitro* propagated plant. An *ex-ante* study by Qaim (1999) showed that the tissue cultured banana technology was likely to raise yield by 150, 132, and 93 percent for small, medium and large-scale farms, resulting in increases in incomes by 156, 145 and 106 percent for small, medium and large-scale farmers respectively.

Tissue culture technology in Africa has increased banana productivity from 20 to 45 tons per hectare (Wambugu and Kiome, 2001). They add that for the typical Churan family, which had average up to 10 individuals, increased production translated to a climb in income from the average of US$1 per day, per family to as much as US$3 per day, per family.

The impact of introduction of tissue culture bananas in Uganda and Tanzania includes; increased banana production (harvest throughout the year), increased productivity (bunch weight), improved banana husbandry (use of manure, mulch, spacing, detrashing and desuckering), recovery of neglected bananas and increased confidence in banana production. Nkuba *et al* 1999, the results of on farm testing in Uganda and Tanzania showed that on average the new banana cultivars yielded a bunch weight of 18.9kg compared with 9.7kg for local cultivars in Kagera, Tanzania (Byabachwezi *et al* 1997; Nkuba, *et al* 2002).

In China's Shandong Province, a micro propagation project that created and distributed virus-free sweet potatoes led to an increase in yields of up to 30 per cent by 1998. Productivity increases were valued at US$145 million annually, raising the agricultural income of the province's seven million sweet potato growers by three to four per cent in one season. Government subsidies helped to encourage adoption of the technology and kept the cost of the planting material low (ISAAA, 2004).

In Vietnam, introducing improved, high-yielding potato cultivars able to resist the late-blight disease had seen yields double, from 10 to 20 tonnes per hectare (ISAAA, 2003). The farmers were themselves multiplying their plantlets through micro propagation, making the seed more affordable.

The use of improved technologies has been the major strategy used to increase agricultural productivity and promote food security. It is proposed that technological change that leads to increases in food production and or reduction in production costs can reduce poverty in four basic ways: raising the incomes of farmers who adopt the technology, changing demand for agricultural labour, reducing food prices (or dampening food price increases), thus making incomes purchase more and, possibly stimulating economic growth that may generate additional employment opportunities and increase wages (Kerr and Kolavalli, 1999). The impact of agricultural technology is demonstrated by the green revolution, which led to a doubling of yields for the major food grains in the 1960s and 1970s, particularly in Asia. The greatest impact was increase in crop production, which contributed to rural employment and lowered food prices (De Janvry and Sadoulet, 2002; Tripp, 2001a).

Thus the practical goal of this research was to provide banana researchers in Kenya additional insight information that they can use in setting research priorities. Since the data collected was subjected to statistical analysis, generated statistics may also be used as baseline for monitoring the impact of future banana innovations.

2.3 Empirical Literature

2.3.1 Review of Economic Assessment Studies

Echeverria, (1990) says that there are methods that have been developed to evaluate agricultural technologies. He categorizes these methodologies in two broad ones.

i) Economic surplus estimations based, for example, on supply shifts due to increases in production attributed to research. These methods allow consumer and producer benefits, benefit/cost ratios, and average rates of returns on investments to be computed and

ii) Econometric estimations usually based on production functions where research investments are one of the inputs. Other inputs would be land, labour, capital, etc and yield being the dependent variable. These methods allow a marginal rate of return on investments to be computed.

The economic surplus methods are particularly useful when distinguishing between benefits obtained by producers and or consumers. In general the larger the size of the farms the more producers will benefit from research conducted on export commodities. The lower the income of consumers the lower the proportion spent on food. The econometric method allows the separation of the effects of different conventional inputs, such as research, extension, education etc. All methods relate the benefits and costs of research over a specified period of time.

Inputs of research are such as researchers and operating funds and outputs are the newly developed technologies. Echeverria, (1990) says that some methods of evaluation measure inputs such as expenditures on research whereas other methods use output measure such as the contribution of a particular technology with the diffusion and adoption of technology over time and likely impact on production of the technology.

In his study of Tanzania maize industry, Nkonya (1999), determined consumer and producer welfare gains from advances in extension and research to help determine how a national taxing schedule should be determined. He used the Tanzanian farm maize production survey data to calculate the rate of shift in supply from advances in extension and research, rate of adoption of new seed varieties and percentage of off-farm marketable surplus to evaluate consumer and producer welfare benefits from advances in extension and research. Welfare analysis was used to determine who benefited more between producers and consumers due to increased maize production from advances in extension and research. This information was needed to determine whether Tanzania consumers or producers should bear greater proportion of the extension and research costs of producing maize. He used Hayami and Herdt, (1977) methodology to compute the distribution of extension and research benefits of staple crops grown by subsistence farmers in low income countries (LICs).

In 1999, Qaim applied an economic surplus model to investigate the impact of both banana and sweet potato biotechnology in Kenya. The economic surplus model was based on linear functions of supply and demand in an economy without international trade. Quoting Alston, (1995) he said that the partial equilibrium model, is a standard procedure for modeling technological progress associated with specific commodities. He further said that those economic surplus measures in a partial equilibrium setting only capture the direct and immediate benefits of a technology for producers and consumers. Indirect effects and spillovers to other markets are disregarded. The assumption is that innovation causes the supply curve to shift downwards in a parallel manner. Hayami and Herdt, (1977) developed a model to complement the market demand curve of a semi-subsistence crop with an additional demand curve for home consumption.

Mills, (1998) used a quadratic programming spatial equilibrium model to analyze the potential impact of maize research in six regions of Kenya. The regions were low tropics, dry mid–altitude and moist mid-altitude, dry transitional, moist transitional and high tropics. The model which is ex-ante allows for reversible trade flows among multiple regions. Using 1992-94 monthly retail maize price data for over 30 markets across Kenya, the study estimated the transaction costs associated with inter zonal trade. Given that regional variations are a reflection of transportation and other miscellaneous costs of mixing maize between regions, Mills used these differences to construct a transactions cost matrix for regional trade. The study simulated the impact of research and other factors on Kenya's maize markets over a thirty year period.

The results of the study indicated significant movements in price and quantity both with research and without research scenarios. Mills also found reversal in the relative magnitude of regional prices over the period using an annual real discount rate of 5 percent, research induced changes in producer and consumer surpluses were estimated. The results, on the whole, reflected high returns to continued maize research in Kenya.

Mills however pointed out that research alone will be inadequate for maintaining Kenyan self sufficiency in maize production, a goal that requires an additional productivity growth of 1.5-2 percent per annum in each of the regions. A sensitivity analysis carried out in the study suggested a strong inverse relation between supply elasticity and each of producer and total benefits from research. Another finding of the study was that fixed price wedge models significantly over estimate the effect of world trade on market prices in major maize growing regions as well as producer's share of research benefits.

Mills (1998) said that there were rigorous methods that had been developed for ex-ante evaluation of research. He argued that the tool kit of techniques ranges from ranking alternatives based on subjective scoring criteria to the formal application of economic principles using a combination of subjective assessments of the potential for generating and adopting technologies and quantitative economic data. He further added that KARI, in its recent evaluation of priorities across all commodities and factor research programs, used the scoring method. He gave an account on how quantitative information can be used in a structured priority setting exercise in which research priorities are based on an assessment of where research has the greatest potential to benefit producers and consumers. He used economic surplus method to set priorities for agricultural research for KARI. The following works show the extent and application of economic models in impact studies.

Mills, (1998) pointed out that the most commonly used measure in extension research investment is the economic surplus (consumer and producer surplus) model. He added that consumer surplus was the value of a good to its consumers over the price received for a good by its suppliers over the variable costs of its production. The changes in consumer and producer surplus resulted from a parallel, downward shift in supply induced by research. Mills emphasizes that the important point was that research benefits were linked directly to the magnitude of the rightward shift in the supply curve. He said that two components drive this shift i.e. technology generation and technology adoption.

Fisher, *et al* (1998) studied the prospects for technical change in the irrigated rice sector of Senegal and measured ex-ante economic returns to recent research efforts. They looked at the recent and potential future economic gains realized from technological innovations and policy reforms, which raised productivity dramatically. To evaluate the impact of WARDA-ISRA work on rice, Fisher *et al*, (1998) developed an economic surplus model. They measured social returns in terms of the change in economic surplus due to the upward shift in the production function associated with the technological change.

The Australian wool industry is the focus of a study by Mullen and Alston (1990) aimed at analyzing the returns to the industry from investment in research and development (R&D). The study aimed at evaluating and comparing the distribution of benefits accruing to wool growers, processing firms and final consumers. They computed benefits based on cost cuts arising from successful R& D at different stages in the production, processing and marketing of wool. The industry employed Australian wool, wool from other countries, and inputs such as labor and capital. A market equilibrium model of the wool industry was used to compare the returns from R&D activities that reduced costs by 1% in wool production, wool processing and textile manufacturing. The method of analysis entailed estimating the change in prices and quantities of wool top, Australian wool from other countries, and processing inputs resulting from a 1% decrease in the cost of producing or processing wool. A key aspect of the study had to do with determination of values for the most important market parameters.

The study found that the returns from farm production with R&D activities were at least twice the magnitude of those from off-farm R&D. In order to yield the same returns as a 1% decrease in farm costs, wool top processing costs have to fall by nearly 6%. Another result of the study was that the share of total benefits accruing to the Australian wool industry from the 3 types of R&D activities ranged between 24% and 58%. The study further observed that while Australian wool growers normally pay the wool levy to finance the R&D activities, they were able to pass on part of the burden of the levy to wool top processors and consumers.

Hayami and Herdt (1977) examined the impact of technologically induced rightward shift in the supply function of a commodity grown and partly consumed by semi-subsistence farmers. They developed a model that incorporated the semi-subsistence production into an analysis of the relationship between technological change and income distribution in a closed economy both among sectors and within sectors. They looked at the impact of technological change on income distribution (the market price impact in semi- subsistence agriculture). They argued that technical progress for a commodity implies a downward shift in supply function, which with a downward sloping demand curve results in an increase in economic welfare through the consumption of a larger quantity at a lower cost. Distribution of the gains in economic welfare between consumers and producers depends on the price elasticities of demand and supply for the commodity. They argue further that in economics where farm produce demand is price inelastic, consumers are the main beneficiaries of farm technological progress, with farmers finding themselves trapped on a technological "treadmill". However, when a major fraction of the commodity is consumed in the households of producers and not traded in the market place, some of the consumers' surplus from technical progress is internalized by those producers. If demand is price inelastic and prices are permitted to adjust to market forces, the portion of consumers' surplus internalized by producers is inversely related to the proportion of output sold. If the commodity's price is fixed by the government policies or determined by the international market, the technological change may not result in any price change. In such a case, the distribution of benefit will accrue to producers in direct proportions to their sales.

Hayami and Herdt (1977) indicated the critical consideration of gains from technical progress in the production of a subsistence crop. This was the crop produced by a mass of small producers so that its market can be approximated by perfect competition. Subsistence was a necessity good characterized by a low price elasticity of demand, a major portion of the crop output was consumed by the producers households and a minor portion sold in the market, and the price for the crop was set by demand and supply in the domestic market.

2.3.2 Financial Feasibility of Investment in Fruit Cultivation

Cheong and Lamport (2010) carried out a financial appraisal of three different options for a sugar estate of Mauritius. The study was conducted to compare financial merits of three different options, namely 1) sugarcane monoculture (2) partial diversification and (3) full diversification. All analyses were conducted for a 30 ha plot over an eight–year project period. In the most likely situation, NPV and IRR of sugar monoculture were computed to be Mur. 9.2 million (US $ 0.30 million in 2009) and 51.9%, compared to Mur. 17.1 million (US $ 0.55 million) and 82.9% for partial diversification, and Mur. 24.5 million (US $ 0.79 million) and 59.0% for full diversification. It was concluded that all the three options were potentially acceptable, but the estate should, in the first instance, adopt a partial diversification strategy as this option would give a higher NPV than sugarcane monoculture, but with lower risks than full diversification.

Harb (2010) studied financial and economic feasibility of sugarcane production in Northern La Paz. Financial analysis was carried out to establish if the industry was financially desirable for those involved in it, while economic analysis was done to establish the potential benefit and damage it could cause for the whole society. Analysis of the agricultural production of sugarcane, sugar and alcohol factory, gave a positive NPV of US$ 25.3 million and IRR equivalent to 23.2%. On the other hand, there was a negative NPV of US$ 7.18 million and an IRR equivalent to 8.34% for the factory. It was concluded that the sugarcane industry was desirable for the national economy, despite the fact that the sector was losing. The sector comprised of the investor and owners of the factory.

Evaluation of the performance of jackfruit- pineapple agroforestry system in Madhupur Tract was a study done by Hassan *et al*, (2008). Intertemporal budget for jackfruit-pineapple agroforestry production system showed that the cash flow in the first year was negative, but it became positive from second year and it continued in subsequent years. At 12% discount rate, gross cost, gross benefit and net present value were Tk. 303729/ha, 457449/ha, and 153720/ha, respectively. Benefit cost ratio of 1.51, net present value of Tk. 457449/ha and internal rate of return of 51% clearly indicated the profitability in jackfruit-pineapple agroforestry production system. The benefit cost ratio indicated that if a farmer invested Tk. 100, he would get Tk. 151.

Byresh (2007) studied the comparative economics of local and improved variety of guava orchards in Dharwad District Karnataka. The study showed that capital investment in guava was economically viable. In this study the NPV of local and improved variety of guava per hectare at 9.5% discount rate were Rs. 213726.99 and Rs. 439913.24 respectively. The B: C ratio was 2.25 for local variety and 4.28 for improved variety at 9.5% discount rate. While the IRR in improved variety of guava was 26% compared to15% for local variety of guava. IRR was more than the opportunity cost of capital; it clearly indicated that investment on guava orchard was financially feasible.

Sundaravardarajan and Ramanathan (2003) reported that B:C ratio and IRR for new cashew plantations were 1.42 and 34.36 percent, while for old cashew plantations it was 1.06 and 17.17% respectively. Further, they suggested that there was need to create an awareness to adopt improved varieties, which not only reduce the cost of cultivation but also to increase the net income among the different size group of farmers.

Chitra *et al* (1997) in the study on economics of ber production in and around Hyderabad city of Andra Pradesh found that, the pay back period in ber cultivation was 4.42 years and the benefit cost ratio was 5.25 indicating the profitability of ber cultivation. The net present value worked out was Rs. 12,061. The IRR was 73.54% which was higher than the lending rates of commercial banks. The results of the study indicated that even though ber required relatively higher initial capital investment compared to other fruit crops, the returns were higher during the bearing period and economic indicators clearly showed that the production of ber was economically viable.

The capital productivity measures in a study by Krishna *et al* (1997) on profitability of mangoes, indicated that investment on mangoes was profitable. The investment could be recovered by farmers in 11.5 years and the budget cost ratio was 1.46: 1. The positive net present value indicated the soundness of investment made in the mango cultivation. The internal rate of return also indicated favourable nature of return.

On average the internal rate of return of ber cultivation was found to be as high as 40 percent, with a pay back period of 5 years and benefit cost ratio of 3.53. The financial analysis further indicated that, investment on ber was an economically viable venture. This was study on profitability of ber cultivation, by Singh and Singh, (1997).

Koujalagi and Kunnal (1992) evaluated financial feasibility of investment in pomegranate orchard in Bijapur District of Karnataka. The study showed that, per acre net present value for the entire life of the project was found to be Rs. 8,283.81. The discounted benefit cost ratio (at 12% discount rate) was 1.53. The pay back period was 6.56 years and internal rate of return was 15.55 percent.

The study on economic potentiality and viability of guava cultivation under scientific management by Hugar *et al* (1991) , revealed that the net present worth was Rs. 738, 042 per hectare. The benefit cost ratio, internal rate of return and pay back period were found to be 3.88, 57.82 percent and six years respectively.

Azad and Sikka (1991) in their study on production and marketing of temperate fruits applied project evaluation measures to study the economic viability of fruits such as apples, peaches, plums, and apricots. The net present value was Rs. 26257.00, for apples, Rs. 89,222.00 for peaches, Rs. 11,737.00 for plums and Rs. 160,541.00 for apricots. The internal rates of return were 22, 33 and 47 percent respectively. The benefit cost ratios were 1.36, 3.87, 4.62 and 5.10 respectively.

Patil and Pramod (1986) studied the economic viability of investment in alphanso mango plantations in Ratnagiri District of Maharashtra, considering 72 orchards from six villages. The study revealed that the capital investment in alphanso mango plantations was economically viable proposition. The B: C ratio was 1.38, NPV was 21.78. The internal rate of return was higher than interest rate of bank (18%) and pay back period was 10 years.

2.3.3 Costs and Returns in Banana Production

In 2006, Rane and Bagade, studied economics of production and marketing of bananas in Sindhudurg District of Maharashtra. The study revealed that the per hectare cost in Dodamarg and Sawantadi Tahsil were Rs. 1.52 lakhs and Rs. 1.53 lakhs respectively. In Dodamarg Tahsil banana was grown as a sole crop where per hectare cost of cultivation was Rs. 1.28 lakhs and in Sawantadi Tahsil the per hectare cost was Rs. 1.15 lakhs. The benefit cost ratio in Dodamarg Tahsil and Sawantadi Tahsil were 2.20 and 2.33 respectively. The average benefit cost ratio of banana cultivation was 2.27. Umesh *et al*, (2005) observed that the establishment cost of cashew was Rs. 15631 per ha in all the varieties studied during the first three years. The maintenance cost per ha from fourth year onwards varied from Rs. 5881 to Rs. 8254 in Chintamani-1, Rs. 5640 to Rs. 8254 in Ullal-4, Rs. 5812 to Rs. 7882 in Ullal-3 and Rs. 5821 to 7929 in Ullal. The net returns of cashew orchard per ha being fairly high were in the order of Rs. 61314, Rs. 62425, Rs. 49672 and Rs. 34231 in chintamani-1, ullal-4, ullal-3 and ullal-1 respectively.

A study on the potential of banana and apple cultivation in Brazil, compounded with the technical and economic indicators of two production systems, both using micro propagated and conventional seedlings was done by Silver *et al*, (2005). The results of economic analysis turned out to be quite satisfactory in this region for both production systems. The net income obtained from the utilization of micro propagated seedlings was 34% higher than the one obtained from the conventional system.

Economically analysed tissue cultured banana and sucker propagated banana in Theni District of Tamil Nadu by Alagumani (2005) , revealed that per hectare cost was high in case of tissue culture banana (Rs.141,040) as opposed to the sucker propagated banana (Rs. 108, 294). The net income was high in case of tissue culture banana (Rs. 112, 262) compared to sucker propagated bananas (Rs. 78, 855), hence higher profitability of tissue culture banana production compared to sucker banana production.

Sundaravardarajan and Mamanathan (2003) estimated the establishment cost of cashew plantation for the first year at Rs. 7690, Rs. 8664 and at Rs. 9,491 for marginal, small and large farms, respectively. The maintenance cost of cashew plantations in case of marginal farms were Rs. 4059, Rs. 4,410, Rs 4,910, Rs. 5,385, Rs 841, Rs. 6332, Rs. 6771 and Rs. 6990 for second, third, fourth, fifth, sixth, seventh, eighth and ninth years respectively. In case of large farms the maintenance costs were Rs. 5040, Rs 5250, Rs. 5764, Rs. 6145, Rs. 6558, Rs 7021, Rs. 7438, and Rs. 7745 for second, third, fourth, fifth, sixth, seventh, eighth, and ninth year. The input output ratio per ha were 1.43, 1.55 and 1.83 for respective farms.

More (1999) studied the economics of production and marketing of banana in Marathwada region of Maharashtra state. The independent variables included in the function were land, labour, machine power, farmyard manure, nitrogen, phosphorus, potash, capital, irrigation and bullock labour. The dependent variable was yield of banana. The coefficients of multiple determinations were 73, 67 and 85 percent, respectively for the marginal, small and large farms. Land and capital had significant influence on yield in all the three categories of farms and others were non-significant.

Sudarshan *et al* (1998) in their project conducted on an experimental field in Bangalore reported that tissue culture banana had a world record of 6,900 plantlets per hectare. The tc banana gave very high yields compared to sucker based plants of the same variety. Given the national yields per plant of 9 to 10 kg (bunch weight) and average commercial banana yield per plant of 15kg to 20kg in sucker based crop, the tc plantlets yield a bunch weight of 40 to 60kg per plant. The plantlets yielded 175 tonnes against 45 tonnes of conventional suckers based banana horticulture in India. The estimated revenue per crop of 11 months was Rs. 12.5 lakhs per ha at a conservative price of Rs. 5 per kg of banana. The revenues were further augmented by selling stem cores, which could fetch Rs. 3 to 5 per kg at whole sale. The tissue culture daughter suckers could also be sold, which could fetch a price of Rs. 5 per sucker.

Singh and Singh, (1997) in their study on profitability of ber cultivation in arid region of Haryana, indicated that the net returns per ha from ber orchards were Rs. 4816 and the average cost of production of ber was found to be Rs. 114 per quintal and Rs. 6746 per ha. The net returns per rupee of investment in ber orchard were Rs. 1.99. Findings of the study lead to the conclusion that ber cultivation was an economically viable alternative to existing crop cultivation.

Economic evaluation of mango cultivation in drought prone areas, of Anantpur District of Andra Pradesh by Krishna *et al* (1997), indicated that investment on mango in the region was a profitable proposition. The establishment cost of per ha of mango during first four years were Rs. 3748, Rs. 2029, Rs. 2012, Rs. 2452 respectively. The annual maintenance cost, i.e. from fourth year onwards were worked out to be Rs. 5169 per ha. The cost of production per ha of mango were found to be Rs. 22083. The net returns obtained from the output were Rs.16, 194 per ha.

2.3.4 Review of Socio-Economic Studies on Tissue Culture Banana Production

Nyamori (2003) carried out a socio economic study of tissue culture banana production in Nyanza. The study was designed to identify empirical socio- economic factors that influence adoption of the tc technology within Abagusii community. The information that was gathered formed the basis for monitoring and evaluation of tc production. The study was also meant to identify constraints to adoption with a view to recommending strategies that would boost up take of the innovation. The survey targeted six groups with 123 members using the “classroom” method with a structured questionnaire. The findings indicated that the female participating in the technology were more than men. Majority of the households that were members of the farmer field schools were poor. He found out that the banana provides an average of Ksh. 500 per month that constitutes 20 percent of the total income generated from farm activities. It was established that land holding within the three Districts was 1.8 acres with approximately 0.153 acres devoted to tc and 0.223 acres to non tc banana production.

Mbogo *et al.* (2002) carried out a baseline socio economic impact study of the tc banana project in Kenya. The study used discounted benefit cost ratios analytic approach in evaluating the economic worth of the tc banana project. A stratified random sample of 72 banana farmers in Maragua and Murang’a region in central Kenya were interviewed using a structured questionnaire. The study findings revealed that establishment and operating cost in tc banana production was about Ksh 229,500 per hectare in year 1 and 68,200 in year 2 and subsequent years after the establishment of the orchard. Prices were determined by “eyeballing”, negotiations and that there was no weight measures. Prices varied from a low of Ksh. 100 to a high of Ksh. 400 per bunch. The findings reveal a rate of return of 15.7 percent to initial capital investment during the first year and 100 percent rate of return in subsequent years. In the study the evaluation of the discounted streams of costs and benefits over a 10-year period for tc banana gives a benefit cost ratio of about 4.8. Functional distribution of income from banana production was 76 percent for capital and 24 percent for labour of which 33 percent of the labour contribution was from women. Banana ripening and trading margin was about 23.8 percent of the average realizable wholesale price for ripe bananas in Nairobi supermarkets.

Mbogo (2001) carried out an economic analysis of the production of tc bananas and an assessment of their market potential in relation to Nairobi as a metropolitan market. The study had five specific objectives; i) to develop on station and on farm activities linked with farmers, extension services, NGOs and other end users to ensure that tc bananas are evaluated, distributed, marketed and utilized, primarily but not exclusively, by small scale farmer; ii) to investigate the market opportunities for different banana cultivars in relation to the tc banana production technology; iii) to explore the possibility of using tc plants to establish “in situ” nurseries from which clean suckers can be obtained as a preferred source of planting material of a Juvenile tc plant and convectional suckers; iv) to create a model project to show successful application of biotechnology for bananas and other commodity crops; and v) to suggest for policy intervention the optimal conditions under which tc innovations could be adopted to benefit small scale farmers.

2.4 Over view of the literature

Previous studies done had shortcomings that included future events without exact values, no management and adoption constraints were factored in like price changes, analysis based on ex-post conceptual framework, time period was short to come up with conclusive data. This study would add value by providing sound and up to date data of 6 years since inception of tc technology in Kenya and Kisii highlands, in particular with conclusive results as the period completes the 10 year cycle of bananas in tropical regions.

The project was important because it aimed to ensure that banana research and dissemination efforts contributed effectively to improving the incomes and livelihoods of banana producing farm households in central Kisii and Kenya as whole.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter starts with a brief description of the research design adopted, followed by a detailed discussion on the sampling frame and procedure, sources and type of data, and methods of data collection and analysis. It concludes with a discussion on the problems encountered in data collection.

3.2 Research Design

This study adopted an *ex post facto* research design. This is a survey research design used to determine reasons or causes for the current status of the phenomenon under study. As a result of the cause-and-effect relationships, this research design does not permit manipulation of the variables (Patton, 2002). The design was adopted in this study because Tissue Culture was studied after it had exerted the effect on the banana production. The researcher then proceeded to study the independent variable i.e. management and socio-economic factors in retrospect for their possible relationship to, and effects on, the dependent variable. The survey allowed the researcher to quantify, relate and justify opinions and attitudes of the respondents.

3.3 Description of the Study Area

The study was conducted in Kisii, which is the hub of banana production in Nyanza Province and Kenya in general. Kisii Central District is one of the 12 districts in Nyanza Province. It shares common borders with Nyamira District to the east, Transmara District to the south, Migori District to the southwest, Rachuonyo District to the north and Gucha District to the southwest.

The District lies between latitudes 0^0 30`S and $0^0$ 58`S and longitudes 34^0 38`E and 34^0E. The District covers an area of 360 km^2 and is administratively divided into 5 divisions, 18 locations and 46 sub-locations as shown in table 3.1 below:-

Table 3.1 Area and Administrative Units of Study District

Division	**Area (km^2)**	**No of Locations**	**No of Sub-locations**	**Estimated Arable Land Area (km^2)**	**Estimated non- Arable Land Area (km^2)**	**Average Farm Size (Ha)**	**Projected population density 2005 persons/Km^2**
Marani	123.7	6	13	101	22.7	0.8	802
Mosocho	87	6	12	70	17	0.4	1173
Kiogoro	61.3	3	10	49	12.3	0.3	1288
Keumbu	71	2	9	60	11	0.4	808
Township	18	1	2	3	15	-	2572
Total	**361**	**18**	**46**	**283**	**78**	**0.5**	**1329**

Source: District Farm Management Guidelines, Central Kisii (2006)

The district has a highland equatorial climate. It receives an average of over 1,700mm of rainfall per year, which is highly reliable. It has two rain seasons, long rains occur between February and June while the short rains occur between September and November. December and January are relatively dry months. The District has two (2) agro-ecological zones namely **UM_1**-coffee-tea zone which covers all the 4 divisions and **LM_2**-marginal sugarcane zone, which covers 1% of Mosocho Division. The high and reliable rainfall, coupled with moderate temperature is suitable for growing of crops like tea, coffee, pyrethrum, maize, beans, finger millet, potatoes, bananas and groundnuts. This also makes it possible to practice dairy farming in the District. The study was conducted in Marani and Mosocho divisions.

This area was suitable for the study because of various reasons. One is that banana, which for along time was considered as a semi-subsistence women's crop, has become an important commercial crop in the area serving the nearby and far urban markets of Kisumu and its environs, Nairobi and Mombasa. Previously, small-scale farmers in the area depended heavily on proceeds from coffee for their livelihood but with the decline in coffee prices, farmers had to look for other sources of income by diversification and commercialization of traditional food crops such as the banana. Banana has the potential for food and livelihood security as it can both be consumed and sold in the market by the farmers. Due to diseases and pests, bananas have limited production in the area, hence KARI introduced tc plantlets that were tolerant. However, in spite of the potential of the technology for reducing poverty in the area, other factors may hamper optimal production from the technology. Thus the area provided opportunities to study the significance of agricultural technologies for vulnerable households.

3.4 Target Population

A population refers to an entire group of individuals, having common characteristics. The study population consisted of farmers who participated in the growing of tissue cultured and conventional bananas in the study area. According to the Ministry of Agriculture annual report for Central Kisii (2006), it was estimated that the population of tissue culture banana farmers was about 500 households. Thus, the study population targeted was 500 and 1050 farmers who engaged in tissue culture and conventional banana production respectively.

3.5 Sampling Technique

To achieve the objectives of this study, the researcher employed three sampling techniques; cluster, purposive and simple random sampling techniques. The divisions with the highest number of tc farmers were purposively selected with the guidance of the agriculture officer and KARI staff. Two sub locations of Marani and one sub location of Mosocho, which had the highest concentration of tc and conventional bananas were selected. Cluster sampling was used to select the villages where study units were found. The techniques were used to select 200 farmers who formed part of the respondents for the study, where 100 of the farmers participated in tissue culture bananas and 100 were conventional banana farmers. When choosing the sample size the following were taken into consideration, the level of variation in the population, the desired precision of the result, and the confidence level at which that precision will be calculated. Other considerations were time and resources availability. The selection of respondents is shown in figure 3.0.

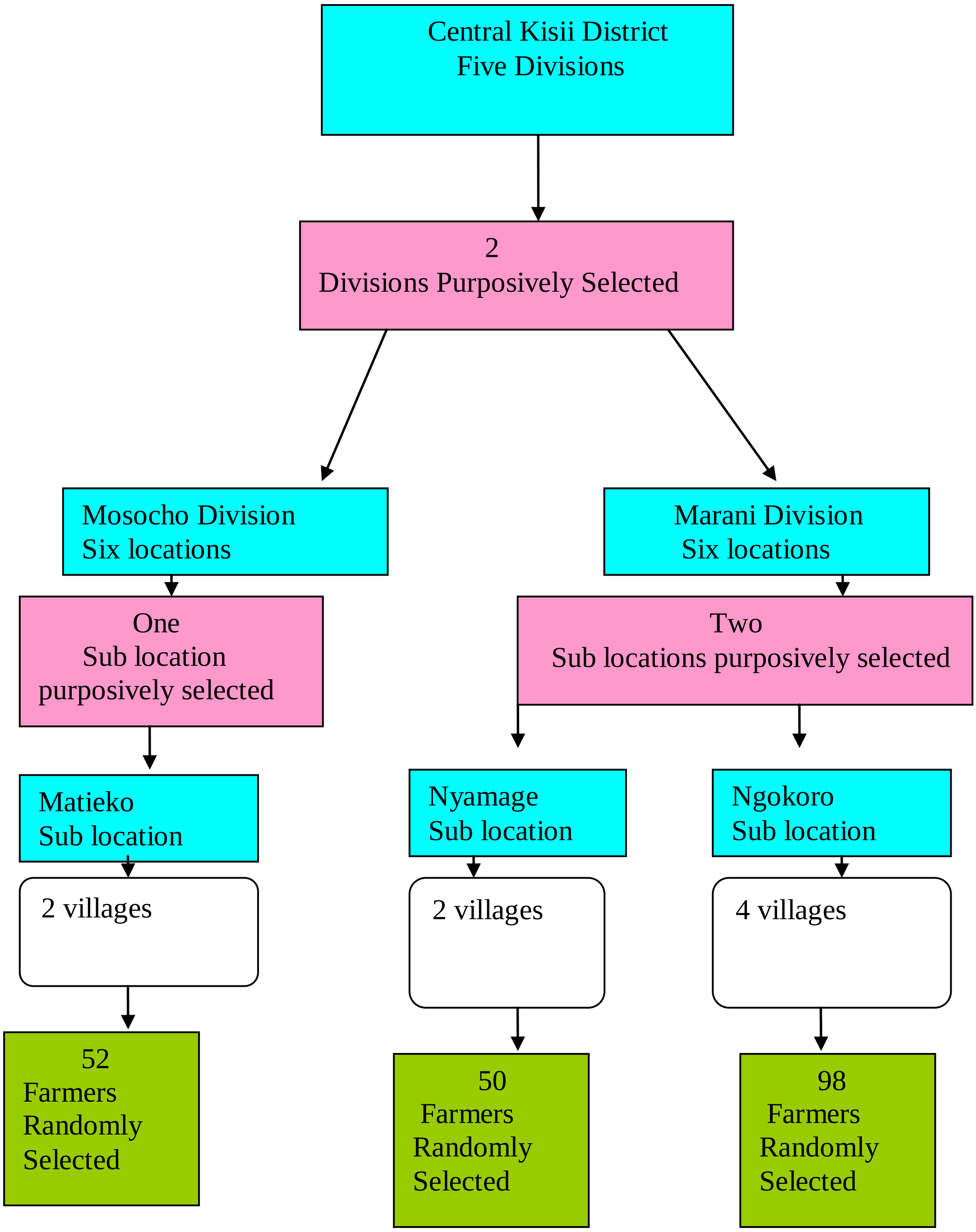

Figure 3.0: Diagram Showing Respondents Selection Process

Source; Authors survey, 2008

3.6 Sample and Sample Size

A sample refers to a smaller group obtained from accessible population; each member is a case i.e. respondent or interviewee. To select working sample, two lists of all participating and non-participating farmers from the selected villages were developed and a simple random sampling technique was employed to select study units. Simple random sampling is a probability sampling technique where each and every item in the population has an equal chance of inclusion in the sample (Pizam, 1999). A total of 98 farmers were selected from Ngokoro sub location which had 260 tc and 500 conventional banana farmers. Nyamage and Matieko sub locations had fewer farmers hence small sample was selected i.e. 50 and 52 farmers respectively. Out of the 98 farmers of Ngokoro, 49 were tc and another 49 were conventional banana farmers. In Nyamage and Matieko the selection was 25 and 26 farmers for each farming system. A total of 200 farmers were selected for the study.

3.7 Sources and Type of Data

3.6.1 Primary Data Sources

Primary data formed the core of data that were used in this study. A face to face interview and discussions for the selected sample of tissue cultured and conventional banana farmers were the main sources of primary data. The primary data comprised of background information, highest level of education, age of the respondent and gender. Data was collected on resources used, labour and management activities, crop yields or production, prices of bananas, banana farming systems and the suitability of tissue cultured bananas and effects of the technology on household's income. This information was supplemented with informal interactions with researchers, extension staff at the district and divisional levels.

3.6.2 Secondary Data Sources

Secondary data were collected from libraries and relevant institutions. The references included economic surveys, statistical abstracts, district development plans, district and divisional reports on tissue cultured and conventional banana production, sessional papers, books journals and articles. From these secondary sources, data such as district banana production, countrys' banana production and area coverage per province, banana yields per hectare and types of major banana markets in the district were obtained. The secondary data provided a better understanding of the research problem.

3.7 Instruments for Data Collection

This involved tools and techniques for data gathering. For the researcher to meet the objectives of the study, the instruments namely; questionnaires and personal observations were used to collect the data.

3.7.1 Questionnaires

The main data collection instrument for the study was the questionnaire. This formed the primary data gathering. The questionnaire was subdivided into sections; each item in the questionnaire was developed to address a specific objective and research hypothesis. The questionnaire was to elicit data on economic factors employed in the production of tissue cultured banana technology and conventional bananas, general information on tc banana technology, general management and socio economic factors of the respondents.

The data necessary for this study was collected through actual visits to the farmers or households who were engaged in conventional and tc banana farming in the study area. Field sizes were estimated by technical observations and field outputs recorded were the farmers own estimates. Where respondents kept formal records and accounts, they provided an ideal source of farm management data. Enumerators were asked where possible to make references to the farmer's documents. The farmer was also allowed to refer to the records to ascertain accuracy. The researcher personally administered questionnaires to the respondents in one site (Matieko of Mosocho division) while two enumerators administered in the other two sites Nyamage and Ngokoro of Marani division.

3.7.2 Personal Observations

This data collection technique was suitable in ascertaining facts obtained from the respondents. It reduced the chances of recording inaccurate or incorrect data in the study area. Observation tool was very useful for evaluation of the physical condition of tissue cultured banana technology enterprise on farmer's plots. The technique provided the basis to confirm physical condition and management style of tc bananas. The researcher was able to observe various tc banana technology projects in the three sub locations.

3.8 Theoretical Framework

The study was based on production theory which places pure emphasis on capital as the key ingredient to the success of a firm. This theory is based on the neoclassical theory of production. Neoclassical economics is a term variously used for approaches to economics focusing on the determination of prices, outputs, and income distribution in markets through supply and demand, often mediated through a hypothesized maximization of utility by income-constrained individuals and of profits by cost-constrained firms employing available information and factors of production, in accordance with rational choice theory. Neoclassical theory rests on three assumptions, 1) People have rational preferences among outcomes that can be identified and associated with a value, 2) Individuals maximize utility and firms maximize profits and 3) People act independently on the basis of full and relevant information. From these three assumptions, neoclassical economists have built a structure to understand the allocation of scarce resources among alternative ends, in fact understanding such allocation is often considered the definition of economics to neoclassical theorists.

The study was based on the idea that capital and labour are substitutes, if the chance of reducing costs, thereby increasing profits as well as production exists, any excess of non-necessities of labour can be compromised. New technologies are ideal advocates of the production theory. The introduction of new technology in a firm, decreases costs, increases production, thereby increasing revenues. Hence the production function using new technology shifts upwards.

3.9 Tools used in Economic Analysis

The analytical tools used included; descriptive statistics, benefit cost analysis (the net present value, benefit cost ratio, and internal rate of return) and regression analysis.

3.9.1 Descriptive Analysis

The descriptive analysis was used to summarize the data from the study. Data was analyzed qualitatively and quantitatively. Descriptive methods were employed and data presented in the form of frequency distribution tables, graphs and pie charts that facilitated description and explanation of the study findings.

3.9.2 Benefit- Cost Analyses (BCA)

BCA is a social evaluation method, based on applied welfare theory (Valk and Graaff, 1995). It involves decision making with regard to the net social benefits of investment made in the public and private sector. The application of the principle of buyer's willingness to pay in determining the worth of a good or service reflects the welfare-theoretical basis of BCA (Valk and Graaff, 1995, In Kristjanson and Zerbin 1995). The basic idea is that the utility of a good or a service is at least equal to the price paid for it, so that a person buying a good or service against a certain price and attaching to this good or service a value greater than its price will derive a net profit. The consumer surplus is equal to willingness to pay less actual payment. Despite the good aspects, BCA has some limitations which include: non consideration of multiplier effects, side effects and cost of banana technologies that cannot be assessed easily. Despite these limitations BCA is widely used in project evaluation.

The production of bananas being a perennial crop is a capital investment as costs and benefits accrue over a period of time. Tissue culture banana production requires initial investment cost with no or fewer benefits in the initial periods. In the study, economic analyses of the viability of conventional and tissue culture banana production technology was based on discounted value of future annual income streams for a definite number of years. The investment appraisal methods used were Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR). The details of the techniques are discussed in the subsequent sub-topics.

3.9.3 Approaches to Banana Economic Analysis

There are three main types of impact studies that are related to time:

Firstly, the prospective ex-ante impact assessment, which is done before actual implementation of planned activities begin. It is useful in helping improve the planning and design process concerning the direction of research efforts. It also indicates the potential benefits to be gained from the research or development of a technology. At the farm level, ex-ante assessment helps identify farmers' needs and evaluate research goals in relation to them.

Secondly, on-going evaluation assists by providing warning signs when there are deviations from the expected results. This assessment can be used to get farmers inputs into the design and evaluation criteria of the technologies being tested. Therefore, the study promotes the dissemination and use of new practices. On-going evaluation provides opportunities to accommodate changing circumstances (policy, economic, environmental, and social).

Thirdly, a retrospective or ex-post impact study is used to show how farmers have used research outputs and indicate other benefits accruing from the technology. It shows how improved technologies have resulted in broader social and economic benefits. They also help target research more to social goals and the needs of the end users. Ex-post studies provide measures of the adoption and effects of new technologies; they give the actual impacts of the intervention which can be compared with the planned impacts.

3.9.4 Adjustment for Time Value of Money

Time value consideration of monetary costs and benefits was crucial in BCA of banana technologies. Farmers are rational, even in the absence of inflation, consumers place more value on one shilling now than the same shilling obtained in latter periods. This can be attributed to the fact that, to satisfy current desires farmers must pay some premium. There is an aspect that a shilling can be invested today to earn some interest in years to come. Hence, there was need to discount money invested and benefits that accrued from banana technologies.

3.9.5 Determining the Discount Rate

To use discount measures, one must decide upon the interest rate to use. Any choice of discount rate may be criticized. For any economic analysis, one can use opportunity cost of capital, social discount rate or borrowing rate. Gittinger (1982) proposes a discount rate of between 8% and 15% for developing countries. Gregeren and Contreras (1992) recommend a discount rate of between 8% and 10%. The interest rate chosen depends on the scale of operation (small scale), rate of interest charged on borrowed loans and savings, farmers objectives and type of project being analysed. Capital is one of the key limiting resources at smallholders' farm level (Macleod *et al* 1998; Upton 1973). It is not easy to know the opportunity cost of capital in certain situations but can only be estimated. An average discount rate of 15% was assumed in the study.

3.9.6 Net Present Value (NPV) Technique

To compute the benefits obtained from banana technologies, the NPV technique was employed. This is the difference between the total present value of all cash inflows (revenue) and total present value of all cash outflows (costs) from banana production.

A profitable banana technology is one with positive NPV, indicating that the costs of production will be recovered and benefits attained. Revenue was an annual income streams accruing from respective banana productions, while costs included establishment costs and annual operational and maintenance costs.

The difference between revenue and costs from banana production gave the Net Annual Flow (NAF). The annual sums during the four years of bananas production were discounted to year one. In the study, farm gate prices provided by farmers and traders were used in order to reflect the actual farm income and expenditure. The formula for NPV (Gittinger, 1982) is shown in equation 3.0.

$$\textbf{NPV} = \sum_{t=1}^{n} \left[\frac{(B_{t-} C_t)}{(1+r)^t} \right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.3.0$$

Where;

NPV represents net present value from bananas

C_t represents annual costs in year ‘t’

B_t represents annual benefits from banana in year ‘t’

‘r’ represents opportunity cost of capital or discount rate

‘n’ represents economic life cycle or number of years

Any of the two banana technologies with zero or positive NPV was viable investment. Technology with highest NPV should be chosen for mutually exclusive alternatives. The limitation is that NPV does not indicate by how much the benefit from a specific banana production technology outweigh the costs in percentage terms.

3.9.7 Benefit –Cost Ratio (BCR)

BCR was computed by dividing the present value of gross cash inflows by present gross cash outflows for both of the banana technologies. The costs incurred and benefits received were computed as present values and their total value of benefit were divided by the present value of costs. BCR in this case gave the index of profitability of technology. A good investment in the technology would require a ratio equal to or in excess of one. A BCR greater than one meant the farmers made profit. If it was less than one it meant the farmer made losses and if it was equal to one then the farmer recovered the cost of investment only. Banana technology with higher ratio will be preferred. The computation formula of BCR was as shown in equation 3.1

$$\textbf{BCR=} \frac{\sum_{t=1}^{n}\left[\frac{(B_t)}{(1+r)^t}\right]}{\sum_{t=1}^{n}\left[\frac{(C_t)}{(1+r)^t}\right]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.1$$

Where;

‘B_t’ represents annual benefits from bananas in year‘t’

‘BCR’ represents benefit cost ratio of bananas

‘C_t’ represents annual costs in year‘t’

‘r’ represents discount rate or opportunity cost of capital

‘n’ represents number of years or economic life cycle of the banana crop

With BCR the evaluator can directly tell by inspection how much the cost would fall (rise) or benefits would rise (fall) before the technology becomes unattractive (Gittinger, 1989). For instance a BCR of 1.90 means that costs have to rise by 90% (1.90-1) or benefits would fall by 47% (1-(1/1.90)) before the technology becomes unattractive.

3.9.8 Internal Rate of Return (IRR) Technique

Computation of IRR can permit the analyst to include in one package the cost of a project/technology, useful life of the project, annual operation costs, the returns necessary to break-even, and the cost of capital (Gittinger, 1989). IRR is the discount rate that equates the present value (PV) of benefits with present value of costs from respective banana technology. It is the maximum interest rate that a technology or project can pay for the resources used while recovering all investment and operating costs. It is the average earning power of the money used in the technology/project over the life cycle. This requires that the analyst solves for a discount rate that equates inflows to outflows for each banana technology. IRR makes NPV= 0 and it has an advantage that the analyst doesn't need to specify the discount rate before computation. The formula used for computation of IRR is as shown in equation 3.2

$$\sum_{t=1}^{n}\left[\frac{(B_t - C_t)}{(1+IRR)^t}\right] = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \ 3.2$$

Where;

'B_t' represents annual benefits from bananas in year't'

'C_t' represents annual costs in years'

'IRR' represents annual rate of return

'n' represents final year where the cash flow is expected in years

't' represents year't'

IRR is computed through an interactive search technique. However, the starting point may have an effect on the estimate and it is therefore, important to make a wise starting point estimate. It should also be noted that some cash flows may have multiple IRRs which may be equal to the number of times the cash flow series changes signs. An acceptance criterion is when IRR is greater than the chosen interest rate or the opportunity cost of capital. IRR only exists when one of the values in net cashflows is negative; if not, then no value of IRR exists. The drawback is that IRR measures the rate of net benefits but not their sizes. Therefore, a small but high yielding project can take precedence over one that is yielding high net benefits but at low rate. The other limitation is that there is no single formula to determine the IRR.

3.9.9 Price Estimates in Banana Technology Economic Evaluation

The pricing of inputs and outputs is shown in Table 4.2. Both tissue culture and traditional bananas had a market price hence, farm-gate prices were collected and used. To take care of seasonal price fluctuations, quarterly prices were taken and an average annual price computed. In estimating input costs, care was taken not to over-estimate or underestimate them by making sure that all items, which had an economic cost from farmers' point of view, were included. For inputs in banana production that had market price like fertilizer, banana suckers and cost of capital (interest rate), transaction costs involved in buying of inputs were considered in computing farm-gate prices. However for non-marketable inputs like manure, farmers were asked to give estimates of values or costs incurred during preparation and utilization. Prevailing wage rates in Kenya shillings were used to value both family and hired labour. It was also assumed that quality of labour was the same and therefore no differential pricing was considered.

The extent to which an evaluator is confident in the estimates of project/technology analyses varies greatly. As earlier noted, in order to get realistic costs and benefits in banana technology analyses, farm-gate prices of inputs and outputs were used. This was perceived to reflect the actual profit accruing to farmers. A part from farm-gate pricing, all sources of outputs and inputs were identified by farmers and analyst for inclusion in the analysis. Finally, through discussions with farmers, all relevant outputs were identified and quantified.

3.10 Regression Analysis

3.10.1 Production Function Approach

A production function shows the relationship between inputs and outputs in a production process. In this approach inputs are used for production and transformed into outputs. In this study production function analysis involved the estimation of the quantitative relationship between inputs and outputs. Many studies have used the production function approach to appraise technical and allocative efficiency of resources in farms. According to Clayton 1983 production function analysis at the farm level has mainly been used for the following purposes; 1) to improve on the current allocation of resources, 2) to investigate the economic rationality of farmers and 3) to derive farm supply functions.

Although production function cannot be used to make specific recommendations, their results are useful for general diagnostic purposes in analyzing farm resource returns and capital productivity, from which suggestions to farmers on whether they are using too much or too little of a resource can be made. They are also very crucial for extension and policy purposes especially when combined with other macro and micro-analysis (Heady and Dillon, 1961).

The main focus in this study was to determine whether the socio-economic and management factors had influence on tc yields. Also to determine if there are possibilities of increasing tc banana yields and farm incomes through the improvement of orchard management and the resources used.

3.10.2 Model Specification

It is appreciated that the choice of a model is influenced by a number of factors which include: 1) considerations on the biological, economic or other environmental factors that relate to the process that is under study, 2) how well the model measures goodness of fit statistically which may be indicated by the coefficient of determination (R^2) or the F-ratio, statistical significance and signs of the estimated coefficient, 3) how easy it is to compute and 4) Subjective judgments on the model (Gujarati, 1995). The model chosen was Cobb Douglas production function because of the following desirable attributes which make it the most desirable in farm analysis. These are: 1) adequate fit of data, 2) it is easy to estimate, 3) the regression coefficients obtained from a log-linearized Cobb-Douglas function immediately give the elasticities of production which are independent of the level of input and 4) it allows for the phenomenon of diminishing marginal returns to be observed without losing too many degrees of freedom. It is therefore said to be an efficient user of degrees of freedom (d.o.f) which is an important quality where research resources are limited and collection of data an expensive exercise.

However, the production function has some limitations as noted by Heady and Dillon, (1961). It is unsuitable when there are ranges of both decreasing and increasing marginal returns and when the response has both negative and positive marginal productivities of the inputs. It imposes a severe prior restriction on the farms technology by restricting the production elasticities to be constant and the elasticities of input substitution to unity. The function may over estimate the optimal level of input X which equates the marginal revenue (MR) to the marginal cost (MC) and it does not give maximum level of output since the output increases with an increase in the level of input.

Despite the weaknesses of the model, it has been adequately used in econometric studies and is very popular. Therefore, it was applied in this study and specified as shown in the equations below-:

$Y=AX_1^{\beta 1} \quad X_2^{\beta 2}$………………..$X_n^{\beta n}$ e^u…………………………………3-3

Y = Output

A = Constant

X_{is}= Factors of production (inputs namely quantity of labour in man-days, manure, fertilizer use and weeding frequency).

β_{is} = Regression coefficients (partial elasticity of output with respect to the inputs), where i=1, 2 ....8. The sums of β_{is} gives information about the returns to scale, i.e. the response of output to a proportionate change in inputs.

U = A multiplicative stochastic error term.

3.10.3 Estimation Method

The Cobb Douglas model was fitted to the data for Marani and Mosocho sites and coefficients obtained using ordinary least square (OLS) estimation method. For ease of estimation of coefficients of the Cobb Douglas model, quantity of tc yields, quantity of labour in man-days, manure in kilograms, fertilizer in kilograms and socio economic characteristics were transformed into log linear form and fitted to the equation. When the function is linearized using the natural logarithms, is expressed as in equation 3.4 below.

$$\text{InY=In A+ } \beta_1 \text{InX}_1 + \beta_2 \text{InX}_2 + \ldots\ldots\ldots\ldots\ldots\ldots + \beta_i \text{InX}_n + \text{U}_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3\text{-}4$$

Where: Y= Yield of tc bananas (kg/Ha)

A= Constant of proportionality

X_1= Quantity of labour (Man-days)

X_2= Quantity of manure applied (kg/Ha)

X_3= Quantity of fertilizer applied (kg/Ha)

X_4= Weeding frequency (No of weeding/year)

X_5= Experience of the farmer (Years)

X_6= Age of the farmer (Years)

X_7= Level of education of the farmer (Dummy)

X_8= Quantity of credit (Ksh)

The descriptions of the variables considered in the model are as follows:

Dependent Variable Y

Tissue culture banana output in kilograms per hectare was the dependent variable. The aim of the study was to establish how socio-economic characteristics and management practices affect yields of tissue culture bananas. The average yields for the years 2004 to 2007 were taken for each farmer. The researcher considered the four years that the tc bananas were in full production. Using this technique the researcher was able to estimate the actual tc yields obtained by small scale farmers in the study area. The average weight of a medium sized tc banana was multiplied by the number of bunches on every farm to get the yields in kilograms. Moock (1976) had used quantity of a crop produced as the dependent variable in production for analysis. However this measure is only appropriate when dealing with monocropping. Thus the dependent variable used in the study was the quantity of output per hectare of the crop grown on the plot. These are the common practices in agricultural economics studies (Huffman, 1977; Lindsay, 1995 and Mbassa, 1997).

According to Moock (1976), the researcher must decide on average values for the unit cost of inputs and outputs in research areas and also in the marketing period because of variation in prices due to space and time. The average price of the medium sized banana was used in computation of farmers' incomes from both tc and conventional banana production.

The Independent Variables

Quantity of Labour

This refers to the quantity of labour in man- days per ha. A man day was taken to be eight working hours. Where children were used, their quantity was assumed to be half that of adults because of their limited energy. The quantity of family labour was taken to be equal to hired labour (permanent or casual). The total quantity was arrived at by summing up all the labour used on land preparation, digging holes, weeding, planting, application of fertilizers, manure and harvesting.

Quantity of Manure and Fertilizer

Respondents were asked on whether they applied any manure and fertilizer on their crops annually. To estimate the quantity of manure used by every farmer in kilograms, the researcher weighed samples of the quantities applied per stool per year. Fertilizer was measured in kilograms as the respondents were able to tell the number of bags bought per year. This was intended to measure the ability of banana farmers to practice the recommended management practices. It was expected that application of manure and fertilizer improves nutritional levels of the soils hence high yields obtained.

Weeding Frequency

This variable measured the ability to practice proper crop husbandry. Respondents were asked on the frequency of weeding their banana orchard. Frequency was measured by number of times the farmers weeded per year. It was assumed that the higher the frequency of weeding the higher the yield obtained from the plot.

Socio-Economic Characteristics

The factors included were experience of the farmer in years, age of the farmer in years, level of education was a dummy variable, numbers were assigned to the various levels these were 1) not educated, 2) primary, 3) secondary, and 4) college level. Quantity of credit was in Kenya shillings. These factors were considered as they were assumed to affect the level of operation and efficiency with which a farmer uses the available resources for production of bananas hence it impacts either negatively or positively on the yields of tc bananas.

Assumptions

In order to carry out multiple linear regression analysis, the study made the following assumptions.

1. The relationship between the logarithm of the banana yield and the logarithms of the predictor variables is linear since MLR model applies to linear relationships.
2. The errors are uncorrected with the individual predictors i.e. $E(\mu_i X_{ii}) = 0$
3. The error term (μ) is a random variable distributed with
   (a) zero mean $E(\mu_i) = 0$
   (b) Constant variable $Var(\mu_i) = constant$
4. Errors are independent of one another

5. There is no exact linear relationship between the predictor variables.

3.11 Hypotheses Testing

The t-test was run to detect statistically significant differences in the continuous variables representing the characteristics of farmers who practiced tissue culture banana technology versus those who had not adopted. Therefore to test the hypothesis that income derived from tc technology did not significantly differ from that derived from conventional technology, samples t-test was used to test for the significance of the observed difference in the mean net income between the two groups. As a result, the following hypotheses were formulated and tested.

H_0: $\mu_{tissue.} - \mu_{trad} = 0$ ……………………………………………………………3-5

H_1: $\mu_{tissue.} - \mu_{trad} \neq 0$ …………………………………………………………..........3-6

To test if a linear statistical relationship existed between the yield of tissue culture banana technology and at least one of the predictor variables, the following hypotheses were formulated and tested.

H_0: $\beta_1 = \beta_2 = \ldots\ldots = \beta_8 = 0$ ……………………………………………………………3-7

H_1: $\beta_i \neq 0$ for at least one i 3-8

Hypothesis identified under socio economic and management factors were formulated and tested.

H_{01}: The quantity of labour in Man-days has no effect on the yield of tissue culture banana technology.

H_{02}: The quantity of manure applied has no significant effect on the yield of tissue culture banana technology.

H_{03}: The quantity of fertilizer applied has no significant effect on the yield of tissue culture banana technology.

H_{04}: Weeding frequency has no significant effect on yield of tissue culture banana technology.

H_{05}: Experience of the farmer has no significant effect on the yield of tissue culture banana technology.

H_{06}: The age of the farmer has no significant effect on the yield of tissue culture banana technology

H_{07}: The farmer's level of education has no significant effect on the yield of tissue culture banana technology.

H_{08}: The quantity of credit has no significant effect on the yield of tissue culture banana technology

The test was used to check the significance of the individual regression coefficients. The expression in 3.7 above is the null hypothesis that the estimated elasticties are equal to zero and that the variables are not significant whereas the expression 3.8 is the alternative hypothesis that the estimated elasticities are not equal to zero and that the variables are significant.

3.12 Limitation of the study

Some of the farmers interviewed did not maintain proper farm records on production quantities, prices or costs of inputs and as such the author depended on the farmers' ability to remember.

A second challenge was the interpretation of the questions from English into the local language. Though the interviewers were thoroughly trained before starting the survey, clarity could not be guaranteed due to different understanding ability of individuals.

Another problem involved questions that required the respondents to recall events in the past. These included questions such as the amount of produce harvested in the previous years, quantities sold and the prices, amounts of manure and fertilizer used.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter deals with the results of the descriptive and benefit cost analysis of the survey data and presentation. The results of socio-economic and management factors are presented. Finally, the cobb-douglas production function results of tissue culture banana production are discussed in detail.

4.2 Sample Characteristics

The socio-economic characteristics of small-scale tissue culture banana production farmers in the study area included sex of the respondent, age of farmer, experience in growing bananas, farm size, area of land under tissue culture bananas, level of education and quantity of credit. Management aspects included labour use in production of tissue culture bananas, manure and fertilizer use, and weeding frequency of tissue culture banana plots.

4.2.1 Gender of Respondents

The survey covered the people responsible for decision making affecting tissue culture banana production and marketing in the farm. Figure 4.0 show that tissue culture banana is seemingly mens' enterprise.

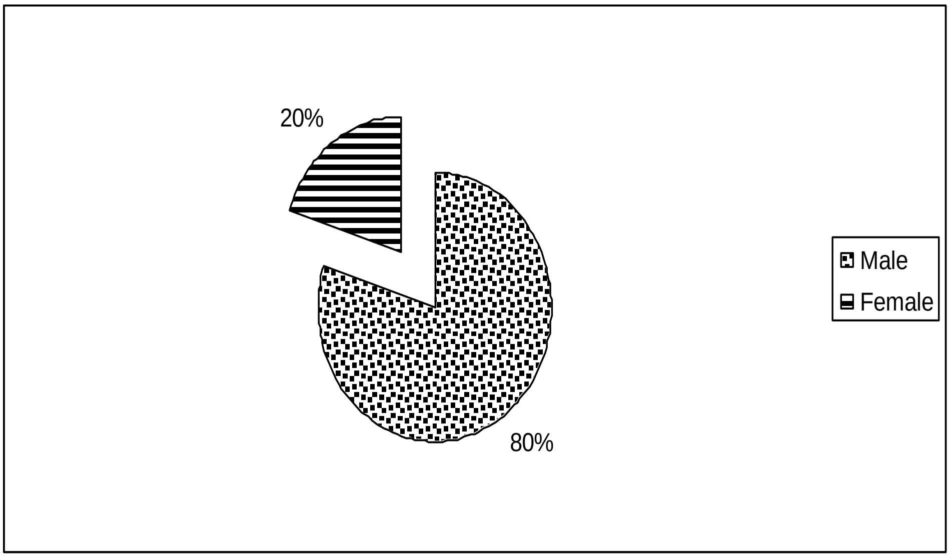

Figure 4.0: Gender of Respondents

Source: Authors survey, 2008

The analysis above indicates that 80% of the respondents were males, and 20% female engaged in tissue culture banana production. Overall we can say that tissue culture banana production in kisii is an enterprise dominated by men since 80% of the sampled population was men while female were only 20%. This could probably be explained by the fact that men have more control of land while women can only access the land, hence men tend to practice more of tc farming in the study area.

4.2.2 Description of Farm Size

Land resource is an important asset and an indicator of social standing and wealth status in Kisii and most communities in Kenya. All farm enterprises compete for the limited land resource and eventually, affect technology adoption and other farm management practices. Farm size may affect fertilizer and manure use in banana production. Based on household goals and preferences, land allocation to different enterprises may be an indicator of how farmers allocate farm resources.

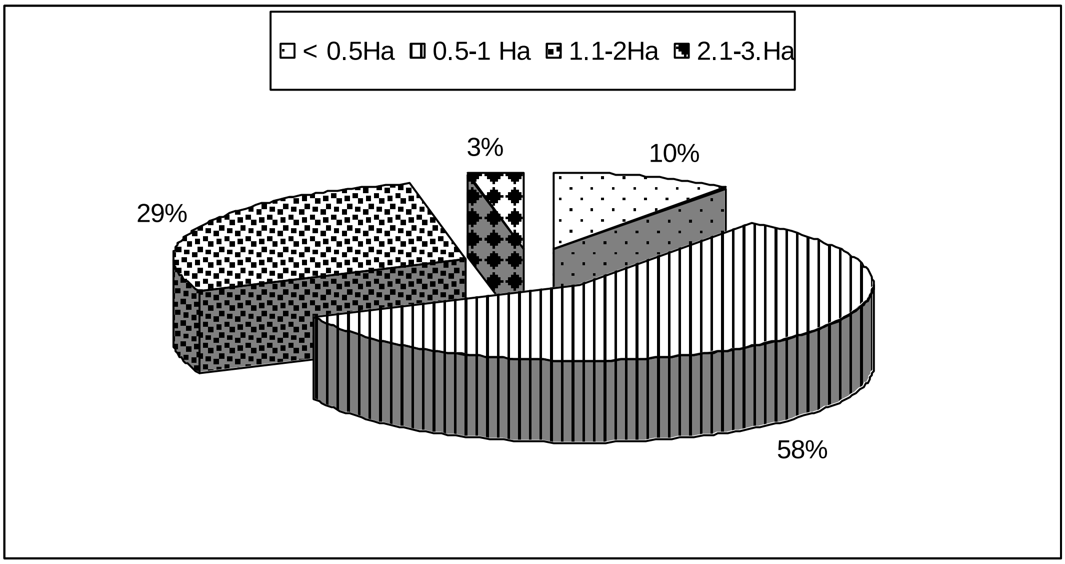

Figure 4.1: Farmers Size of Land

Source: Authors survey, 2008

Reading from this figure it is indicated that 58% of the respondents had land of between 0.5-1 hectares, 29% had land between 1.1-2 hectares, 10% had land less than 0.5 hectares while only 3% had land more than 3 hectares and above. The farm size varied greatly amongst the farmers. The average farm size was found to be 0.7 hectares. A larger percentage of farmers in the area of study, as depicted in the figure above owned less than 1 hectare. Those who owned more than 3 hectares are 3% of the sample. The small acreage explained why farmers had allocated less acreage to tissue culture banana production. Therefore, because of the small farm sizes, emphasis on banana production should be geared towards high yielding varieties. The small farm sizes demand intensive technologies and high level of management in order to increase yield per unit area so as to meet annual food and income requirements.

4.2.3 Socio Economic Factors

The general characteristics of the farmers in the study area are presented in Table 4.0. From the Table it could be observed that, the most frequent occurring age interval of the banana growers was 26-54 years and it was also revealed that main occupation of most of them was agriculture and only 26 farmers out of 100 were having subsidiary occupation.

So far as the literacy was concerned it was observed that majority of the respondents were literates (92 per cent), having their education ranging from primary to college level. This might have enabled the respondents to allocate manageable size of the area under banana to get higher returns. The remaining 8 per cent of growers were illiterate.

Table 4:0 Socio Economic Factors Identified in the Study

Socio Economic Factors	Response	Frequency	Percent
Age of respondents	Below 25 years	13	13.0
	26-54 years	63	63.0
	55 years and above	24	24.0
	Total	**100**	**100.0**
Level of formal Education	Not Educated	8	8.0
	Primary	48	48.0
	Secondary	27	27.0
	College	17	17.0
	Total	**100**	**100.0**
Access to credit	Yes	41	41.0
	No	59	59.0
	Total	**100**	**100.0**

Source: Authors survey 2008

Reading from the table 4.1 above it is indicated that majority (63%) of the respondents were between the ages 26 – 54 years, 24% were 55 years and above, and only 13% were 25 years and below. It is therefore evident that a greater percentage of banana farmers are in the age of 26-54. It is also evident that the older population above 56 years is not active in tc banana production. This could be attributed to the strenuous work and good crop husbandry and management required by tissue culture banana farming for which they may not cope up with.

When respondents were questioned on their level of education 48 of them indicated that they were primary school certificate holders, 27 were secondary school certificate holders, 17 were college certificate holders and the rest 8 did not attain any formal education. Finally, 41 of the respondents agreed that they have access to credit facilities, while 59 did not have access. Tissue cultured banana being a high investment enterprise may have been perceived by these respondents mostly due to their education and access to credit

4.2.4 Description of Management Factors

Tissue cultured plants have their own initial roots and continue growing as soon as they are planted. They have more active leaves which means, they grow faster than conventional suckers. For this efficiency to be realized the plants must not be subjected to external growth constraints such as lack of water or nutrients in the first five months. Hence, watering may be required in dry spells. Desuckering is a laborious practice in tc bananas. This is because tc plants produce numerous suckers soon after planting and these have to be removed continuously to avoid competition for nutrients with the mother plant as this reduces the first harvest yield. It is recommended that tc plants be planted in deeper holes to reduce the tendency of the mats pushing up to the surface. Plants with exposed mats are poorly rooted and can easily be blown down by winds (Robinson, 1996). These practices make labour demand for tc cultivation be higher hence, a more tasking venture than conventional bananas. The per hectare average quantities of labour used in local and tc banana cultivation were 110 and 153 man days respectively.

Farm yard manure application was a regular practice in tc banana cultivation. This was applied at planting and subsequent years of the crop cycle. They applied on an average 3.74 tonnes of farmyard manure per hectare. The general recommended dosage of farmyard manure is about 7 tonnes per hectare per year. The farmers were applying less than the recommended level may be because of less awareness about the usage of farm yard manure and the problem of its availability.

Fertilizer application was commonly practiced by banana farmers in the study area. They used different types of complex fertilizers like DAP at planting and CAN for topdressing in the subsequent years. The amount of nutrients applied to the crop was 50 kgs of CAN per hectare per year in tc production. The general recommended dosage of fertilizer is about 140 kgs per hectare. The farmers were found to be applying less than the recommended dose in tc banana production.

Table 4.1 Management Practices Identified in the Study

Management practices	Response	Frequency	Percent
Weeding frequency	Once	38	38.0
	Twice	51	51.0
	Thrice	11	11.0
	Total	**100**	**100.0**
Manure application	Yes	47	47.0
	No	53	53.0
	Total	**100**	**100.0**
Use of fertilizer	Yes	34	34.0
	No	66	66.0
	Total	**100**	**100.0**

Source: Authors survey 2008

When questioned on their frequency of weeding, more than half (51%) of the respondents agreed that they do weed twice a year, 38% do weed once a year, while the rest 11% weed thrice a year. The recommended number of weeding per year is 3-6 hence, farmers were found to be under weeding. This could have led to low yields in tc production since weeds were left to compete with the main crop.

4.2.5 TC Farmers Farming Experience

From the figure below it is realized that majority of the respondents (47%) had been farming between 5-15 years, 31% had been farming for less than five years, while the rest 21% had farmed for more than 15 years. The number of years a farmer had been growing bananas was meant to measure the experience of the farmers in dealing with the crop. It is also taken that the more years a farmer has engaged in banana enterprise, the ease at which he can adopt the changing technology for better output.

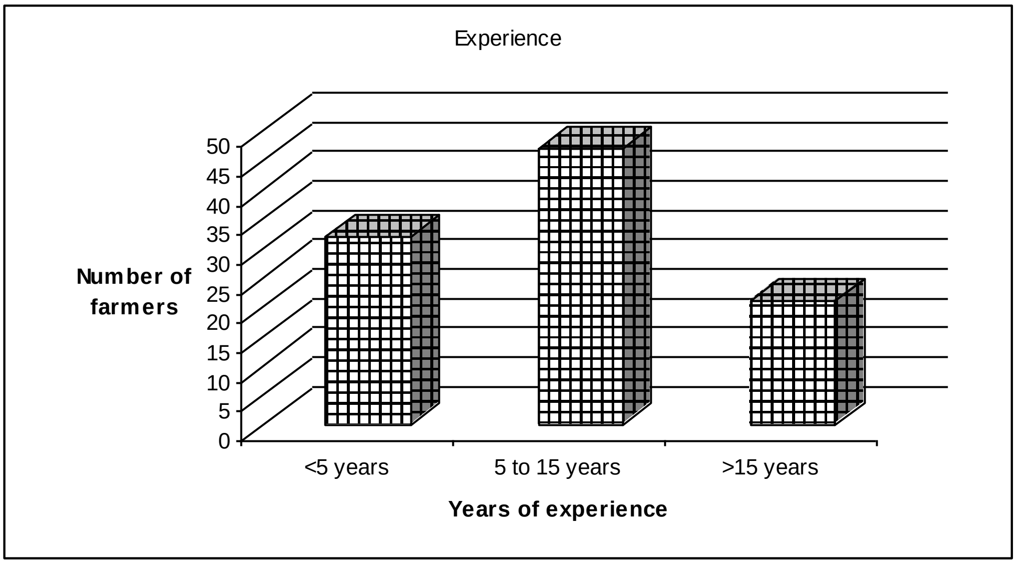

Figure 4:2 TC Farmers Farming Experience in years

Source: Authors survey 2008

4.2.6 Farmers Income from Bananas

Respondents for traditional bananas were asked on the yearly income they get. It is indicated in figure 4.3 below that 85% of the respondents earned on average Ksh. 40,000/=, 14% of them earned Ksh.60, 000, while only 1% earned less than 30,000/=. When tc banana farmers were asked on their yearly income, 41% of them earned Ksh. 40,000/=, 35% earned about Ksh. 60,000/=, while 24% of the farmers earned 70,000 and above. The incomes realized in tc bananas were far much below what was predicted by Qaim as 156% higher for small scale farmers. The low incomes could be attributed to poor management of the orchards by the farmers which led to low yields per year.

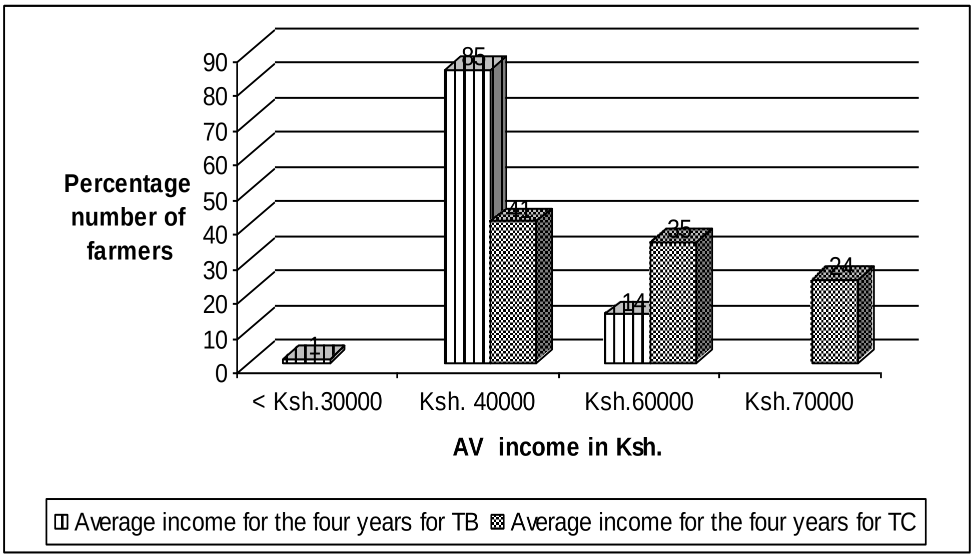

Figure 4.3 Average Banana Incomes

Source; Authors survey, 2008

4.3 Benefit Cost Analysis Results

In analyzing the investment feasibility, the establishment costs, maintenance costs and gross returns from the main crop were considered at 15 percent discount rate representing the opportunity cost of capital. The pricing of inputs and outputs of bananas is shown in the table 4.2.

Table 4.2: Input and Output Pricing of Bananas Planted in Kisii Central

Input/output	Source of information	Pricing technique	Price (Ksh)
Banana yields	Farmers/traders	Farm-gate price /bunch	100-280/ bunch
Land preparation	Farmer	Prevailing market rates	2400-3000/acre
Digging planting holes	Farmer	Prevailing market wage rates	10/ hole
Tissue culture banana suckers	Farmers/ traders	Purchase price + transportation cost	100-120/ sucker
Traditional banana suckers	Farmers/traders	Purchase price + transportation cost	25-40 /sucker
Fertilizer	Farmer / trader	Purchase price + transportation cost	1450-1600/50 kg bag
Cost of fertilizer application	Farmers	One person applies 2.5 bags/50 kg per day	70-100 per bag /50 kg
Hired labour	Farmers	Prevailing market wage rate	80-120/ workday
Family labour	Farmers	Opportunity cost of market wage rate	80-120/ workday
Cost of capital	AFC Banks, farmers	Interest rates on loans given out (15%)	5-30 per 100

Source: Authors survey, 2008

The prices in the table were used to compute the gross returns of the farmers and the costs incurred during establishment of the orchard. Yields of tc were found to be 22.032 tones per hectare compared to 45 tonnes per ha as had been predicted by Qaim. The methods used to evaluate the economic attractiveness of the technologies were: Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost

Ratio (BCR). The techniques take care of time and magnitude of cashflows that accrue in the course of banana economic life cycle.

Net present value (NPV) criterion helps to evaluate the benefits accrued and costs incurred during the project life. One advantage of NPV is that it gives an idea about surplus money that would be generated by a project at a given discount rate. It is an absolute measure and varies with level of investment and discount rates. In this study NPV was calculated by discounting the gross cash inflows from banana production. The NPV of local and improved variety of banana per hectare at 15 percent discount rate were Ksh.64, 383.56 and Ksh. 64,884.42 respectively.

The formal selection criterion of NPV is to accept all the projects with positive values. Applying this principle, net present value of banana clearly indicated financial feasibility of investment in both local and improved banana. Net present value of conventional variety of banana was slightly higher than that of tc production. Results of BCA are presented in table 4.3 below.

Table 4.3 Results of Benefit Cost Analysis

Banana technology	NPV (Ksh)/ ha (At 15% discount rate)	BCR (At 15% discount rate)	NBCR	IRR (Percentage)
Tissue culture	64383.56	1.866	0.866	16.031
Traditional	64884.42	2.569	1.569	20.95

Source: Authors survey, 2008

Benefit-cost ratio is another tool for appraising the worthiness of investment and it helps to ascertain the profitability of an enterprise. In banana cultivation, initial investment is made to establish the orchard and maintenance costs are incurred during subsequent years after establishment. During first year of maintenance, the cash outflows or costs exceed the cash inflows or returns and therefore the costs in these years are met out of returns obtained from the subsequent years.

The decision in B-C ratio frame work is to select the projects where the ratio is more than one. The B-C ratio was 2.569 for local bananas and 1.866 for tc production at 15% percent discount rate which satisfies the rule indicating the worthiness of investment on banana orchard. The B-C ratio indicates expected returns for each Kenya shilling of investment in banana enterprise. Return per shilling of investment in conventional banana was ksh.2.57, almost one and half times the tc production of Ksh. 1.866.

The BCR for both technologies were greater than one, indicating that costs incurred in the production process of bananas were recovered and profits made. From the BCRs, if costs were to rise by 87% (1.866-1.00)*100) for tissue culture bananas, and by 157% (2.57-1.00)* 100) for traditional bananas then the technologies will be rendered unattractive to farmers because the net benefits would fall below break even point. For tissue culture banana technology, benefits would fall by 53.6% (1/1.866) while for traditional bananas, benefits would fall by 38.9% (1/2.569) before the farmer breaks even.

IRR is suggested to be a very suitable measure for evaluating the profitability of investment on different projects. The IRR is the rate of discount at which the present worth of project is zero or the discounted costs are equal to the discount returns. It is superior over the other measures since it takes into consideration the reinvestment opportunities of enterprises during the life span.

The formal selection criterion of IRR is to accept the projects with IRR more than the opportunity cost of capital. The internal rates of return were 16.031 per cent for tc production and 20.95 per cent for conventional production. The IRR represents the maximum rate of interest at which the growers can borrow from lending agencies and invest on banana orchard. In other words, it is the average earning power of money invested on banana during its life span. Since IRR was more than the opportunity cost of capital it clearly indicated that investment on banana orchard is financially feasible. An IRR of 20.95% for traditional bananas meant that farmers on average received about Ksh. 0.21 extra per year for a shilling invested in its production. When compared with the cut off interest rate of 15%, which was the opportunity cost of capital, the production of traditional bananas was economically viable. Tissue culture banana technology had an IRR of 16.031% this indicated that the farmer got Ksh. 0.16 annually for every shilling invested in growing the bananas. This was less beneficial especially when compared to the cut off discount rate of 15%.

4.4 Comparison of Profitability in TC and Conventional Banana Production

To compare profitability of investment in tissue culture banana production against conventional banana production, the independent samples t-test was used.

The independent t-test compares the means between two unrelated groups on the same continuous dependent variable (in this case the net income from investment).

In order to carry out the independent samples t-test, the study made the following assumptions.

i) The independent variable consists of two independent groups.

ii) The dependent variable (Net income) is approximately normally distributed.

iii) Similar variances exist between the two groups (Homogeneity of variances).

4.4.1 Group Statistics

Table 4.4 shows that the mean net income of the traditional banana over the four years stood at Ksh. 32430 with a standard error of Ksh. 1992.48; on the other hand, the mean net income of the tissue culture banana over the four years stood at Ksh.25051.35 with a standard error of Ksh. 898.20. These results clearly show that the net income derived from the traditional banana is higher than that derived from tissue culture banana.

Table 4.4: Descriptive Statistics from Profitability Analysis

	Type of banana	N	Mean	Std. Deviation	Std. Error Mean
Net income over four years	Tissue culture	100	25051.35	8981.98895	898.19889
	Traditional	100	32430.00	19924.82511	1992.48251

Source: Authors survey, 2008

4.4.2 Test of Significance of the Mean Difference in Income.

The independent samples t-test was used to test for the significance of the observed difference in the mean net income between the two groups.

Table 4.5: The Results of the Test of Mean Difference in Income

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Net income over four years	Equal variances assumed	52.36	.000	3.376	198	.001	-7.37865	2185.577
	Equal variances not assumed			3.376	137.64	.001	-7.37865	2185.577

Source: Authors survey, 2008

As shown from the table, Levene's Test for Equality of Variances indicates that the two groups have unequal variances since the 'sig' value is less than 0.05. Thus we use the Equal Variances not assumed row.

Consequently, the study found that tissue culture banana had statistically significant lower average net income (Ksh. 25051.35.45 ± 8981.99) over the four years as compared to traditional banana (Ksh. 32430 ± 19924.83); t(198) = 3.376, p=0.001. The null hypothesis in this case is accepted.

4.5 Yield of Tissue Culture Banana Technology Predictor Variables.

The study sought to identify and analyze the effects of socio-economic characteristics and management practices on the yield of tissue culture banana technology.

To investigate which of the analyzed variables best predict the yield of bananas, the yield of banana function was estimated using the Cobb Douglas production Model.

$Y= Ax_1^{\beta 1}\ x_2^{\beta 2}\ x_3^{\beta 3}\ x_4^{\beta 4}\ X_5^{\beta 5}\ x_6^{\beta 6}\ X_7^{\beta 7}\ x_8^{\beta 8}\ e^{\mu}$ ……………………….........3-9

The Cobb-Douglas production function was therefore reduced into linear form by taking logarithms on both sides resulting into the linear function.

$\text{In } Y= \text{In } A+ \beta_1 \ln x_1+ \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4+ \beta_5 \ln x_5 + \beta_6 \ln x_6+ \beta_7 \ln x_7 + \beta_8 \ln x_8+\mu$ ……………………………………………………………………………..3-10

4.5.1 Model Summary Results

Table 4.6: Regression Results of the Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
dimension 1	.972[a]	.945	.940	.046391096

a. Predictors: (Constant), quantity of credit, farmers age, farmers level of education, weeding frequency, farming experience, Quantity of manure applied, quantity of labour, Quantity of fertilizer applied

Source: Authors survey, 2008

As shown from the results R= 0.972, R- square = 0.945, adjusted R- square= 0.940, and the SE= 0.04639. Multiple correlation R coefficients indicate the degree of linear relationship of the tc banana yield with all the predictor variables, whereas the coefficient of multiple determination R-square shows the provision of the total variation in the tc banana yield that is explained by the independent variables in the regression equation. The adjusted R-square takes into account the number of variables in the model and is therefore a more reliable measure of total variation.

The results from the regression analysis gave an adjusted R-square value of 0.940, which means that 94.0% of the total variation in the yield of tissue culture banana technology is accounted for by the variation in the socio-economic characteristics and management practices.

4.5.2 Test for Significance of the Regression Model.

Analysis of variance (ANOVA) was used to test for the significance of the regression model. This test was used to check if a linear statistical relationship existed between the yield of tissue culture banana technology and at least one of the predictor variables. Consequently, the following hypotheses were tested.

H_0: $\beta_1 = \beta_2 = \ldots\ldots = \beta_8 = 0$ ……………………………………………………………..3-11

H_1: $\beta_i \neq 0$ for at least one *i*……………………………………………………….3-12

Table 4.7: ANOVA Test Results

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	3.359	8	.420	195.074	.000[a]
	Residual	.196	91	.002		
	Total	3.554	99			

a. Predictors: (Constant), Quantity of credit, farmers age, farmers level of education, weeding frequency, farming experience, Quantity of manure applied, Quantity of labour, Quantity of fertilizer applied

b. Dependent Variable: Yield of tissue culture bananas

Source: Authors survey, 2008

As shown from the table, $F= 195.074$, $p< 0.01$

The F test provides an overall test of significance of the fitted regression model. The F value of 195.074 indicated that all the variables in the equation were important hence the overall regression was significant. H_0: $\beta_1 = \beta_2 = \ldots\ldots = \beta_8 = 0$ was rejected and it was concluded that at least one of the coefficients from H_0: $\beta_1 = \beta_2 = \ldots\ldots = \beta_8$ was significant. Thus a regression relation actually existed between the yield of tissue culture banana technology and at least one of the independent variables.

4.5.3 Test of Individual Regression Coefficients

The individual regression coefficients test was used to check the significance of the individual regression coefficients. The hypothesis statements to test the significance of a particular regression coefficient β_j; were

H_0: $\beta_j=0$ ………………………………………………………………………...3-13

H_1: $\beta_j \neq 0$ ……………………………………………………………………..3-14

Table 4.8: Results of the Individual Regression Coefficient Test

Model	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics
	B	Std. Error	Beta	T	Sig.	VIF
(Constant)	8.234	.374		22.018	.000	
Quantity of labour	.205	.079	.198	2.605	.011	1.538
Quantity of manure applied	.006	.003	.096	1.736	.086	2.056
Quantity of fertilizer applied	.078	.015	.639	5.055	.000	2.423
Weeding frequency	.031	.010	.089	2.961	.004	1.489
Farming experience	.130	.020	.363	6.642	.000	1.936
Farmers age	.008	.022	.010	.384	.702	1.188
Farmers level of education	.025	.019	.035	1.320	.190	1.159
Quantity of credit	.112	.041	.291	2.712	.008	1.042

a. Dependent Variable: Yield of tissue culture bananas

Source: Authors survey, 2008

The results indicate that the quantity of labour (in man days), quantity of fertilizer applied, weeding frequency, farming experience and quantity of credit were significant at the 0.05 level since all their p- values fall below the significance level of α= 0.05. The null hypothesis H_0: β_i= 0 is therefore rejected for all the predictor variables except for age, manure applied and education level of the farmer.

The $\beta_{i's}$ are the coefficients that estimate the elasticity's of yield of tissue culture banana technology of the socio-economic and management practices. These elasticity's show the percentage change in the yield of tissue culture banana technology when socio-economic and management practices change. The results show that a 1% increase in quantity of labour, other independent variables held constant would lead to a 0.205% increase in the yield of tissue culture banana; a 1% increase in quantity of fertilizer applied would lead to a 0.078% increase in the yield; a 1% increase in weeding frequency would lead to a 0.031% increase in the yield; a 1% increase in farming experience would lead to a 0.130% increase in the yield; and a 1% increase in quantity of credit would lead to a 0.112% increase in the yield.

The constant value of 8.234 indicates that tissue culture banana yield without proper socio-economic and management practices stood at 8.23% with a margin error of 0.374 either side. The results further show that farming experience (t= 6.642) followed by quantity of fertilizer applied (t=5.055) are the main socio-economic and management practices that predict the yield of tissue culture banana technology.

The variance inflated factors (VIF) measure the existence of multicollinearity whereby VIF values above 2.5 would indicate a threat of multicollinearity. Since none of the VIF values are above the cut point of 2.5, this indicates that there was no threat of multicollinearity. Hence the estimated beta values were considered stable.

From table 4.8 there was a positive relationship between the level of output of bananas and the quantity of manure, fertilizer applied and weeding frequency. This scenario was expected as the level of production depends largely on the quantities of these inputs used on the farm. However, this can only be up to a level that is considered optimal after which farmers will be operating at sub optimal level.

An interactive quantitative variable for credit had a positive sign, an indication that access to credit increased tissue culture banana yields. This was quite expected given that poor farmers were given credit to pay back with an interest rate of 15% and that banana production is a capital investment project which takes time to pay back.

Farmers may have had funds to manage their orchards for efficient production for the period they were repaying the loans and other subsequent years after the loan repayment was over.

A positive sign on the years of school variable indicates that an increase in the level of education increases tc banana yields. This reveals that a level of education equivalent to secondary school is sufficient for a tc banana producer to make informed decisions and improve banana production. This could probably be explained by the fact that very high education (university and college) increases the desire for new technology farming and therefore, the farmer probably concentrates on salaried employment but supports tissue culture farming financially. The coefficient also indicates that farmers engaged in off-farm income earning activities tended to exhibit higher levels of efficiency leading to increased tc yields. The positive relationship suggested that involvement in non-farm work was accompanied by reallocation of time and resources towards farm related activities, such as adoption of new technologies and gathering technical information that is essential for enhancing tc banana production. The positive coefficient could also imply that production output increases with an increase in level of education of the household head, hence high tc banana yields.

The variable for age was negative, suggesting that as age advanced, production output went down. The reason for this is probably because the age variable picks up the effect of physical strength as well as farming experience of the household head. Although farmers become more skillful as they grow older, the learning by doing effect is attenuated as they approach middle age, as their physical strength starts to decline. Similar conclusions were made by Huffman (2000).

The average age of banana farmers was about 40 years old. Thus the farmers were old and should be able to make rational decisions about their farm operations. They kept an average family size of eight in line with African tradition of large family size. These family members provide farm hands during tc banana farming activities. The old age of the farmers translated to high farming experience as majority started farming at an early age. This experience is important for day –to-day running of the farming activities, as tc banana cultivation is a very tasking venture.

4.6 Challenges in Tissue Culture Banana Farming

To assess tissue culture banana production in Central Kisii, it was necessary to focus on constrains and challenges faced by the farmers. These were cited as high labour requirement, lack of organized market resulting to low prices, scarcity of land, perishability of the produce, inadequate credit facility, lack of collateral to secure loans, inability to keep proper farm records, inadequate technical skills in tc banana management and poor infrastructure in banana producing areas. These problems cut across the whole district hence they were expected to hamper the production and profitability of tissue culture bananas.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary, conclusions, recommendations of the study undertaken and suggestions for further research. The information so presented was obtained from the research.

5.2 Summary of Findings

Banana farming in Kisii Kenya has continued to play an important role in the economy of the region. It is a crop that does well both in the local and international market. The demand for bananas has been increasing while supply on the other hand has been on a declining trend. There is therefore a need to look into ways of increasing banana production so that the sector can fully contribute to the country's economic development. Hence, the introduction of tissue culture (tc) techniques for banana propagation was thus perceived as having the potential to help reverse the situation since it would ensure timely availability of clean planting material. This increase is only possible by increasing on the per acreage yield by employing intensive management practices to tissue culture bananas. It is therefore important to identify the problems that the small scale tissue culture banana farmers face. This will enable policy makers and researchers to develop and adopt appropriate strategies in order to increase banana output and farmers income.

The main objective of this study was to describe tissue culture banana production in Marani and Mosocho Divisions of Kisii Central District, compare profitability of tc and conventional banana production and identify farm level problems facing the tc small scale farmers then explore measures that could be employed to curb and if possible reverse the trend. The investigation was done through descriptive analysis, benefit cost analysis, and production function analysis. The yield results revealed that on average tc produced 22 tonnes per hectare. This is far much below the potential yield predicted by Qaim as 45 tonnes per hectare. Intensive management is therefore needed in tc production to achieve the target yield.

The demographic factors, revealed that 58% of the farmers owned land between 0.5-1 hectares, 29% own between 1-2 ha, 10% less than 0.5 ha and only 3% owned land from 3 hectares and above. Average area of land under tissue culture bananas was 0.25 ha. The small acreage explains why farmers have allocated less acreage to tissue culture banana production. Regarding gender of the household head, the results showed that 80% of farmers were men and 20% were females. Overall we can say that tissue culture banana production in kisii is dominated by men. The aproximate age of tissue culture banana farmers was found to be 40 years. Thus the farmers were old and should be able to make rational decision about their farm operations. The old age of the farmers translated to high farming experience as majority started farming at an early age. Furthermore, the high average age of the farmers also indicated that youth tended to shun from tissue culture banana farming. When farmers were asked on whether they accessed credit for tc banana production, 41% indicated they did, while 59% did not.

On management factors, out of all the farmers interviewed, 47% and 34% applied some manure and nitrogen fertilizer to the tc banana orchards in the subsequent years respectively. This revealed that the ability of tc banana technology farmers to practice the recommended management practices was poor. Application of manure and fertilizer improves nutritional levels of the soils hence high tc banana productivity obtained. Weeding was poorly done with only 11% of the farmers weeding thrice annually, 51% twice and 38% once. The weeding should be done more often to leave the plots weed free hence reduce the attacks by weevils and nematodes. Desuckering is a practice that was poorly done leaving many suckers around one stool against the quantity of manure and fertilizer applied. Many suckers led to high competition for the available soil nutrients resulting to low productivity of tissue culture banana technology.

A benefit cost analysis of tissue culture banana technology resulted to an NPV of Ksh. 64,383.56, while conventional banana technology gave an NPV of Ksh. 64,884.42. Both NPVs were positive, an indication that the two projects were viable. The BCR for both technologies were greater than one, i.e. 1.866, and 2.569 for tc banana and conventional banana technologies respectively, indicating that costs incurred in the production process of bananas were recovered and profits made. With reference to BCR, the profits made from conventional banana technology were higher than those from tissue culture banana technology. These results could be associated with the poor management practices done by the tissue culture banana farmers. An IRR of 20.95% for traditional bananas meant that farmers on average received about Ksh. 0.21 extra per year for a shilling invested in its production. While tissue culture banana technology had an IRR of 16.031% this indicated that the farmer got Ksh.0.16 annually for every shilling invested in growing the bananas. This was least beneficial especially when compared to the cut off discount rate of 15%.

In the production function analysis a Cobb-Douglas type of production function was estimated for tissue culture banana production. The results from the regression analysis gave an adjusted R-square value of 0.940, which meant that 94.0% of the total variation in the yield of tissue culture banana technology was accounted for by the independent variables. The results of the analysis showed that the quantity of labour (in man days), quantity of fertilizer and manure applied, weeding frequency, farming experience and access to credit significantly affected the output of tissue culture bananas at farm level. The results further show that farming experience (t= 6.642) followed by quantity of fertilizer applied (t=5.055) were the main socio-economic and management practices that contributed to the yields of tissue culture banana technology. This was followed by weeding frequency, access to credit and manure application. Farmers' age and level of education insignificantly influenced the yields of tissue culture banana technology.

5.3 Conclusion

Tissue culture banana farming is very tasking but profitable venture; it can enhance food security, generate income and create employment opportunities. The profitability factor is only possible if farmers can be committed to exploit the potential benefits and opportunities that are involved in tissue culture banana production. Based on the findings of this study, it was concluded that tissue culture banana technology farming had potential to be profitable so long as financial resources are put in place. It was found that the age range for tc farmers was 26-54 years. If median value is taken for the age interval, it is approximated that majority of the farmers were about 40 years. This implied that youths in the study area had not embraced tissue culture banana faming; hence it has remained a preserve for the elderly people. This was deemed a risky scenario in the future of tc production as the advanced age picks up the effect of physical strength as well as farming experience of the household head. Farmers are known to become more skillful as they grow older, but the learning by doing effect is attenuated as they approach middle age, as their physical strength starts to decline, hence there is a bleak future for tissue culture banana production technology in the study area.

The low coverage of the enterprise in terms of area was supported by the view that, an average of 0.25 ha was devoted to tissue culture banana production; this is due to small land holdings. It was also concluded that, low enterprise coverage was as a result of the high initial and labour costs involved in tissue culture banana production. Farmers in the study area had inadequate expertise needed for tissue culture banana farming and have not fully adhered to tissue culture banana farming requirements. This has led to low production per hectare and subsequently low returns. High input costs had constrained farmers who have resulted to applying less or none of the recommended inputs.

The socio economic and management factors analyzed in the study area indicated that they significantly had an impact on the yields of tissue culture bananas and that farming experience and quantities of fertilizer were the most significant and potent contributors to the total output. This experience is paramount for day –to-day running of the tc farming activities, as tc banana cultivation is a very tasking venture. Fertilizer and manure application as factors of management incidentally were the most paramount inputs or resources needed in production of tc bananas. Proper application of these management aspects could lead to increased productivity of tc bananas in the study area.

Increased income from bananas could imply reduced vulnerability of the households hence able to finance their expenditure on education and food as a basic need. Education would have an impact of lowering illiteracy levels in the study area, more off farm jobs would be accessed consequently, farmer’s purchasing power would increase, and management of banana orchards would improve and lead to high productivity and expansion of area under tc bananas.

5.4 Recommendations

Farmers in the study area should commit more money towards the purchases of fertilizer and manure since these were the most significant management factors that had the greatest impact on the output produced. Application of fertilizer and manure in the subsequent years of banana growth cycle should be emphasized to improve and maintain soil fertility for proper nutrient uptake hence, increased productivity. To improve the output and lighten the future of tc banana technology, a deliberate effort should be made to encourage the youths to engage in tc banana farming activities. Youths are regarded as the future and economically active age group of the farmers.

The farmers should be provided with more technical skills on tc banana management and record keeping. Farmers require constant trainings on good agricultural practices of tc bananas through relevant stakeholders and collaborators in the study area. The skills shall be vital in monitoring, evaluating and detecting new interventions necessary in entrenching introduced technologies.

The technology promoting institutions need to intensify and facilitate flow of information and exchange of research findings on banana yields and the recommended management practices for increased productivity. Farmers need to be enlightened on proper farm records through field days, exhibitions and workshops at local levels. Importance of proper farm records on farm level decisions should be imparted on farmers for this will help improve on decision making and determination of returns.

On farm preparation of farm yard manure and compost should highly be practiced by farmers in the study area. This will improve the availability of the organic matter for good agricultural practices in banana production.

In order to reduce the problem of poor management in tc banana production, due to low purchasing power of inputs, collaboration between farmers and credit providers need to be enhanced as it will lead to improved management.

5.5 Suggestions for Further Research

The researcher strongly believes that more research is needed to gain more insight in the field of banana production. It is therefore necessary to carry out further research on the technical efficiency resulting from adoption of recommended technologies in banana production.

An inter comparison study between banana production and other farm enterprises could be undertaken. This shall reveal the best option farmers have in regard to viability and profitability of tc banana farming against other enterprises they undertake on the farm.

There is need for further study into the impact of banana improvement on livelihoods of adopters in the study area. This shall help understand the way in which an agricultural technology fits into the livelihood strategies of households or individuals with different types of resources, taking account of sociological differences that may exist between gender and ethnic groups

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APPENDICES

APPENDIX I – INTRODUCTORY LETTER

I am a student at Moi University pursuing a Master of Philosophy Degree in Agricultural Economics and Resource Management. I am carrying out a research study entitled 'An economic assessment of tissue culture banana production in Kisii district, Kenya.'

You have been selected as one of my respondents and your help in filling in the questionnaire will be highly appreciated. All information will be treated with strict confidentiality, as the purpose of this study is for academic purposes only.

Yours faithfully

Lisa. A. J

APPENDIX II – QUESTIONNAIRE FOR FARMERS

This questionnaire is to collect data for purely academic purposes. The study seeks to assess the economics of tissue culture banana production. All information will be treated with strict confidence.

***Answer all questions as indicated by either filling in the blank or ticking the option that applies*.**

PART 1; GENERAL INFORMATION

Questionnaire number-----

1 Enumerators name --------------------------

2 Date of interview ----------------------------

3 Name of the farmer (optional)--

4 Division --------------- Location---------------------Sub location----------------

Village ----------------------

PART II; SPECIFIC INFORMATION

SECTION A; FARM ENTERPRISES AND OPERATOINS

(5) Name the crops you grow on your farm

1.

2.

3.

4.

6) What is the area occupied by each crop

7) What was the total yield of each enterprise (specify units)?

8) How much did you sell?

9) What was the selling price per produce per unit?

Crop	Area (ha)	Yield (bags)	Amt. Sold (bags)	Selling price (ksh/bag)

10) **Labor input**

a) i) How many permanent laborers do you have on your farm? ----------------

ii) How many hours do they work per day?

iii) What is their salary? Ksh

iv) What were their specific duties?

Operation	No of Employees	Hours Worked/day	Salary	Total cost (ksh)	

b) i) How many casuals do you engage in your farm? ----------

ii) For what operations do you employ the casuals?

Operation	**No of casuals**	**Hours Worked/day**	**Days Worked /week**	**Wages Ksh./day**	**Total cost (ksh)**

SECTION B; PURCHASE OF INPUTS

11) Which one of the following do you use in planting bananas?

Fertilizers….. ( )

Manure… ( )

None….. ( )

Others (specify)

I.) if fertilizer what types of fertilizer do you use?

II.) What amounts of the fertilizer was applied to the crop

III.) How many times do you apply in a year

IV.) What was the unit cost of each fertilizer (Ksh)/50kg bag?

Type of fertilizer used	Amount of fertilizer (bags)	Number of applications in a year.	Cost Ksh/bag

vi) If you don’t use fertilizers give reasons for not using

a)--

b) --

12) How do you cultivate your banana field?

Hand ( )

Tractor ( )

Animals ( )

ii) What are the charges per Ha.using each of the above methods?

iii) What was the total cost?

Means of operation	Area ploughed (Ha)	Ploughing cost (Ksh)	Harrowing cost (Ksh)	Total cost (Ksh)
Hand				
Animals				
Tractor				

13) Which type of bananas do you plant?

- Tissue culture ( )

- Traditional type ( )

ii) Which type gives the highest yields?

iv) Do you think this is the highest yield you can obtain?

-Yes ( ) -No ( )

v) Give reasons

…………………………………………………………………………………………

…………………………………………………………………………………………..

…………………………………………………………………………………………

Section C:Tissue Culture Production Détails

14) What is your experience with tissue culture bananas?

Very good ( ) Good ( ) Fair ( ) Bad ( )

15) What is the total acreage of your farm?

Less than 1 acre ( ) 1 – 3 acres ( ) 3 – 5 acres ( ) over 5 acres ( )

16) Of this land, approximately what fraction have you allocated to tissue culture banana growing?

¼ acre ( ) 1/2acre ( ) 1acre ( ) more than 1 acre ( )

17) How many stools of tissue culture banana do you have?

1 – 50 ( ) 51 – 100( ) 101 – 200( ) More than 200( )

18) How many stools of traditional banana do you have?

1 – 50 ( ) 51 – 100( ) 101 – 200( ) More than 200

19) What is your average annual income in Kshs from banana farming?

Less than 10,000( ) 10,000-20,000 ( ) 20,000-40,000 ( )

40,000-60,000 ( ) Over 60,000( )

20) Do you apply manure on tc bananas yearly Yes (…) No (…….)

21) How much manure do you apply annually ……………………………… (.kgs)

22) Do you apply nitrogen fertilizer on tc bananas annually Yes (….) No (….)

23) If yes how much………………………………………………………… (kgs)

24) How many times do you weed your banana orchard in a year……… (Number)

Once (…) twice (…) thrice (….) four times (.....)

25) How many times do you prune your bananas……………………….(Number)

26) Do you do desuckering of your tc bananas ………Yes (…..) No (…...)

27) If yes how many times……………………………………………… (Number)

28) Approximate the yields per acre.

Tc bananas ………………………………………………………………(kgs)

Traditional bananas…………………………………………………...(kgs)

28a) Approximate the yields per acre for last 4 years indicating bunch sizes.

Technology yields / year	Yields 2004	Yields 2005	Yields 2006	Yields 2007
Tc banana technology				
Conventional banana technology				

29) How much do you sell a bunch of banana?

Small bunch ……………………………………………………………. (Ksh)

Medium bunch … …………………………………………………….... (Ksh)

Large bunch… …………………………………………………………. (Ksh)

29a) What is your average annual income from banana farming ………… (ksh)

Income in Ksh/type of bananas	2004	2005	2006	2007
Tissue culture bananas				
Conventional bananas				

30) Do you keep any records of banana production Yes (…..) No (…..)

31)**. The following items relates to profitability and sustainability of tissue culture banana production. Please circle where it applies on a scale of 1-5.**

	STATEMENT	Strongly disagree	Disa gree	Und ecid ed	Agre e	Strong ly agree
a	Tissue culture banana production has a higher profit margin than the traditional methods	1	2	3	4	5
b	TC production is affordable in terms of inputs	1	2	3	4	5
c	TC banana production maximizes the production capacity	1	2	3	4	5
d	Products of TC are more superior than using traditional methods	1	2	3	4	5
e	Products of TC fetch higher prices in the market because of their superior quality	1	2	3	4	5
g	TC banana production blends well with the current farming practices	1	2	3	4	5
h	The family can survive from the income generated through TC production	1	2	3	4	5
i	Farmers have formed an organization to help each other in TC banana production	1	2	3	4	5

SECTION D; Socio- economic and demographic data

32) Gender - male ( ) - female ( )

33) Who makes farm decisions? Husband ( ) - wife ( ) Both ( )

34) Age in years.

Below 25years ( ) 26-40 years ( ) 40- 55 years ( ) over 55 years

35) Marital status?

Single ( ) Married ( ) Divorced ( ) Widowed ( )

36) Family size …………………...?.(Number of family members)

37) Did you access any credit for tc banana farming Yes (........) No (.......)

If yes how much.. (Ksh)

38) Education level (Highest level of education attained).

Not educated (1) Primary level (2) Secondary level (3)

College level (4) University level (5)

39) For how long have you been engaged in banana production?

Less than 5 years ( ) 5-15 years ( ) over 15 years ( )

40) Are you employed (Main occupation).

Teacher ( ) Farmer ( ) Civil Servant ( ) Businessman/woman

Any other (specify)..

41) If employed elsewhere other than agriculture, what is your monthly salary?

Below Ksh 10,000 ( ) - Ksh 10001- 20000 ( ) -20001- 50000 ( )

Over Ksh 50000( )

42) What forms your major expenditure components?

-Children education ( ) - food ( ) -farming ( ) others specify --------

ii) Approximate the amount you spend on each of the components above

Children education- below Ksh 10000 ( ) -Ksh 10001- 30000 ( )

0ver Ksh 30000( )

Food - below Ksh 1000 ( ) -Ksh 1001- 3000 ( ) - 0ver Ksh 3000( )

Farming- below Ksh 1000 ( ) -Ksh 1001- 3000 ( ) - 0ver Ksh 3000 ( )

Others specify --------------------

43) What are your total earnings per year including that from supplementary sources?

Below Ksh. 20000 ( ) Ksh 20001- 40000 ( ) Ksh 40001- 60000( )

Over Ksh 60000( )

44) What challenges do you face in banana farming……………………………....

………………………………………………………………………………………..

………………………………………………………………………………………..

APPENDIX III – INTERVIEW SCHEDULE

The following questions guided the researcher during the interview:

i) What characterizes production economies of tissue culture bananas?

ii) What is the profitability and sustainability of tissue culture production?

iii) How adaptable is tissue culture banana production to current farming practices?

iv) What is the potential of tissue culture banana production on alleviation of hunger?

v) What are the challenges facing profitability of banana production in Kisii?

vi) What is the way forward as far as maximization of banana production economies is concerned?