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By Shellmith Mugo

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FACTORS INFLUENCING TISSUE CULTURE BANANA OUTPUT AND ITS IMPACT ON INCOME IN NYAMUSI DIVISION, NYAMIRA NORTH DISTRICT, KENYA

Mugo, S.W[1]*., Bunde A.O*[1]*.Korir M.K*[2]*, Mudaki J.S*[3]*.,*

shellmugo@yahoo.co.uk; aggreyotieno@yahoo.com

School of Business & Economics, Department of Economics, Moi University, P.O. Box 3900 – 30100, Eldoret.

ABSTRACT

Banana occupies a distinct place in the national as well as in the household economy of Kenya. This study was done to establish the factors affecting production of tissue culture bananas and whether incomes of tissue culture banana growers were significantly different from those growing conventional bananas. The specific objectives of the study were to determine the relationship between factors of production (extension services, inputs, manure and land size) and output per acre. This research put to light the differences between tissue culture bananas and non-tissue culture bananas in terms of yields and income generated. The null hypotheses of the study were firstly that none of the factors of production had an effect on output and secondly that tissue culture bananas had no impact on household's income. The target population was 4,200 farmers who had benefited from the Southern Nyanza Community Development Project (SNCDP) in Nyamusi division of Nyamira North district. The sample was 366 households comprising of two strata, those who produced tissue culture bananas and those who produced conventional bananas. A systematic sampling procedure was used to get the sample farmers in the two strata that were interviewed. The researcher employed the following tools for data collection: questionnaires, interviews and document analysis. Data collected was both primary and secondary data which was cross-sectional. SPSS and excel were used to analyze data. A Cobb-Douglas production function was used where the quantity of banana produce was regressed against factors of production and household characteristics (age, education and gender). Estimated coefficients (elasticities) were tested for level of significance in determining production. T-tests of means of income were used to assess the differences in incomes of the two groups of households, those who produced tissue culture bananas and those who produced conventional bananas. The study revealed that tissue culture banana growers had relatively higher incomes compared to conventional banana growers. The results found land size under tissue culture bananas, manure applied, extension services and age of household head to be significant determinants of production with elasticities of 1.861, 0.0716, 0.017 and 0.341 respectively. Gender and level of education of household head had no effect. Poverty Eradication Commission, Ministry of Devolution and Planning and SNCDP's Project Management Unit need to understand the importance of tissue culture bananas in improving incomes of smallholder farmers thus reduction of poverty. More extension officers should be employed and extension visits intensified. The Government should subsidize tissue culture banana plantlets to ensure its affordability.

Key Words: Tissue Culture Bananas, Impact on Income, Nyamira, Kenya.

INTRODUCTION

1.0 Introduction

This chapter presents the background to the study, statement of the problem, the study objectives, research hypotheses, significance of the study and the scope of the study.

1.1 Background to the Study

Banana is an important fruit crop of the world which is cultivated over an area of more than four million hectares and its annual production is more than seventy million tonnes (FAO, 2006). Bananas are now grown pantropically in one hundred and thirty countries which is more than any other fruit. Edible Musa spp. originated in Southeastern Asia and spread westwards along the major trade routes that transported other fruits. Most of the bananas are used as fresh fruits. Bananas are also used in many other forms including banana puree, ice cream, baked desserts and can also be made into beer and wine. Kenya produces over one million tonnes of the crop valued at seven billion shillings. The average yield per hectare of banana in Kenya has been established to be fifteen tonnes. Unfortunately, over 40% of the countries production is lost due to poor harvesting and handling techniques, inadequate banana market and due to fungal diseases like panama and pests like banana weevil. These diseases and pests make the harvested crop to be of poor quality thus diminishing the returns to farmers. Because of the aforesaid reasons, the country is losing its local market to imports from Uganda, a country that produces ten million tonnes valued at 1.7 billion dollars of fruit making it the second largest producer of bananas in the world after India.

Banana is thus an essential staple crop throughout the East Africa. It is also an important source of trade and income. To safeguard sustainable banana production and generate wealth for smallholder farmers, high quality planting material is crucial. Banana in smallholder farmer systems in East Africa is traditionally propagated by means of suckers, which contain pests and diseases. Plants produced through tissue culture are mostly free from pests and diseases (with a few exceptions). There are many further benefits to using tissue culture plants: firstly they are more vigorous, meaning faster growth and higher yields. Secondly, they are more uniform, allowing for better planned marketing; and they can be produced in large quantities in a short period of time, facilitating distribution of both existing and new cultivars. In other words, tissue culture technology can help banana farmers to make the transition from subsistence to income generation.

Southern Nyanza Community for Development Program (SNCDP) is one of the programs funded by International Fund for Agricultural Development (IFAD) to a tune of 87.5%, Government of Kenya to a tune of 10% and the community 2.5% through their contributions of locally available materials with the main objective being contribution to poverty reduction and improvement in livelihoods of rural communities in the project area. The project area covers seven districts: Homabay, Kuria, Ndhiwa, Nyatike, Nyamira North, Rachuonyo North and Suba that were among the poorest districts in the relatively high potential agricultural area of Southern Nyanza. In Nyamusi, before project intervention which started in 2004, the community was faced with the following problems: high incidence of poverty of 60%, food insecurity, lack of clean and safe water and high incidence of water-borne diseases, and strong socio-cultural traditions and norms. The project focuses extensively on rural poverty reduction, working with poor rural populations to eliminate poverty, hunger and malnutrition; raise productivity and incomes; and improve the quality of their lives. Tissue culture banana is one of the inputs promoted and technical officers are given allowances when they do extension services.

Earlier studies on tissue culture banana technology have shown that while increase in yields especially on small-scale farms has been substantial, adoption rates are still low (Mbogoh *et al*., 2002; Qaim, 1999; Wambugu and Kiome, 2001). Several constraints to the adoption of tissue culture banana technology noted include: high cost of the tissue culture plantlets compared to conventional suckers, higher labor and inputs requirements, limited availability of clean land, and limited established marketing and distribution systems. However, several development organizations and NGOs have sought to address some of these constraints by introducing facilities to provide credit, information, the orderly supply of necessary and complementary inputs, infrastructure investments and marketing networks. This study sought to determine the factors influencing tissue culture banana output and its impact on income in Nyamusi division, Nyamira North district.

1.2 Statement of the Problem

The general impact of tissue culture banana production has often been mixed. Some studies indicate that tissue culture bananas lead to an improvement in yields for they are less prone to attack by banana diseases and pests, have shorter maturing period and provide reliable family income. However, other studies show the contrary; higher costs in purchasing inputs yet yields are lower than non-tissue culture bananas. Some households have not adopted this technology in the project area in Nyamusi. It is perceived that such households achieve low agricultural production than those who have adopted the technology. This can curtail the positive effects, and therefore, the visibility of the programme in the division. There is therefore need for measuring the impact of the tissue culture bananas production project which is on its eighth year.

1.3 Objectives of the Study

The general objective was to find out the main factors affecting output of tissue culture bananas.

The specific objectives were:

(i) To determine the relationship between factors of production (extension services, inputs, manure and land size) and output per acre in Nyamusi division.

(ii) To determine the statistical difference in income between tissue culture bananas and conventional bananas in Nyamusi division.

1.4 Hypotheses

The hypotheses of the study were:

H_{o1}: None of the factors of production (extension services, inputs, manure and land size) affects output of tissue culture bananas in Nyamusi division.

H_{o2}: There is no significant difference in incomes from tissue culture bananas and conventional bananas in Nyamusi division.

1.5 Justification of the Study

Poverty Eradication Commission and Millennium Development Goals Agency which funds interventions related to the eight millennium development goals should begin promoting tissue culture bananas for food security and improvement in income which will help in the alleviation of extreme poverty and hunger in the country which is the first Millennium Development Goal. There is higher productivity of tissue culture bananas as compared to conventional bananas which translates to increased incomes of tissue culture banana growers. International Fund for Agricultural Development, Project Management Unit of the project and Ministry of Devolution and Planning which is the lead government agency in SNCDP should thus improve the interventions that will further take place to include tissue culture bananas.

1.6 The Scope and Limitation of the Study

The study was concerned with factors influencing tissue culture banana output and its impact on income in Nyamusi division. It was conducted in 5 sub-locations in Nyamusi division of Nyamira North district between July and August 2012 and a sample of 366 households selected from 4,200 households. The data was collected through questionnaires and personal interviews. Most household heads interviewed did not maintain records on production quantities, manure applied and number of extension services received and as such the study depended on the farmer's ability to remember.

METHODOLOGY

3.1Theoretical Framework

This study is based on the theory of the firm, which states that given a level of technology and production inputs, an efficient producer will achieve maximum (technical) production of outputs. This theory assumes effects of external and internal factors on different households (especially smallholder farmers) in agricultural production. Within a given agro-ecological environment, agricultural productivity is determined by amount of land, labor, capital and other inputs that are used, and by the quality of these factors such as fertility of land and education of farmer. As a general proposition and providing technologies and managerial skills are the same, farmers who have identical access to identical factors (both quality and quantity) will produce identical outputs of a given crop; that is productivity will be identical. If they use different technologies or different quantities of these factors, or there is difference in quality of these factors, their productivity will differ. Thus there may be differences in the productivity of tissue culture and non-tissue culture bananas (Quisumbing, 1995).

3.1.1 Production Function Approaches

Production functions are of many forms ranging from simple linear production models to complex ones involving quadratic models that require lots of information for data analysis. A production function is a technical relationship between inputs and outputs that specifies the maximum level of output possible, given input levels. Some of the production functions include Cobb-Douglas Production function and Constant Elasticity of Substitution function. Cobb Douglas Production Function was tested and developed against statistical evidence by Charles Cobb and Paul Douglas (1900-1947). In its most standard form for production of a single good with two factors, the function is;

$$\mathbf{Y = AL^{\alpha}K^{\beta}} \quad \ldots\ldots \mathbf{3.1}$$

Where Y is total production (monetary value of all goods produced in a year),

L is labor input,

K is capital input,

A is total factor productivity and

α and **β** are output elasticities of labor and capital respectively. These values are constants determined by available technology. They measure responsiveness of output to a change in levels of either labor or capital used in production, *ceteris paribus*. Constant Elasticity of Substitution was introduced by Arrow, Chenery, Minhas and Solow hence it is also known as the ACMS function. It takes the following form:

$$\mathbf{Q=A\,[Ak^{-\rho} + (1\text{-}\alpha)\,L^{-\rho}]^{-t/\rho}} \qquad \mathbf{3.2}$$

Where

A (>0) is the efficiency parameter which represents the 'size' of the production function,

K and **L** are capital and labor inputs respectively

α is a distribution parameter which helps explain relative factor shares ($0 \leq \alpha \leq 1$),

ρ is the substitution parameter which helps derive the elasticity of substitution

t is time specific

A choice of a functional form is influenced by 3 rules (Heady and Dillon, 1992). Firstly, it must relate to the logic or basic mechanics of the production process under investigation. Secondly, the chosen form should afford easy manipulation and derivation of useful economic statements and thirdly it should ensure computational ease that is feasible. A Cobb Douglas type of production function is mostly used due to its ability to meet the above conditions and that it has been preferred by a number of authors (Gallagher, *et al*.1997; Olagoke, 1991). The Cobb Douglas production function model has been widely used because of its convenience for interpretation of elasticities of production, its estimation of parameters involve fewer degrees of freedom than others and its computational simplicity. It therefore adheres to the apriori economic norms of production.

3.1.2 Empirical Models

Yadav et al. (2005) did a comparative study on Resource Productivities and Resource Use Efficiencies of traditional and tissue culture banana cultivation in Parbhani district of Maharashtra State in India. By using multi-stage sampling design, 60 traditional and 30 tissue culture banana growers were selected from the whole of Parbhani district. Traditional banana growers and tissue culture banana growers were selected from the same villages. With the help of pre-tested schedule, data was collected from both the types of banana growers by using personal interview method. To determine resource productivity and resource use efficiency in banana production, Cobb-Douglas production function (non-linear) was used on the basis of goodness of fit (r^2) separately for the two methods of banana cultivation. The data was therefore, subjected to functional analysis by using following form of equation.

$$\mathbf{y = ax1b_1.\ x^2\ b_2 \ldots xn.b_n.ei} \qquad \mathbf{3.3}$$

Where

y = dependent variable

x1 = Independent resource variable

a = Constant representing intercept of production function

b_i = Regression coefficient of respective resource variable

The regression coefficient obtained from this function directly represents the elasticities of production, which remain constant throughout the relevant ranges of inputs. The sum of coefficients i.e. B_i indicates the nature of returns to scale. This function can be presented into linear form by making logarithmic transformation:

Log y = log a + b_1 log x1 + b_2 log x 2 + … +b_n log xn + loge……………………….………………………....**3.4**

For fitting production function in both traditional and tissue culture banana cultivation methods, nine inputs (variables) were considered as important factors by considering the problem of muticollinearity in estimating production function and the equation fitted was of the following formula.

y = a x1b_1. x2 b_2. x3 b_3. x4 b_4. x5 b_5. x6 b_6. x7 b_7. x8 b_8. x9 b_9………………………………….……………………………**3.5**

Where,

y = Yield (qt/ha)

a = Intercept of production function

b_i= Regression coefficient of the respective resource Variable (i = 1, 2, 3, ……9)

x1, x2, x3, x4, x5, x5, x6, x7, x8, x9 are Area of banana (ha), Human labour in man days, Bullock labour in pair days, Suckers in number, Farm yard Manure (FYM) in quintal, Nitrogen in kg, Phosphorus in kg, Potash in kg and Irrigation in number respectively.

The regression coefficients in Cobb-Douglas production function are the elasticities of production and can be used to determine the influence of independent variables or inputs on output data collected from banana growers. From the results on traditional banana enterprise, all variables except x2 (human labour) indicated positive contribution towards yield of banana. The regression coefficient of not a single variable was significant at one and five per cent level of productivity but contribution of area (x1) under banana was highly significant at 10 per cent level of productivity followed by x5 (FYM) and x8 (Potash) variable. This means increase in yield level of traditional banana is directly proportional to increase in use of these inputs above the mean level. The elasticity of production of variable x1 (area) was 0.518, which means one percent increase in area increased yield of banana by 0.518 per cent. Similarly one per cent increase in FYM and Potash increased the banana yield by 0.13 and 0.019 per cent respectively. The negative elasticity of human labour may be due to less utilization of this input and its use might have not attained the saturation level. The coefficient of multiple determination (R^2) was 0.913 indicating 91.3 per cent variation in traditional banana production was explained by all independent variables.

On tissue culture bananas, results indicated that except variable x5 (FYM), x7 (Phosphorus) and x8 (Potash), all variables positively contributed towards the yield of tissue culture banana. The contribution of x4 (Plantlet) was highly significant, which means yield level of tissue culture banana increases with increase in use of x4 (plantlet) above mean level. Among significant variables elasticity of production of variable x4 (plantlet) was 0.972, which indicates one per cent increase in number of plantlet increases yield by 0.972 per cent. The negative elasticity in respect of FYM, phosphorus and potash may be due to excess utilization of these inputs; their use might have crossed the recommended level. R^2 value was found to be 0.987 showing best fit.

T. Alagumani (2005) did an Economic Analysis of Tissue-cultured Banana (TCB) and Sucker-propagated Banana (SPB) in the Theni district of Tamil Nadu state in India. Probit model was employed to find out the factors influencing the adoption of tissue culture. The proportionate random sampling technique was adopted to select 60 sample farmers who raised banana through suckers and 30 farmers who used tissue-cultured plantlets. Personal interview method was followed to collect data from sample farmers. The Cobb-Douglas type production function was used to establish the input-output relations with gross returns as dependent variables and inputs as independent variables. The functional relationship is expressed by:

$$\mathbf{Y = aX1b_1\ X2b_2\ X3b_3\ X4b_4\ X5b_5\ X6b_6\ e^U} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\mathbf{.3.6}$$

Where,

Y = Gross return from TCB or SPB (Rs/ha)
X1 = Sucker/plantlet cost (Rs/ha)
X2 = Cost of manures (Rs/ha)
X3 = Fertilizer cost (Rs/ha)
X4 = Labour cost (Rs/ha)
X5 = Land area under TCB/SPB (ha)
X6 = Dummy variable (1 for planting during August-September season, 0-otherwise)
b1 to b6 = Elasticity coefficients corresponding to each Xi's.

The dependent variable in the model was adoption of TCB. Its value was taken as 0 for non-adoption and 1 for adoption. Adoption of TCB was dependent on both economic and non-economic factors, as shown:

$$\mathbf{Ii = B_1 + B_2\ (EDN) + B_3\ (GINCOME) + B_4\ (BUNCHWT) + B_5\ (AREA) + e} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\mathbf{3.7}$$

Where:

Ii = 1, if farmers adopted TCB 0, if farmers adopted SPB
EDN = Educational status of the farmer (Illiterate – 1, Primary – 2 , Middle – 3, High school – 4, Higher secondary – 5, College – 6)
GINCOME = Gross income from TCB/SPB (in Rs/ha)
BUNCHWT = Average bunch weight of TCB/SPG (kg)
B_2 toB_6 = Co-efficient
B_1 = Intercept

On tissue-cultured banana results, the co-efficient of multiple determination (R^2) was 0.82 which indicated that 82 per cent of the total variation in the gross return was explained by the selected six variables for functional analysis. The co-efficient of plantlets (X1), manure (X2), and fertilizer (X3) were positive and significant at 1 per cent level. Labour cost (X4) had negative and non-significant influence on gross income, while the land and dummy variable used for planting season had positive but non-significant influence. On Sucker-propagated banana results, the coefficient of multiple determination (R^2) was 0.69 which indicated that 69 per cent of the total variation in the gross return was explained by the selected six variables in the functional analysis. The co-efficient of sucker cost (X1) and fertilizer cost (X2) were positive and significant at 1 per cent levels. These two variables had influenced the gross return in SPB. The sum of elasticities of resources was 0.69 for SPB, which indicated the decreasing returns to scale.

The Probit Model was employed to find out the factors influencing the adoption of tissue-cultured banana. The value of R^2 is 0.74 which indicates that 74 per cent of variations on decision to adopt tissue-cultured banana was explained by the variables included in the model. The Pearson Goodness of Fit (chi-square) was 213.80 for the whole function, which was significant at one per cent level of probability. The variable, area under banana (AREA) was found to have a negative and significant influence on the adoption of TCB at one per cent probability level. This implied that increase in farm-size would reduce the probability of adoption of TCB. The coefficient for area was –0.1159 which indicated that increase in area by one hectare would reduce the probability of adoption by 0.12 per cent on an average, i.e. in the study area TCB was cultivated only in small and marginal areas because of the need of special care for TCB cultivation. Gross income from banana (GINCOME) and bunch weight (BUNCHWT) had positive and significant influence of TCB adoption. The coefficient for bunch weight was 0.05. It meant that increase in bunch weight by one kg would increase the probability of adoption of tissue-cultured banana by 0.05 per cent on an average. Based on these results, one could conclude that bunch weight is the most influencing variable for the adoption of tissue-cultured banana. The study has shown that tissue-cultured banana was more profitable than sucker-propagated banana.

Milu (2008) studied 180 households in 5 districts in Mount Kenya region of tissue culture and conventional banana growers. One of his objectives was differences in incomes between non-adopters and adopters of tissue culture bananas. To estimate correlates of households' incomes, a classical linear regression model was used as follows:

$$\mathbf{Y_i = X_i \alpha + \mu_i} \qquad \textbf{3.8}$$

Where Y is log of household income,
X is a row vector of explanatory variables where tissue culture banana biotechnology adoption dummy is included
α is a column vector of the coefficients to be estimated and
μ is the random error term.

The explanatory variables used included education and age of household head, land size and credit availability. Average tissue culture banana production and incomes were found to be significantly lower than those of non tissue culture banana growers. The tissue culture banana productivity was also found relatively lower than that of non-tissue culture banana. Tissue culture production costs were found to be relatively higher than those of non-tissue culture bananas. The high cost of tissue culture banana production was attributed to the following observations: firstly households growing tissue culture bananas were doing that alongside other non-tissue culture banana varieties, secondly some households opted not to plant tissue culture bananas at all, and thirdly relatively low scale of tissue culture production compared to non-tissue culture varieties. On determinants of tissue culture banana adoption, his findings were that education of household head negatively affected incomes because highly educated heads had higher income earning potential and more alternative income earning opportunities. Age of household head also negatively affected incomes. Household land size holding on the other hand positively affected incomes. According to the study, farm was the most important source of income in rural Kenya and small changes in land size produced significant changes in household incomes. Credit availability was also positively related to incomes. The results implied that adoption of tissue culture bananas was supply driven attributed to the NGOs supporting it and it could not be sustained after the NGOs move out.

Kabunga N. et al. (2011) analyzed the yield effects of TC banana technology among smallholder farmers in Kenya, using primary survey data. In total, 385 banana farmers composed of 223 adopters and 162 non-adopters, were sampled from Meru, Embu, Kirinyaga, Kiambu, Murang'a and Thika districts since these are the main banana-growing districts where TC dissemination efforts have been ongoing for many years. Endogenous switching regression model was used. The selection equation is a binary adoption model, where farmers choose whether or not to adopt TC technology based on farm, household, and contextual characteristics:

$$\mathbf{A = Z\gamma + \mu} \quad \ldots\ldots 3.9$$

Where A is a dummy variable for TC adoption,
z is a vector of explanatory variables,
γ is a vector of parameters to be estimated,
and μ is an error term with mean zero and variance $\delta^2 \mu$

The two outcome equations are banana production functions:

$$\mathbf{y1 = X\beta_1 + \varepsilon \text{ if } A=1} \quad \ldots\ldots 3.10$$

$$\mathbf{y2 = X\beta_0 + \varepsilon_2 \text{ if } A=0} \quad \ldots\ldots 3.11$$

Where y1 and y2 are continuous variables, representing banana yield for adopters and non- adopters respectively. *X* is a vector of explanatory variables, and β_1 and β_0 are parameters to be estimated for the adopter and non-adopter regimes. ε_1 and ε_2 are the respective error terms.

From the results, increasing irrigation in TC orchards by 1% would increase yields by 0.41%, while the estimate for non-adopters is insignificant. The estimation results imply that TC bananas were probably more negatively affected by the drought than traditional bananas. Another notable difference between the two regimes is the role of farmer age. In TC bananas, age contributes significantly to higher yields (albeit at a diminishing rate), while this is not the case in traditional bananas. Age can be seen as a proxy for farmers' experience and managerial ability. TC bananas require changes in traditional crop management practices, and they are also more sensitive to the implementation and timing of certain maintenance operations. More experienced farmers seem to have an advantage in this respect.

Proper crop management also requires access to good information. This is underlined by the information constraint coefficient, which is negative and highly significant for TC adopters, but not for non-adopters. TC farmers who feel information constrained have more than 30% lower yields than their colleagues with good access to relevant information. Hence, extension and training is critical for the successful adoption of TC banana. Without sufficient technical support, the adoption experience may turn out to be negative.

Simple mean value comparisons revealed no significant difference in banana yields between adopters and non-adopters of this technology. But the regression results and related simulations have also demonstrated that the potential of TC technology has not yet been fully tapped in Kenya. In other words, the productivity effects could be higher with improved conditions. TC technology is knowledge-intensive, and it requires a change in traditional crop management practices, including higher levels of inputs, especially water. While TC adopters in Kenya use more inputs than traditional banana growers, input intensities are still very low in an international comparison, which is largely due to limited access to credit and irrigation. The results clearly show that higher irrigation intensities would lead to much higher net yield gains of TC technology. This holds true for both current adopters and non-adopters of this technology. The current study addressed the factors affecting tissue culture banana output and its impact on income in Nyamusi division. The study thus intended to determine whether tissue culture banana productivity and the resultant incomes could ensure that tissue culture bananas are sustained even after the project comes to an end.

3.2 Conceptual Framework

The study determined factors affecting output of tissue culture bananas and whether incomes of households growing tissue culture bananas were significantly different from those growing conventional bananas. Specifically it established the relationship between factors of production and household characteristics (extension services, availability of inputs, manure, land size, age, gender and education of household head) and output per acre. High frequency of extension services is essential for farmers to increase the productivity of tissue culture bananas as it helps to disseminate advice and to diagnose farmer constraints. Additionally, the greater the size of land under tissue culture bananas the higher the output. Gender of a household head affects time allocated to agricultural activities, for example women roles in African set-up is different from that of men and despite women heading households, it does not exonerate them from non-agricultural activities. This directly influences scale and intensity of farm operations**.** Educated farmers are better able to process information and search for appropriate technologies to alleviate their production constraints. The belief is that education gives farmers the ability to perceive, interpret and respond to new information much faster than their counterparts without formal education and thus improve their productivity. The relationship between age and output is two-way since older people may have higher accumulated capital, experience and more contacts with extension thus higher productivity. On the other hand, older people are sometimes thought to be less productive due to health or ageing complications.

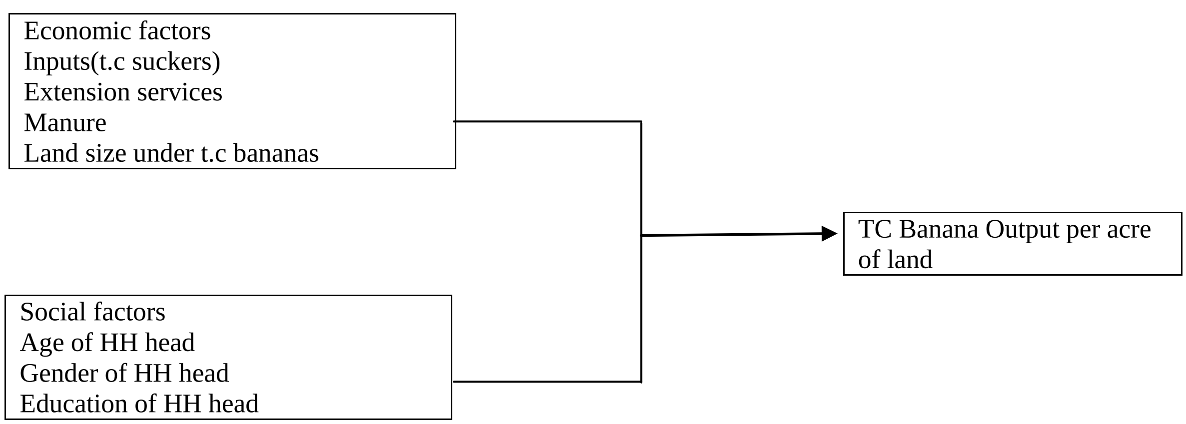

Figure 1: Conceptual framework of factors affecting tissue culture banana output.Source

Authors' conceptualization, 2012

3.3 Study Area

Nyamusi division is one of the divisions in Nyamira North district and borders Rachuonyo North to the North, Borabu to the South East, Buret to the East and Nyamira to the South West. The district covers an area of 219.3km2. Human population as at 2009 census for the district was 166,017. The district forms part of what is popularly known as "Gusii highlands" since the district's topography is hilly with Kiabonyoru hills being outstanding features. The two topographic zones in the district lie between 1,250 m and 2,100 m above the sea level. The low zones being swampy, wet lands and valley bottoms while the upper zones are dominated by the hills. On the other hand the soils found in the district are deep red volcanic nitisols with vertisols at valley bottoms and pitsols at swampy areas. The wetlands in this district are generally under threat from encroachment by farmers, brick making, and eucalyptus trees (blue gum). The district is characterized by small scale farming of food and cash crops with vast unexploited irrigation potential. Maize and beans form the major food crops followed by bananas and avocados. Major cash crops include coffee and tea. Keeping local cattle (zebu) dominate livestock practices with few exotic dairy animals and poultry farming (Kenya, 2008-2012). Nyamusi division was selected as the area of study because it has the highest production of tissue culture bananas among the seven districts considering that most farmers had planted the conventional types before SNCDP was introduced.

3.4 Research Design

The study adopted both qualitative and quantitative techniques of data collection and analysis. A correlation design was employed in the study. Correlation design collects more than one information from one characteristic and compares how they vary. The purpose is to explain how characteristics vary together and predict one from the other (Wiersma, 1995). The research examined both dependent and independent variables in order to answer questions of correlations between the factors associated with the study.

3.5 Target Population

Target population is defined as all the members of a real or hypothetical set of people, events or objects to which a researcher wishes to generalize the results of the study (Borg and Gall, 1989). The target population for the study was all beneficiaries of tissue culture bananas, numbering 4,200 in the project area in Nyamusi.

3.6 Sample Size

Sampling means selecting a given number of subjects from a defined population as representative of that population. Any statements made about the sample should also be true of the population (Orodho and Kombo, 2002). It is however agreed that the larger the sample, the smaller the sampling error. To get the sample size, the following formula was used:

$$\mathbf{n = N / [1 + Ne^2]} \quad \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{3.12}$$

Where:

n is sample size,
N is target population and
e is standard error which is usually 0.05.
Using the formula, = 4,200 / [1 + 4,200(0.05)] =366
A sample size of more than 10 or at least 30 percent is usually recommended for social sciences (Cooper and Schindler, 2006; Kotler, 2001). The study covered a sample of three hundred and sixty six (366) farmers from Nyamusi division, that is 183 tissue culture banana producers and 183 conventional banana producers.

3.7 Sampling Design

The sampling technique that was used to select the sample was the stratified systematic sampling method. There were two strata, one comprising those who produced tissue culture bananas and the other those who produced conventional bananas. A systematic sampling procedure was used to select the sample farmers. Enumerators were used to carry out the interviews. The transect walk was used to get the targeted farmers for both tissue culture and conventional banana growers. On a path, the first household on the right hand side was selected arbitrarily and the second skipped, then the third also selected thus all households with an odd number were selected. On the left hand side of a path, all households with an even number were selected.

3.8 Data Collection Procedures

The study utilized two types of data: primary and secondary data. The data collected was cross-sectional data. Data was collected by desk review of several documents including reports, surveys and published work; Focus Group discussions with different stakeholders and field visits to banana farms and hardening nurseries. A structured questionnaire was used in the study to elicit information related to farm productivity from all the selected respondents. This was considered appropriate as it tended to collect all relevant responses that would facilitate analysis and comparison of parameters.

3.9 Model Specification

Most of early empirical work in production functions used Cobb-Douglas production function (Quisumbing, 1995):

$$\mathbf{Y=\alpha_0 L^{\alpha 1} T^{\alpha 2} e^{u}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{3.13}$$

Where:

Y is output,
L is labor input (hired or family), and
T is a matrix of land, capital and other conventional inputs.
Usually, the equation is estimated by ordinary least squares (OLS) by linearizing the Cobb-Douglas production function:

$$\mathbf{LnY = \alpha_{0} + \alpha_1 lnL + \alpha_2 lnT + \beta lnE + \acute{o}Gender + \acute{\Gamma}Age + \varepsilon,} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{3.14}$$

Where Y, L and T are as defined above, E is educational attainment or variable for level of schooling, Gender is the gender of household head, and Age is the age of household head in years. The study used the value of crop production at household level as the dependent variable by multiplying the output per household by the average price per kilogram for the year 2011. The average price per kilogram of tissue culture bananas was Kshs.20 while the average price for conventional bananas was Kshs.14. The value of crop produced was found more appropriate than yields since it fits farming systems practiced in study area where more than one crop was grown. Adopting this model, factors of production; land, inputs, manure and extension services were used to estimate production function together with household characteristics (age, education and gender). From equation (3.3) above, we specify the production function as follows:

$$\mathbf{LnY = b_{0} + b_1 lnI + b_2 lnLd + b_3 lnES + b_4 ln\ M + b_5 lnE + b_6 lnGender + b_7 lnAge + \varepsilon} \qquad \ldots\ldots\ldots\ldots \mathbf{3.15}$$

Where, Y is the value of crop produced at household level, and I, Ld, ES and M represent the factors of production; source of inputs, land, extension services and manure respectively. E, Gender and Age represent the educational level, age and gender of household head. The b_0 is the intercept and b_1 to b_7 are coefficients (elasticities) of independent variables to be estimated, and ε is the error term. Table 3.1 below shows variable description and their units of measurement.

Table1: Variable Description and Measurements

Variables	Code	Unit of Measure	Description
Value of crop	Y	Kenya Shillings	Total value of household Banana output
Inputs	I	Dummy variable	0-Buying from nursery 1-Direct from project 2-From other farmers 3-Other sources
Land	Ld	Acres	Total area under banana 2011
Manure	M	Dummy variable	0-None 1-1/2 debe per stool 2-1 debe per stool 3-2 debes and above per stool
Extension services	ES	Dummy variable	0-None 1-Bi-annually 2-Quarterly 3-Monthly
Education	E	Dummy variable	0-No formal education 1-Primary not complete 2-Primary complete 3-Secondary not complete 4-Secondary complete 5-Post secondary training
Gender	GENDER	Dummy variable	Male Headed Household-1 Female Headed Household-0
Age	AGE	Years	Age of household head in

Source: Author, 2012

3.10 Data Analysis

Two methods of data analysis were used in the study namely descriptive analysis and inferential analysis. The descriptive analysis was used to describe the socio-economic characteristics of tissue-culture banana growers. It entailed utilization of tables, percentages and figures. Regression analysis on the other hand was used for inferential analysis. A Cobb-Douglas production function was used where the quantity of agricultural produce was regressed against factors of production (land, inputs, manure, extension services) and household characteristics (age, education, gender). Estimated coefficients (elasticities) were tested for level of significance in determining agricultural production. In order to assess the incomes of the two groups of households, those who produce tissue culture bananas and those who produce non-tissue bananas, t-tests of means of income to check the differences was done.

3.11 Validity and Reliability

Mugenda and Mugenda (1999) define reliability as a measure of the degree to which a research instrument yields consistent results or data after repeated trial. A pilot study enabled the researcher to assess the clarity of the questionnaire items such that those items found inadequate or vague were either discarded or modified to improve the quality of the research instrument thus increasing its reliability. The researcher formulated individual structured and unstructured questions that formed the basis for the interviews with the respondents. A clear layout of the questionnaire was established. Validity is defined as the accuracy and meaningfulness of inferences, which are based on the research results (Mugenda and Mugenda, 1999). In other words, validity is the degree to which results obtained from the analysis of the data actually represents the phenomena under study. Validity, according to Borg and Gall (1989) is the degree to which a test measures what it purports to measure. All assessments of validity are subjective opinions based on the judgment of the researcher (Wiersma, 1995). The pilot study helped to improve face validity and content of the instruments. According to Borg and Gall (1989), content validity of an instrument is improved through expert judgment; the researcher sought the assistance of her supervisors, who, as experts in research, helped improve content validity of the instrument.

RESULTS AND DISCUSSIONS

4.1 Socioeconomic Characteristics

The socioeconomic characteristics discussed include age, sex and education of household head. Age of household head ranged between 27 to 89 for tissue culture banana growers while that of conventional banana growers ranged between 24 to 80. The mean age for both tissue culture and conventional banana growers was 46; the mean difference of age was thus insignificant. Table 4.1 shows the mean of age and education level of household head.

Table 4.1: Selected Household Socioeconomic Characteristics

Variable	t.c mean	c. bananas mean	Mean difference
Age of Household head in	46	46	
Years	(0.21)	(0.22)	0
Educational level of HH	1.17	1.08	
Head	(0.47)	(0.56)	0.09

Note: Standard errors are in parenthesis.

Source: Authors' survey results, 2012

Education level of household heads (Table 4.2) ranged from no formal education (0) to post secondary education (5). About 4% and 10% of tissue culture bananas growers and conventional banana growers respectively had no formal education, while about 17% and 8% of tissue culture banana growers and conventional banana growers respectively had post secondary training.

Table 4.2: Education Level of Household Head

Code	Education level	% t.c bananas	% conventional bananas
0	No formal education	3.83	9.84
1	Primary not complete	12.57	19.13
2	Primary complete	22.95	23.50
3	Secondary not complete	18.03	26.23
4	Secondary complete	25.68	13.66
5	Post secondary training	16.94	7.65
	Total	100.00	100.00

Source: Authors' survey results, 2012.

The above results exposed the issue of growing of tissue culture bananas by those farmers who had higher literacy levels as indicated by farmers growing tissue culture bananas who had completed secondary education and post secondary education as compared to those who were growing conventional bananas. Education as a measure of human development index is a basic requirement in improvement of welfare of households since it enables information access and when some proportion of household heads were illiterate as has been observed, then one anticipates high incidences of poverty among such households due to lack of empowerment (UNDP, 2002)

4.2 Land under Bananas

Land under bananas (Table 4.3) ranged from 0-1/4 acre, >1/4-1/2 acre, >½-1 acre to above 1 acre.

Table 4.3: Land under Bananas

Code	Land size	% t.c bananas	% conventional bananas
0	$X \leq 1/4$ acre	66.12	65.03
1	$¼ < X \leq 1/2$ acre	30.05	24.59
2	$½ < X \leq 1$acre	3.28	8.59
3	Above 1 acre	0.55	1.64
	Total	100.00	100.00

Source: Authors' survey results, 2012.

Most farmers (66% and 65% tissue culture banana and conventional banana producers respectively) had small land sizes under bananas ranging between 0-1/4 acres. The issue of land size is important because land size of ¼ and above acres is what makes economic sense as revealed from the direct interviews with the project implementers. From the study thus only about 34% and 35% of farmers under tissue culture and conventional bananas respectively were able to economically benefit from the bananas they were growing. The above discussion exposed the issue of small land sizes by households which is not economically viable.

4.3 Extension Services

Extension services were very important in the study because of impacting technical know how to the farmers. The frequency of extension services (Table 4.4) ranged from None, Bi-annually, Quarterly to Monthly.

Table 4.4: Extension Services Received

Code	Frequency	% t.c bananas	% c. bananas
0	None	0.55	61.20
1	Bi-annually	25.14	35.52
2	Quarterly	62.84	3.28
3	Monthly	11.47	0.00
	Total	100.00	100.00

Source: Authors' survey results, 2012.

From the results, about 1% and 61% of tissue culture and conventional banana growers respectively did not receive extension services in the year 2011. Most farmers who had planted tissue culture bananas received extension services more regularly than those who had planted conventional bananas; those who received it bi-annually, quarterly and monthly were about 25%, 63% and 11% respectively as compared to those who had planted conventional bananas about 36%, 3% and 0% respectively. This is due to the fact that extension services were demand driven and most farmers were reluctant to seek the advice of technical officers unless when their crops were attacked by pests and diseases. Also, SNCDP paid field allowances to technical officers to follow up on the tissue culture banana growers who had been supported by the project.

4.4 Sources of Inputs

The various sources of tissue culture and conventional banana plantlets (Table 4.5) were pre-hardened nursery, direct from project, from other farmers and other sources. Through SNCDP, some tissue culture plantlets were purchased per financial year and these were given to selected farmers freely; these farmers were supposed to use their farms as bulking plots.

Table 4.5: Various Sources of Inputs

Code	Input source	% t.c bananas	% c. bananas
0	Buying from pre-hardened nursery	1.09	0.00
1	Direct from project	47.00	0.00
2	From other farmers	51.91	100.00
3	Other sources	0.00	0.00
	Total	100.00	100.00

Source: Authors' survey results, 2012.

From the results, all farmers who had planted conventional bananas got the suckers from other farmers. Most farmers who had planted tissue culture bananas got the suckers from other farmers (52%), direct from project (47%) and from pre-hardened nursery (1%). This implies the project has a major impact because what is got from other farmers is also originally from the project through a process of replication.

4.5 Manure Application

Manure application (Table 4.6) ranged from None, ½ *debe*, 1 *debe* to 2 *debes* and above per stool.

Table 4.6: Application of Manure

Code	Manure Application	% t.c bananas	% c. bananas
0	None	2.19	15.30
1	½ *debe* per stool	5.46	34.97
2	1 *debe* per stool	40.98	43.17
3	2 *debes* and above per stool	51.37	6.56
Total		100.00	100.00

Source: Authors' survey results, 2012.

From the results, about 5%, 41% and 51% of tissue culture banana growers applied ½ *debe*, 1 *debe* and 2 *debes* and above of manure per stool respectively. About 35%, 43% and 7% of conventional banana growers applied ½ *debes*, 1 *debe* and 2 *debes* and above of manure per stool respectively. Thus about 51% and 7% of tissue culture banana growers and conventional banana growers respectively applied 2 or more debes per stool of manure. This shows that tissue culture banana growers had been sensitized on the ideal manure application of 2 debes per stool and only about 2% of tissue culture banana growers did not apply manure at all compared to about 15% of conventional banana growers. This can be attributed to the higher productivity of tissue culture bananas compared to conventional bananas.

4.6 Empirical Model Results

4.6.1 Production Structure

Results from the Cobb-Douglas production function as specified in equation (3.4) are given in Table 4.7. Gross value of tissue culture and conventional bananas produced by each household during the year 2011 was used as the dependent variable. Inputs, that are source of suckers, extension services, manure and land were factors of production considered. Age, gender and education were also included as household characteristics.

Table 4.7: Household Level Estimation of Cobb-Douglas Production Function
Tissue Culture Bananas

Variables	Co-eff.	Std. Err.	t	[95% Conf. Interval]	
Source of inputs	0.003331	0.240	0.139	-0.456	0.523
Extension services	0.017*	0.302	0.056	-0.599	0.633
Land under bananas	1.861***	0.324	5.740	1.201	2.522
Manure	0.0716*	0.270	0.265	-0.0396	0.1828
Age of HH Head	0.341*	0.318	1.073	-0.306	0.988
Gender of HH Head	0.000	0.000	0.000		
Education of HH Head	-0.242	0.142	-1.701	-0.531	0.048
Constant	12.081	1.231	9.818	9.574	14.587
n	183				
R^2	0.622				
F-test	10.990				

Conventional Bananas

Variables	Co-eff.	Std. Err.	t	[95% Conf. Interval]	
Source of inputs	0.000	0.000	0.000		
Extension services	0.475***	0.280	1.696	-0.114	1.065
Land under bananas	1.217***	0.167	7.292	0.866	1.568
Manure	0.147**	0.197	0.744	-0.134	0.428
Age of HH Head	-0.007185	0.301	-0.024	-0.640	0.626
Gender of HH Head	0.000	0.000	0.000		
Education of HH Head	-0.223	0.121	-1.839	-0.477	0.032
Constant	12.179	1.188	10.249	9.683	14.676
n	183				
R^2	0.771				
F-test	11.989				

Note: Superscripts ***, **, * show statistical significance at 1%, 5% and 10% respectively.

Source: Authors' survey results, 2012

The coefficient of multiple determination indicated that more than 62% and 77% of the variations of the household level of gross value of tissue culture and conventional bananas produced were associated with factors of production specified in the model. The model was a better fit for conventional bananas than tissue culture bananas. Discussion on the various independent variables is presented in the sub-headings that follow.

4.6.2 Input Source for Production per Household

Regression results for tissue culture bananas (Table 4.7) showed that source of inputs was not statistically significant with very low elasticity of production (0.003331). This indicated that production was inelastic to changes in source of inputs. For conventional bananas, source of inputs is not statistically significant due to the fact that all conventional banana suckers were got from other farmers.

4.6.3 Extension Services

Extension services significantly and positively affects tissue culture banana production ($t=0.056$; $p<0.1$) though weakly at 0.017. On the other hand, extension services significantly and positively affects conventional banana production ($t=1.696$; $p<0.01$). Proper crop management also requires access to good information. Hence, extension is critical for the success of TC banana so that farmers can adjust crop management practices more competently to the new technology. Without sufficient technical support, the productivity effects would look much worse and this could lead to frustrating experience among farmers.

When frequency of extension services increased for example from bi-annually to quarterly, the value of production increased by 0.017% and 0.475% for tissue culture and conventional bananas respectively. This might imply that conventional banana producers benefit from extension services in farming more than conventional banana producers which further emphasized differences in production structure in the tissue culture and conventional banana production. Reasons for low elasticity of extension services in production of tissue culture bananas could be that trainings were usually done to beneficiaries of tissue culture banana suckers before they could plant thus the farmers were imparted with the technical know how to manage the suckers as got from the direct interviews with the project implementers.

4.6.4 Land

Land, the most important factor in agricultural production had the largest elasticity of all the four factors of production (inputs, extension services, manure and land) in both tissue culture and conventional banana production of 1.861 and 1.217 respectively. It was also strongly and positively significant with ($t= 5.740$; $p <0.01$) for tissue culture bananas and ($t= 7.292$; $p <0.01$) for conventional bananas. As noted in the descriptive analysis section, average land sizes are extremely too small in the study area. Thus, small changes in land size are supposed to produce significant swings in value of banana produce. It was measured in terms of area under bananas including owned and hired plots of land. The value of banana produce increased by more than 18% and 12% under tissue culture and conventional bananas respectively when area under bananas increased by 10%. The size of elasticity of land in tissue culture was higher than that of conventional bananas. This implied that when land under bananas was increased by 10%, there would be a 6% difference between production increase in tissue culture bananas and conventional bananas. This suggests that farmers growing tissue culture bananas are more likely to be land constrained than conventional banana producers and they will benefit more than conventional banana producers should land be reallocated from other enterprises. The above results further support our hypothesis of differences in value of output in the two household categories.

4.6.5 Manure

Manure positively and significantly affects tissue culture bananas ($t=0.265$; $p<0.1$) and conventional bananas ($t=0.744$; $p<0.05$) with elasticity of production of 0.0716 and 0.147 for tissue culture bananas and conventional bananas respectively. This implies that when manure increased by 10%, production increased by 0.716% and 1.47% for tissue culture bananas and conventional bananas respectively. The elasticity under conventional bananas is greater than for tissue culture bananas which imply that conventional banana growers benefit from manure in agricultural production more than tissue culture banana growers. This can be attributed to the fact that under tissue culture bananas, proper management is key for example spacing, de-suckering and pruning thus manure alone cannot lead to high productivity.

4.6.6 Human Capital

Regarding human capital variables, education of household head as measured by dummies from No formal education to Post Secondary training was expected to positively affect agricultural production. Farmers with some formal education are expected to acquire new ideas and information more successfully than those who are less educated, and thus improve their productivity. However, the coefficient of education has the contrary sign (negative) and is not statistically significant in both tissue culture and conventional banana production. It is possible that the content of formal education has little bearing on farming skills as a whole. In fact, the process of formal education orients students away from agriculture and the returns to education in off-farm work may be higher thus encouraging farmers with alternatives (educated) to take up off-farm work. Saito *et al*, (1994 pg.35-39) made similar observations and conclusions. Age, another variable of human capital which measures farmer's experience was found negative and not statistically significant in conventional bananas but positive and significant in tissue culture banana production ($t=1.073$; $p<0.1$). On conventional bananas, it means that younger farmers generally are more productive than older ones and the issue of experience does not count. Under tissue culture bananas, age is a great contributor to banana production with a high elasticity of production of (0.341). Age can be seen as a proxy for farmers' experience and managerial ability. TC bananas require changes in traditional crop management practices, and they are also more sensitive to the implementation and timing of certain maintenance operations (Vuylsteke, 1998). More experienced farmers seem to have an advantage in this respect.

4.6.7 Gender

The coefficient of the dummy variable representing gender in both tissue culture and conventional banana production suggested that gender of household head is not statistically significant in production of bananas. This is similar to previous studies in Kenya which found gender of the household head not statistically significant in determining agricultural production (Moock, 1976; Bindlish and Evenson, 1993).

4.7 Differences in Productivity and Incomes between Tissue Culture and Conventional Bananas

Productivity and incomes of TC and conventional bananas are shown by Table 4.8

Table 4.8 Differences in Productivity and Incomes between Tissue Culture and Conventional Bananas

Variable	t.c mean	conventional bananas mean
Yields (tonnes)	17.158	8.053
t-value	-4.302	
Incomes (Kshs,annual)	343,169	112,737
t-values	-13.164	

Note: Superscript * shows statistical significance at 1%

Source: Authors' computation, 2012

Mean values of output produced under tissue culture bananas (17.158 tonnes) were higher than those of conventional bananas (8.053 tonnes). Additionally, mean values of incomes of households growing tissue culture bananas (Kshs.343,169) were higher than those growing conventional bananas (Kshs.112,737). The difference in yields between tissue culture bananas and conventional bananas ($t=-4.302$, $p < 0.01$) was not statistically significant. Also difference in incomes from tissue culture bananas and conventional bananas were not statistically significant (t=-13.164, $p < 0.01$). Thus hypotheses two which says there is no statistically significant difference in incomes from tissue culture bananas and conventional bananas in Nyamusi division, should be accepted.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The objective of this study was to determine the factors influencing tissue culture banana output in Nyamusi division and to determine whether incomes of tissue culture banana growers was statistically different from those of conventional banana growers. This analysis began by a Cobb-Douglas production function analysis to determine the contribution of each of the inputs (extension services, land under bananas, manure, source of inputs, age of HH Head, gender of HH Head and education of HH Head) to banana output. This was then followed by checking statistical difference in income between tissue culture banana growers and conventional bananas growers. The mean age for both tissue culture banana growers and conventional banana growers was 46 thus the mean difference of age was insignificant. It was observed that tissue culture banana growers had attained a higher level of educational attainment than conventional banana growers with about 17% and 8% of tissue culture banana growers and conventional banana growers respectively having post-secondary training.

There were no significant variations between land size with most farmers having small land sizes under bananas ranging between 0-1/4 acre that is 66% and 65% for tissue culture and conventional banana producers respectively. Extension services varied among the households with about 1% and 61% of tissue culture and conventional banana growers respectively not receiving extension services in the year 2011. Extension services impacted technical knowhow to the farmers and enabled farmers to adjust crop management practices more competently. Manure application also varied among the households with only about 2% and 15% of tissue culture and conventional banana growers not applying manure during the year.

The Cobb Douglas production function results indicated that extension services, manure and land significantly affected production of tissue culture bananas in the study area. Production increased by 0.17%, 0.716% and 18.61% respectively as extension services, manure and land increased by 10%. Even though elasticity of extension services was low, it was significant and had the expected positive sign. Age of the household head as a measure of experience had effect on tissue culture banana production; production increased by 3.41% as age of household head increased by 10%. Under conventional banana, production increased by 4.75%, 1.47% and 12.17% respectively as extension services, manure and land increased by 10%. Regarding human capital, education had no influence on either tissue culture or conventional bananas production probably due to the fact that formal education oriented individuals away from agricultural production to off-farm opportunities where returns to education may be higher. Gender too had no effect on bananas production.

Mean values of output produced under tissue culture bananas (17.158 tonnes) were higher than those of conventional bananas (8.053 tonnes). Additionally, mean values of incomes of households growing tissue culture bananas (Kshs.343, 169) were higher than those growing conventional bananas (Kshs.112, 737).

However, there is no significant difference between productivity and the incomes of conventional and tissue culture banana producers.

5.2 Conclusions

The goal of this study was to identify the determinants of tissue culture banana production among farmers in Nyamusi and to determine whether incomes of households growing tissue culture bananas were significantly different from those growing conventional bananas. The findings indicate that households that produce tissue culture bananas realize higher production when compared to those that produce conventional bananas. Also households growing tissue culture bananas have higher incomes than those growing conventional bananas. Thus it can be concluded that tissue culture banana production in Kenya is economically worthwhile. The variables found significant and positive predictors of tissue culture productivity included frequency of extension services, manure application, land size under bananas and age of household head. The tissue culture banana technology has brought many benefits to farmers. The most important is the availability of improved, disease free planting materials. This way, the farmers can now be able to replace their degraded orchards with superior material which is early maturing (12-16 months compared to the conventional banana of 2-3 years), bigger bunch weights of more than 30 kg and a higher annual yield per unit of land (Wambugu and Kiome, 2001). This is a very significant achievement given the very small farm sizes (0-1/4acres) with a majority of the farmers. The uniformity and more simultaneous plantation development of the TC plantlets further promises easier marketing and co-ordination of the whole production process.

5.3 Recommendations

Within a given agro-ecological environment, agricultural productivity is affected by the size of land put into production, extension services offered, manure application and other inputs that are used; and by quality of these factors such as fertility of land, the experience and health of the farmer. Laws and institutional structures, public policy and social fabric of the society all affect access that farmers have to these production factors and inputs. Increasing agricultural productivity involves three sets of issues: policy issues of how to provide an enabling macro-economic environment for farmers, particularly an appropriate incentive framework; technological issues of how to increase productivity within the confines of the agro-ecological and physical environment; and organizational issues of how to improve agricultural support services to the farmer and their access to inputs. Subsidizing the cost of production through provision of affordable tissue culture banana plantlets will ensure that more farmers grow it across the country. A long side, the Government should employ more extension officers and extension visits should be intensified. On the other hand, the farmers need to be sensitized on the importance of seeking extension services regularly for technical support and use of farm yard manure which will increase productivity per unit area.

REFERENCES

Bindlish, V., and Evenson, R (1993). Evaluation of the performance of T&V extension in Kenya. World Bank Technical Paper 226, *Africa Technical Department Series*. Washington, D.C: World Bank.

Borg, W.R., Gall, M.A (1989). *Educational Research: An Introduction*, 5th Ed. New York: Longman.

Cooper, D.R and Schindler, P.S (2006). Business Research Methods. New York: Mc.

FAO (2006). STAT.http: //faostat.fao.org,.

Gallagher M., Goetz S.J., Debortin D.L (1997). Efficiency Effects of Institutional Factors: Limited Resource Farms in Northeast Argentina In: Rose R., Taner C. and Bellamy M.A.(eds) 1997. Issues in Agricultural Competitiveness: Markets and Policies Proceedings of the *22nd International Conference of Agricultural Economists,* held at Harare Zimbabwe, 22nd-29th August 1994 (IAAE Occasional Paper No.7).

Heady, E.O., and Dillon J.L (1992). Agricultural Production Functions. Iowa City, IA: IOWA University Press.

Kenya, Office of the Prime Minister and Ministry of Planning and National Development (2009). Nyamira District Development Plan 2008-2012. Nairobi: Government Printers.

Kotler, J. and John P.Kotler's (2001). Eight Steps to Successful Change.

Mbogoh, S.G, Wambugu, F.M, Sam, W (2002). Socio-economic Impact of Biotechnology Applications: Some Lessons from the Pilot Tissue- Culture (tc) Banana Production Promotion Project in Kenya, 1997- 2002. Durban, South Africa: Paper presented during the XXV IAAE Conference, August 2003.

Milu, M (2008). Smallholder Adoption and Economic Impacts of Tissue Culture Banana in Kenya. Department of Agricultural, Food and Resource Economics: Michigan State University.

Moock, P (1976). The Efficiency of Women as Farm Managers in Kenya. American Journal of Agricultural Economics 58 (5): 831-835.

Mugenda, O., and Mugenda, A (1999). Research Methods. Nairobi: ACTS press.

Olagoke, M.A (1991). Efficiency of Resources Use in Rice Production Systems in Anambra State, Nigeria in: Cherryl R.Doss and Carol Oison (Eds) 'Issues in African Rural Development. *African Rural Social Sciences Research Networks.*

Orodho, A.J., Kombo, D.K (2002). Research Methods. Nairobi: Kenyatta University, Institute of Opening Learning.

Qaim, M (1999). Assessing the Impact of Banana Biotechnology in Kenya. New York: ISAAA Briefs No. 10.

Quisumbing, A.R (1995). Gender Differences in Agricultural Productivity; A survey of Empirical Evidence, Discussion Paper No.5.Washington D.C: World Bank.

Saito, K., Mekkonen, H., and Spurling, D (1994). Raising the Productivity of Women Farmers in Sub-Saharan Africa, Discussion Paper 230. Washington, D.C: World Bank.

T. Alagumani (2005). Economic Analysis of Tissue-cultured Banana and Sucker-propagated Banana. Agricultural Economics Research Review Vol. 18 pp 81-89.

UNDP (2002). Human Development Report. Kenya: Institute of Development Studies: UoN,.

Vuylsteke, D.R (1998). Field Performance of Banana Micropropagules and Somaclones in S.M. Jain, D.S. Brar and B.S. Ahloowalia (eds.), Current Plant Science and Biotechnology in Agriculture. Dordrecht: Kluwer Academic Publishers.

Wambugu, F.M., Kiome, R.M (2001). The Benefit of Biotechnology on Small-scale Banana Producers in Kenya. Nairobi: ISAAA.

Wiersma, W (1995). Research Methods in Education: An Introduction, 6th Ed. Needham Heights, Massachussets: A Simon and Shuster Company.

Yadav, M.U., Nagure, D.V., Phuke, K.D., Kalalbandi, B.M (2005). A Comparative Study of Resource Productivities and Resource Use Efficiencies of Traditional and Tissue Culture Banana Cultivation In Parbhani District of Maharashtra State. Karnataka: J.Agric.Sci.