African Crop Science Journal, Vol. 21, No. 4, pp. 311 - 321 ISSN 1021-9730/2013 $4.00
Printed in Uganda. All rights reserved ©2013, African Crop Science Society

SOCIO-ECONOMIC FACTORS AFFECTING APPLE PRODUCTION IN SOUTH-WESTERN UGANDA

P.R. NTAKYO, J. MUGISHA[1] and G. ELEPU[1]
National Agricultural Research Organization, P. O. Box 295, Kampala, Uganda
[1]College of Agricultural and Environmental Sciences, School of Agricultural Sciences, Department of Agribusiness and Natural Resource Economics, Makerere University, P. O. Box 7062, Kampala, Uganda

Corresponding author: jomugisha@agric.mak.ac.ug

(Received 18 June, 2012; accepted 22 July, 2013)

ABSTRACT

Apple (*Malus domestica*) accounts for 50% of the world's deciduous fruit tree production. Apple, commonly known as a temperate crop, has become a gainful cash crop for the people in south-western Uganda. The objective of the study was to determine the various costs involved and how different socio-economic factors influence production in south-western Uganda. The analysis was based on data from a research institute orchard and a survey of 136 farm households. There was positive net cash flow (US$ 2,398.5) after the fourth year. Labour was the highest cost accounting for 41.8 percent of total production costs. Organic fertiliser, farmers experience and labour were the most critical factors of production. They had a positive and significant effect, explaining 63.6 percent of the variation in apple production. Organic fertiliser had the highest elasticity (0.77), followed by labour and land with 0.28 and 0.01, respectively.

Key Words: Labour, *Malus domestica*, organic fertiliser

RÉSUMÉ

La pomme (*Malus domestica*) compte pour 50% d'arbres de production mondiale de fruits caduques. Communément connu comme étant une culture à regions tempérées, la pommee est devenue une culture de rente bénéfique pour le people du sud ouest de l'Uganda. L'objectif de cette étudeétait de déterminer divers coûts impliqués et la manière dont différents facteurs socioéconomiques influencent sa production au Sud Ouest de l'Uganda. L'analyse était basée sur des données d'un institut de recherche sur le verger et des données d'enquête sur 136 ménages des fermiers. Après la quatrième année, il n'y avait pas de *cash flow* positif (US$ 2,398.5). La main d'oeuvre faisait le coût le plus élevé avec 41.8 % du coût total de production. La fumure organique, l'expérience de fermiers et la main d'oeuvre des facteurs critiques de production. Ils ont manifesté un effet positif et significatif, explicant 63.6 % de la variation dans la production de la pommee. La fumure organique avait l'élasticité la plus élevée (0.77), suivi de la main d'oeuvre et la terre avec 0.28 et 0.01, respectivement

Mots Clés: Main d'oeuvre, *Malus domestica*, fumure organique

INTRODUCTION

Apple (*Malus domestica*) accounts for 50% of the world's deciduous fruit tree production. The leading apple growing country is China, producing about 41% of the world's apples; followed by the United states, India and Turkey (USDA, 2013). In Africa the leading producer is South Africa, followed by Egypt and Kenya. Total apple production in East Africa has not had a stable trend; it increased from 16.5 tonnes in 2002 to 21.0 tonnes in 2005. Since then, production has reduced by 36.2% to 13.4 tonnes in 2011 (FAO Statistics). In Uganda, the apple industry started in 1999 when the Forestry Resources Research Institute (FORRI) and Kawanda Agricultural Research Institute (KARI) initiated trials in the highlands of south-western Uganda, with the aim of offering farmers an alternative source of income (ICRAF, 2003).

Subsequent studies indicate that apples are adapted to the highland conditions of Uganda and could be integrated into existing agroforestry systems (Turyomurugyendo *et al.*, 2004). This would offer opportunities for widening the limited range of available nutritive foods and income generating enterprises for the people living in Uganda's highlands. It is anticipated to be a major cash crop in the highlands of south-western Uganda (Kabale district).

Currently, apple production is being promoted by the Uganda government under the National Agricultural Advisory services (NAADS) programme in the highlands of Kabale, Kisoro and Kanungu districts with high altitudes (1500-2400 m above sea level) that offer a favourable climate.

Two varieties are grown, namely Anna (red) and Golden Dorset, while the common varieties on the Uganda market are Golden delicious (yellow), Fuji (red), Fugi (white) and Granny Smith (green) imported from South Africa, Kenya and China (Chemining *et al.*, 2005). The fresh apple fruits are sold in supermarkets and open markets directly to consumers. The marketing system is not well organised and post- harvest handling is still a challenge according to farmers. However, the United States Agency for International Development (USAID) preliminary economic estimates indicate that apples can be a profitable enterprise in Uganda if good farm management is practiced (Chemining *et al.*, 2005).

Promotion of apple production in Uganda raises a number of pertinent questions among farmers and researchers. For instance, what are the costs and expected returns? What are the critical socio-economic factors affecting production? What is the magnitude of the impact of these factors on output? This study, therefore, was aimed at estimating production costs and returns from apple, in addition to estimating a production function to quantify the significance of the economic relationships between apple production and the various variables that influence the quantity produced.

METHODOLOGY

A cross-sectional survey using a questionnaire was conducted in Kabale district in south-western Uganda in March and June 2007 to collect data from the previous two seasons from a sample of 136 farm households located in four sub-counties.

Multistage sampling techniques were used to select the sample. Kabale district was purposively selected because it leads in apple production in the country. From the district, leading apple growing sub-counties of Kyanamira, Bubare, Bukinda and Kamuganguzi were also purposively selected. The National Agricultural Advisory Services (NAADS) service providers for the respective sub-counties provided lists of all apple farmers from which respondents were randomly selected. Subsequently, 34 farmers were selected from each sub-county, making a total of 136 farmers. In addition, NAADS staff and National Agricultural Research Organisation scientists working directly with apple farmers were interviewed using an interview guide.

Apart from the data collected from individual household farms, production costs and output used to generate the net present value were based on production records supplied by Kachwekano Zonal Agricultural Research and Development Institute (KAZARDI), which pioneered apple growing in Uganda. Yield patterns over 15-year life of the trees were also projected based on the yields of KAZARDI orchard. Whereas apples can be productive up to 40 years, it was more realistic to consider production in the short-run. Since apple is a non-traditional crop in Uganda, its productive life period is still uncertain.

Annual production variable costs comprised of labour, fertilisers, pesticides, packaging, organic fertiliser, stakes and ropes. The fixed costs comprised of land and secateurs. The other implements such as hoes, pangas, spray pump, spades and wheel barrows were not considered because they were also used in the production of other enterprises. The cost of apple seedlings and initial land preparation was considered as capital investment at the onset of the enterprise.

All costs and returns were estimated in Uganda shillings (UGX) and converted to US Dollars (US$ 1= 1,560 UGX). To compute gross income, all fruits produced were valued at UGX 4,000 (US$ 2.56) per kg, the average price that was offered by supermarkets in Kabale and Mbarara for good quality fruits. The difference between annual gross income and annual total costs was the net cash flow. All fruits produced, irrespective of whether they were sold, were valued to compute income. Like other previous studies (Glover *et al.*, 2002), it was assumed that year six costs and yields were representative of an average mature production year. This study further assumed that maximum yield was attained in sixth year, and the average productive life of the trees would be fifteen years (Parker *et al.*, 1998; Musana and Rubaihayo, 2001).

Labour was measured in person-days, where a person-day was considered to be eight working hours. This was based on the average time hired labourers work per day in most of the study sub-counties according to survey results. Gender and age were not considered because most operations were done by adults, and the wage rate was not discriminative of gender. Farmers' experience was considered to be the number of years the farmer had spent in apple production. The quantity of organic fertiliser (goat manure) used was estimated in terms of basins weighing 15 kg and was later converted into metric tonnes per season. Apples produced were estimated in numbers and converted into kilogrammes. About twelve apples were equivalent to one kilogramme.

Excel spread sheet was used to generate means of costs and returns and net present value (NPV).

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} \text{ ...... Equation 1}$$

Where; n = number of years, t = 1, 2,…, 15, i = Discount rate; B_t = Benefits in each year; and C_t = Cost in each year.

This study used 28 and 6 percent as discount factors in computing the NPV. It was adopted from Uganda Centenary Development Bank, which provides agricultural loans at an interest rate of 28 percent. Six percent interest was given to fixed deposit, which in this case was considered to be the best low risk alternative available for off-farm investment

An econometric model was used to estimate apple production function, which was expressed as a Cobb-Douglas type production function as:

$$Y = f(X) = AX_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4},\ \beta_1 \ldots \beta_4 > 0 \text{ .... Equation 2}$$

Where Y = the quantity of apples produced (kg); X_1 = land allocated to apples (ha), X_2 = labour used for all activities in apple production (person days), X_3 = amount of organic fertiliser applied in a season (tonnes), and X_4 = the number of apple trees a farmer had.

Considering the natural logarithms of Equation 2, the production function was expressed as:

$$InY = A + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \varepsilon \text{ .... Equation 3}$$

Apart from the measurable inputs, there were other factors such as farmers' experience, education level and the number of extension visits to the farmer that were included in the model and presented as:

$$InY = A + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5 InX_5 + \beta_6 InX_6 + \beta_7 InX_7 + \varepsilon \text{ .... Equation 4}$$

Where X_5 was farmer's experience (number of years) in apple production, X_6 was the farmers level of education (number of years spent in school), X_7 was number of times an extension officer visited the farmer in a season; $\beta_1 \ldots \beta_7$ were coefficients estimated to represent the partial elasticities of output with respect to predictor variables, ε was the error term, and A was the technology parameter.

Using Weighted Least Squares techniques, the log linear function (Equation 4) was estimated to determine the factors that affect apple production. Marginal productivities were estimated to determine the returns of critical inputs in apple production. The marginal productivities were calculated as:

$$MP_{land} = \beta_1 \frac{Y}{X_1} \quad \text{.......................... Equation 5}$$

$$MP_{labour} = \beta_2 \frac{Y}{X_2} \quad \text{.......................... Equation 6}$$

$$MP_{organic\ fertiliser} = \beta_3 \frac{Y}{X_3} \quad \text{.................. Equation 7}$$

Where Y = the geometric mean of output, X_1, X_2 and X_3 = the geometric means of land, labour and organic fertiliser, respectively; and β_1, β_2 and β_3 = estimated coefficients of land, labour and organic fertiliser, respectively.

Value marginal products (VMPs) were calculated by multiplying marginal productivities by UGX 3,000, (US$ 1.16), the average cost of apples per kilogramme. Data were entered in Statistical Package for Social Scientists (SPSS version 9) to generate descriptive statistics. Econometric analysis was done using STATA to estimate a Cobb-Douglas type production function.

RESULTS AND DISCUSSION

Profitability of apple production. The cost of production for apples varied widely depending on tree density, location and management practices (Table 1). The greater the density of trees, the more labour and materials required; hence, the higher the costs involved.

At an average of 800 trees per hectare, annual total cost of production according to farmers' estimates was US$ 1,221.9 (Table 2). This was not significantly different from US$ 1,282 spent annually at the Karengyere Research Institute orchard (Table 3).

Labour costs were the highest accounting for 41.8% of the total annual production costs (Table 2). This was followed by organic fertiliser and land rent, which accounted for 27.5 and 20.9%, respectively. As earlier found by Chemning *et al.* (2005), labour and fertiliser requirements are high in apple production; thus raising the total cost of production. Consequently, farmers employ suboptimal levels of these critical resources resulting into low output and poor quality apples leading to less returns. Similar results were reported in the United States (Glover *et al.*, 2002) and China (Marchesini *et al.*, 2005).

Further analysis of annual production costs and returns showed that apple production was profitable with net returns of US$ 2,820.5 per annum (Table 3). Statistical analysis using a t-test showed that the mean yield at the Research Institute Orchard was significantly higher than that obtained by farmers ($P<0.01$). The wide variation was attributed to the difference in age of trees and management practices. The orchard at Karengyere Research Institute had reached peak production stage of 6 years, while most farmers' trees had not. However, the yields in both cases were low compared to the temperate region where 17 to 25 t ha^{-1} have been reported (Marchesini *et al.*, 2005). This could be explained by the difference in climatic conditions, specifically the winter effect on flowering, variety variations and level of management.

Returns also varied depending on fruit quality and marketing channel used by the farmers (Table 4). Those who sold apples using direct market alternatives such as neighbours and open markets received higher returns due to a higher price than those who used wholesale marketing channels

TABLE 1. Summary statistics for variable costs of apple production in south-western Uganda

Item	Minimum	Maximum	Mean	Std. Deviation
Labour (person-days)	38.1	2,533.5	511.9	0.2
Pegs (bundles)	0.2	28.5	13.1	6.8
Pesticides (kg)	0.9	316.7	62.1	66.9
Ropes (rolls)	0.6	158.3	19.3	23.6
Manure (kg)	4.1	2,533.3	335.9	448.7

TABLE 2. Production costs of apples per hectare per year in south-western Uganda

Costs	Quantities	Unit cost (US$)	Total costs (US$)	Percentage of total cost
Variable costs				
Labour (person-days)	459	1.1	511.5	41.8
Pegs (bundles)	4	0.3	12.81	1.0
[1]Pesticides (Dithane and Ridomil) (kgs)			62.1	5.1
Ropes (rolls)	12	1.6	19.2	1.6
Organic fertiliser (tonnes)	17	19.2	335.8	27.5
Total variable costs			900.0	
Fixed costs				
Secateurs (depreciation)	4	2.6	10.3	0.8
Spray pump (depreciation)	2	25.6	51.3	4.2
Hoes	6	0.6	3.8	0.3
Land rent (US$ per ha year^{-1})	1	256.5	256.5	20.9
Total fixed costs			321.9	
Total costs			1,221.9	

[1] Pesticides were purchased in small quantities and used in combination; farmers could not estimate how much of each they had used but they could estimate how much they had spent

TABLE 3. Estimated annual returns per hectare for apples in south-western Uganda

	Sample farmers	Research Institute (Karengyere Orchard)	t- test
Yield estimates (tonnes)	2.1	6.0	-16.5***
Price per tonne (US$)	1,923.1	1,923.1	
Gross returns (US$)	4,038.5	11,538.5	-16.5***
Total cost (US$)	1,221.9	1,282.1	-14.8
Net returns (US$)	2,820.5	10,256.4	-15.3***

*** significant at 5% level

such as supermarkets (Table 4). Whereas 87.5 percent of sampled farmers indicated easy access to the market, they cited lack of organised market as a limiting factor to higher returns from apples. Majority (99%) sold their fruits locally on individual basis to various customers. The challenge is that selling direct to neighbours might be feasible to only small scale growers. In contrast, wholesale markets might be appropriate for large scale and small scale growers who cannot perform direct marketing services themselves. Similar findings were reported by Parker *et al*. (1998) while investigating economics of high density apple orchard management in North Carolina, United States of America.

Cash flow projections for a one-hectare orchard with a tree density of 800, for a fifteen year production period, indicated that an apple orchard was worth US$ 53,525.6 and 307,500 per hectare at 28 and 6 percent discount factor, respectively (Table 5). Results revealed that farmers who establish a new apple orchard experience net cash outflows for the first three years, and break even in year four. From the

TABLE 4. Marketing channels used by apple farmers of south-western Uganda

Marketing channel	Proportion of farmers using the channel (%)	Price offered (US$ per kg)		
		Mean	Minimum	Maximum
Neighbours	60	3.8	2.3	3.8
Vendors	7	3.4	2.3	4.6
Open market	13	3.7	2.3	4.6
Supermarket	19	3.6	1.9	3.8
Trader from Kampala	1	3.1	3.1	3.1

cumulative cash flows, the minimum initial investment was about US$ 3,525.6 per hectare before any returns were realised.

In agreement with previous studies (Parker *et al*. 1998; Abdul and Afzal, 2005) this analysis shows positive net present values (NPVs) for 15 years production period implying that apple production is a profitable enterprise. Nevertheless, this analysis was based on apple production as a mono-crop contrary to the farmers' situation. Since different crops have different production costs and returns, the net present value and pay back period could be different if an intercrop is incorporated in the NPV equation. Furthermore, the highest cost incurred was during establishment and this was mainly the cost of seedlings; implying that with initial support, many farmers could venture into the enterprise.

Socio-economic factors. Estimates of a Cobb-Douglas type production function are presented in Table 6. Organic fertiliser had the highest input elasticity, followed by farmer's experience and labour. It follows that they are the critical variables in apple production.

The model was a good fit since it could explain 63.6 percent of variation in apple output. An increase of one percent in person-days spent on apple activities would increase output by 0.28 percent. The significance of labour ($P<0.05$) means that it is a major factor in apple production. However, the elasticity of 0.28 indicates that labour was inelastic implying that it would require a significant increase in labour to impact on output. The explanation is that apple production is labour intensive as shown by the average labour required per hectare of 459 person-days per year. As alluded to by Tresnik and Parente (2007), in a study on apple production in Europe, organic fruit production requires more labour since it involves manual operations such as weed control, defoliation and thinning. It is important that all the recommended practices namely; pruning, defoliation, training, spraying, weeding and thinning be optimised to raise output substantially.

In a related study in Washington State, Mon and Holland (2005) affirmed that organic apple production was more labour intensive than conventional production. High elasticities of labour have been reported in production of other crops such as groundnut in Malawi (Edriss and Mangisoni, 2004) where average labour required per hectare was 60 percent of the total labour required for all farm activities.

The coefficient of organic fertiliser applied in apple fields was 0.77 and was significant at one percent level. This implies that a one percent increase in organic fertiliser applied would cause a 0.8 percent increase in apple output. In agreement with Dima and Odero (1997), organic manure enhances soil fertility for sustainable production. Thus, yields continue to increase in subsequent years after application of manure. Mon and Holland (2005) reported similar findings in Washington State, in the USA where organic apple production produced higher returns to land and capital than conventional production. The significant effect of organic fertiliser is not only in fruits but also in vegetable production. In Nigeria its use significantly increased yield by 3.3 tonnes per hectare (Alimi *et al*., 2006).

Farmers' experience in apples was also significant at 5 percent level (Table 6). Its coefficient shows that it is inelastic, implying that

TABLE 5. Net present value analysis for apple production in south-western Uganda

Year	Yield (t ha^{-1})			Annual costs				
		Gross income (US$)	Labour	Fixed costs	Variable costs	Total costs (US$)	Net cash flow (US$)	Cumulative cash flow (US$)
0	0	0	86.5	2,102.6	0	2,179.5	-2,179.5	-2,179.5
1	0	0	210.9	872.4	123.1	641.0	-641.0	-2,820.5
2	0	0	145.5	322.8	219.2	705.1	-705.1	-3,525.6
3	0.3	833.3	173.7	322.8	341.0	833.3	-19.2	-3,525.6
4	1.8	4,615.4	196.8	322.8	151.9	641.0	3974.4	384.615
5	6.0	15,384.6	333.3	322.8	573.1	1,217.9	14,166.7	14,551.38
6-15	21.6	55,384.6	333.3	322.8	593.9	1,217.9	54,166.7	68,653.9-555,897.4
Total	224.1	574,679.5	4,480.1	7,493.6	7,347.4	19,294.9		
NPV at 28 % discount factor							53,525.6	
NPV at 6 % discount factor							307,500	

apple yields increase less linearly with farmers experience. Experience in apple production is a major factor, as some of the important operations such as training, defoliation, pruning and spraying require skill which is accumulated over time. These results are consistent with theory because farmers' experience is correlated with age of trees and output is expected to increase with tree maturity up to peak production at six to seven years. On the contrary, Olujenyo (2008) found a negative effect of experience on maize production which the author attributed to use of obsolete methods of farming, traditional tools and varieties.

Results further indicated that, an increase of one percent in land under apple production increased apple output by 0.01 percent (Table 6), but it was not significant. Allocating a big piece of land to apple production did not translate into significantly high production. A large area is associated with high labour input and yet labour was a constraint to most farmers. As such, specific operations were not timely carried out, thus affecting output. In addition, the spacing of trees which determines the density of the orchard varied among farmers. The mean spacing between trees was 17.8 ft with a standard deviation of 6.5, which was quite high. Farmers with large land holdings tended to use recommended spacing of 15 -18 ft which was relatively large compared with those with small land.

Another possibility could be that large orchards are associated with technical inefficiency, which is in agreement with previous studies such as Lau and Yotopolus (1971), and Kumbhakar (1994) who found that crop farms of less than 4 hectares were relatively more economically efficient.

Similarly, number of apple trees, education level of the farmer and number of extension visits were not significant. In the case of apple trees, it was expected because the trees were of different ages as depicted by the variation in farmers' experience. Most trees had not reached peak production and, therefore, their number did not cause a significant variation in output.

Farmers' formal education was not significant and this was anticipated since both the educated and non-educated farmers were trained in apple production technologies. In agreement with Walingo (2006), agricultural technologies require

TABLE 6. Estimates of the apple production function in south-western Uganda

Explanatory variables	Elasticities	Robust standard errors	t-values	p –values
Constant	3.266	0.712	4.58	0.000
In (Land area) (ha)	0.014	0.089	0.16	0.875
In (Labour) (person-days)	0.287	0.142	2.01	0.046
In (Numbers of apple trees)	0.025	0.145	0.17	0.863
In (Organic fertiliser) (tonnes per hectare)	0.774	0.116	6.37	0.000
In (Farmers' experience) (years)	0.461	0.185	2.49	0.014
In (Education of the farmer)	0.053	0.126	0.43	0.671
In (Number of extension visits)	0.132	0.129	1.03	0.307
Adj R-squared	63.62 %			
Sum of weighted deviations	3.049e+05			
Sample size (n)	136			

special training on the subject. Otherwise, the level of formal education alone cannot be used to predict the attainment of expected output though it enhances the potential of individuals. On the contrary, the effect of schooling was significant under improved technology.

The coefficient of number of extension visits was 0.13, which was highly inelastic (Table 6). This is attributed to the system used by National Agricultural Advisory Services (NAADS) service providers, where farmers are trained in groups other than individual visits. In this respect, it was recognised that the number of trainings attended by the farmer could have yielded more meaningful results in terms of explaining the relationship between extension services and output in production. Nonetheless, the importance of visiting individual orchards should not be minimised. Alene and Manyong (2006) reported that regular contact with extension staff at individual farm level plays a great role in raising the productivity of improved technologies. For instance, individual inefficiency and diseases that affect production are easily identified.

It is evident from Table 6 that production elasticities for all inputs were below unity, implying that increasing the respective inputs by one percent would increase apple output by less than one percent. Conversely, the return to scale parameter was 1.71 indicating increasing returns to scale. Farmers were still operating in irrational stage I of the production function, where the inputs employed were not efficiently utilised. Similar findings were reported by Ainembabazi *et al*. (2005) in sorghum production, Gowa *et al.* (2001), and Paris and Caputo (2004) in clonal coffee, and Ogundari and Ojo (2007) in food crops. This means that efficient utilisation of inputs through better management options will be key to increasing output in apple production.

Marginal productivity and marginal value products. The marginal productivities and their respective value marginal products (VMPs) are presented in Table 7. All marginal productivities were positive, thus exhibiting the production function property of monotonicity (Chambers, 1988). The input with the highest marginal productivity was organic fertiliser, followed by labour and land. The marginal value product of labour was US$ 0.8 which was below the average labour wage rate of US$ 1.0.

This suggests that it was not advisable to increase labour in apple production. This could be attributed to higher wages relative to apple fruit prices (Table 4). In addition, most farmers' trees had not attained optimum production, thus depicting low labour productivity. In a related study, Bagamba *et al*. (2007) found that in Uganda, labour in banana in low altitude areas had low marginal returns due to higher wages relative to prices of banana. Similarly, Okoboi (2010) reported low labour productivity in maize in western Uganda.

The marginal value product for land was equally very low compared to the unit cost of

TABLE 7. Estimates of marginal productivities (MP) and marginal value products (VMP) of major inputs in apple production

Variable	Geometric mean	Elasticities	Unit input cost (US$)	MP	VMP (US$)
Labour	2.65	0.287	1.10	0.433	0.80
Land	2.23	0.014	259.10	0.025	0.05
Organic fertiliser	1.12	0.774	21.00	2.758	5.30
Output		3.990			

land (Table 7), an indication that it was not worth increasing land under apple production beyond the current acreage in the short run. This was due to the fact that the average productivity of land under apples was still low since the apple trees had not reached peak production. It could also be attributed to overestimation of land under apple production since the plots were not physically measured. Low land productivity could also be attributed to allocative inefficiency of other inputs. As Okoboi (2010) argues, households with small land holdings and low incomes use less of most inputs and obtain lower land productivity. These results suggest that farmers should consider the economic advantage of improving small orchard management as a means to meet increased demands for apples other than increasing on acreage. Adoption of labour saving technologies, particularly in weeding and defoliation, should be the option for increasing returns from apples by a significant reduction of production costs

Results further indicate that, it was not cost effective to add more organic fertiliser beyond the current rates since its marginal value product was also below its marginal input cost. However, this could be due to the fact that some of the trees were still in a growing stage and had not reached peak production. It could also be explained by limited knowledge of how much manure to use as reported by the farmers, thus leading to over-utilisation. Its bulkiness is another factor that could lead to high costs per unit of organic fertiliser and hence low marginal productivity. This is consistent with previous studies which reported low marginal returns to investment in organic fertiliser in crop production in Uganda (Nkonya *et al*., 2005).

CONCLUSION

Apple production in south-western Uganda is a profitable enterprise as depicted by positive returns and NPV. The major limiting factors in production are labour, organic fertiliser and experience of the farmer. Apple production is still in its infancy as depicted by increasing returns to scale. Marginal value productivities of land, labour and organic fertiliser are lower than their marginal factor costs suggesting that it is not worth increasing their quantities in apple production.

REFERENCES

Abdul, R. and Afzal, M. 2005. Returns on apple orchads. DAWN group of Newspapers. www.dawn.com/2005/09/12/ebr6.htm.

Ainembabazi, J., Bashaasha, B., Mugisha, J. Pender, J. and Hyuha, T.S. 2005. Technological change in sorghum production in Eastern Uganda. *African Crop Science Conference Proceedings* 7:947 -954.

Alene, D.A. and Manyong, V. M. 2006. The effects of education on agricultural productivity under traditional and improved technology in northern Nigeria: An endogenous switching regression analysis. *Empirical economics* 32:141-159.

Alimi, T., Ojewole, O.C., Olubode-Awosolo, O. and Idowu, E.O. 2006. Economic rationale of commercial organic fertiliser technology in vegetable production in Osun State of Nigeria. *Journal of applied Horticulture* 8 (2): 159 -164.

Bagamba, F., Burger, K., Ruben, R. and Kuyvenhoven, A. 2007. Market access, agricultural productivity and allocative efficiency in the banana sector of Uganda. In: sustainable poverty reduction in Less favoured areas. Problems, options and strategies. CAB International. pp. 301.

Chambers, G.R. 1988.Applied production analysis: A dual approach. Excerpt, University of Maryland, Cambridge University Press. New York, USA.

Chemining, G., Mulagoli, I., Mwonga, S., Ndubi, J., Tum, J. and Turyamureba, G. 2005. Kabale Apples: Boom or Bust? A study to develop strategies to exploit market opportunities for apple farmers in Kabale, Uganda. Working Document Series 125.

Davis, B., Reardon, T., Stamoulis, K. and Winters, P. 2002. Promoting farm/non-farm linkages for rural development. Case studies from Africa and Latin America, Food and Agricultural Organisations of the United Nations Rome, Italy. p. 206.

Dima, S.J. and Odero, A. N. 1997. Organic farming for sustainable agricultural production. A brief theoretical review and Preliminary empirical Evidence. *Environmental and resource Economics* 10(2): 177-188.

Edriss, A. and Mangison, J. 2004. Socio-economic factors influencing the adoption of CG7 Groundnut Technology in Malawi. *Eastern Africa Journal of Rural Development* 20 (1): 12-21.

Gowa, A. K., Bashasha, B. and Tayebwa, B. 2001. Determination of optimal levels of resource use in clonal robusta coffee production in central Uganda. *Eastern Africa Journal of Rural Development* 17 (1): 1-8.

Glover, J., Hinman, H., Reganold, J. and Andrews, P. 2002. A cost of production analysis of conventional, integrated and organic apple production systems. Agricultural Research Center publication, Washington State University, USA. XB1041.

Griesbach, J. 2007. Growing temperate fruit trees in Kenya. World Agroforestry Centre, Nairobi, Kenya. ISBN: 9290592184, 9789290592181

ICRAF. 2003. International Centre for Research in Agro-forestry. Temperate fruits go tropical: Apples, peaches, pear and plums take to the hills of Uganda. ICRAF, Nairobi, Kenya.

Kalirajan, P.K. and Shand, R. T. 2002. Types of education and agricultural productivity: A quantitative analysis of Tamil Nadu rice farming. *The Journal of Development Studies* 232-243.

Kumbhakar, C. S. 1994. Efficiency estimation in a profit maximising model using flexible production function. *Agricultural Economics* 10:143-152.

Lau, J. L. and Yotopoulos, P. A. 1971. A test for relative efficiency and application to Indian agriculture. *The American Economic Review* 61 (1): 94-109.

Lokina, B.R. 2004. Production technology and the role of skipper skills in Lake Victoria fisheries. Department of Economics, Goteborg University, Goteborg, Sweden. A thesis book

Marchesini, S., Hasimu, H. and Canavaria, M. 2005. Production costs of pears and apples in Xinjiang (China). Department of Agricultural Economics and Enginering of the Alma Mater Studiorum-University of Bolgina, China. Working paper DEIAgraWP-05-003

Mon, P.N. and Holland, D.W. 2005. Organic apple production in Washington State: An input-output analysis. Washington State University, WA 99164, USA. *Renewable Agriculture and Food Systems* 21(2):134-141.

Musana, M.S. and Rubaihayo, E.B. 2001. Agriculture in Uganda Volume II. Crops, NARO. Fountain Publishers / CTA/NARO. Kampala, Uganda. pp. 532 -555.

Nkonya, E., Pender, J., Kaizzi, C., Kato, E. and Mugarura, S. 2005. Policy options for increasing crop productivity and reducing soil nutrient depletion and poverty in Uganda. Iternational food Policy Research Institute (IFPRI). Environment and Production Technical Discussion paper No. 134.

Ogundari, K. and Ojo, S. 2007. Economic efficiency of small scale food crop production in Nigeria: a stochastic frontier approach. *Journal of Social Sciences* 14(2): 123-130.

Okoboi, G. 2010. Improved input use and productivity in Uganda's maize sub-sector. Economic Policy and Research Center. Research series No. 69. Kampala, Uganda.

Olujenyo, F.O. 2008. The determinants of agricultural production and profitability in

Akako Land, Ondo-State, Nigeria. *Journal of Social Sciences* 4(1):37 -41.

Paris, Q. and Caputo, R. M. 2004. A primal-dual estimator of production and cost functions with an error-in-variables context. Agricultural and resource economics working paper No. 04-008, Department of Agricultural and Resource Economics, University of Carifornia, Davis, USA.

Parker, L.M., Unrath, C.R., Safley, C. and Lockwood, D. 1998. High density apple orchard management. North Carolina Sate University College of Agriculture and Life Sciences. North Carolina Cooperative Extension Service. AG-581, USA.

Tresnik, S. and Parente, S. 2007. State of the art of integrated crop management and organic systems in Europe, with particular reference to pest management. Apple production. Pesticides Action Network (PAN) Europe. EC2A 4JX London, United Kingdom.

Turyomurugyendo, L., Boffa, J.M. and Hakiza, J.J. 2004. Introduction of deciduous fruit tree growing in the tropical highlands of Kabale, Uganda. *Uganda Journal of Agricultural Sciences* 9: 470 - 480.

UBOS, 2006. Uganda Bureau of Statistics. Uganda National household Survey 2005/2006. Report on Socio Eonomic Module, Uganda Bureau of Statistics, Ministry of Trade and Industry, Kampala, Uganda.

United States Department of Agriculture Foreign Agricultural Service, 2013. Fresh deciduous fruit (apples, grapes and pears): World Markets and Trade. A study report by USDA, USA.

Walingo, M. 2006. The role of education in agricultural projects for food security and poverty reduction in Kenya. *Journal of international Review of Education* 52 (3-2): 287-304.

Weir, S. 1999. The effects of education on farmer productivity in rural Ethiopia. Centre for the study of African economies, Working Paper No.WPS/99-7. Department of Economics, University of Oxford, United Kingdom.

Wordofa, D. 2004. Poverty reduction policy responses to gender and social diversity in Uganda. *Gender and Development* 12 (1): 68 - 74.