Asian Journal of Agricultural Sciences 6(2): 54-61, 2014
DOI:10.19026/ajas.6.5303
ISSN: 2041-3882; e-ISSN: 2041-3890
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Submitted: September 24, 2013 Accepted: October 10, 2013 Published: March 25, 2014

Research Article

Comparison of the Profitability of Small-scale Greenhouse and Open-field Tomato Production Systems in Nakuru-North District, Kenya

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Abstract: Tomato (*Lycopersicon esculentum* Mill) is among the most important vegetables grown in Kenya. Its popularity as a commercial crop is on the rise compared to other cash crops like coffee, due to declining land sizes as it can be grown on small-scale. It is mainly grown in the open-field, but the prevalence of greenhouse tomato growing is also noteworthy. Greenhouse tomato production is less susceptible to diseases and weather conditions. However, the uptake of the greenhouse tomato growing technology has been wanting, with the cost of greenhouse installation and maintenance being quoted as the key impediment. But studies in other places have revealed that in the long run, when entire costs and returns are taken into account, use of the technology is economically viable. Using survey data from 216 tomato producers, this study compared the profitability of greenhouse and open-field tomato production systems in Nakuru-North district. The study used Gross margin and Net Profit to determine and compare the profitability levels for both greenhouse and open-field tomato production systems. The results indicate that the mean net profit/m^2 for greenhouse tomato was more than 10 times higher than that of open-field tomato production system. The study therefore, recommends promotion of greenhouse tomato production for improved smallholder livelihoods.

Keywords: Greenhouse tomato growing, gross margin, net profit, open-field tomato growing, profitability, small-scale farmer

INTRODUCTION

Tomato is an important commercial vegetable crop in Kenya, with a potential for increasing incomes in rural areas, improving living standards and creating employment (Ssejjemba, 2008). It can also be a source of foreign exchange. In Nakuru-North district, tomato is one of the major vegetable crops, in terms of acreage where it is largely grown in the open-field. This production system is prone to the adverse effects of weather like floods, drought, diseases and pests. Consequently, the average tomato yield in the district is 15 tons/ha (GoK, 2007), a performance far below the national production level of 30.7 tons/ha (GoK, 2009). To increase tomato productivity in the district, there is need for adoption of improved and sustainable production technologies that are not only profitable, but also responsive to the changing climatic conditions. In addition, due to increased land fragmentation owing to increased human population, farmers will be required to utilize their land and water resources more efficiently for maximum productivity. The sub-sector's role can only be aptly realized through the adoption of not only the sub-sector's high production technology but also one that is profitable.

While choosing a production system for adoption, various factors like costs, returns and availability of information, among others, are considered by farmers. The adoption of either greenhouse or open-field tomato production systems, which have varying production costs and return levels is therefore guided by such considerations for either of the systems, as they have an implication on their economic performance. Information on the profitability of the two systems in Nakuru-North district is however, quite limited and variable. This is what necessitated this study.

MATERIALS AND METHODS

Area of study: The study was carried out in Nakuru-North district. It is one of the districts that make up Nakuru County and one of the major tomato producing areas in Kenya (Ssejjemba, 2008). The district occupies an estimated area of 647 km^2, has an estimated human population of 20,200 farm families (GoK, 2007) and has two divisions namely Bahati and Dundori. The district's Agro-ecological zones include: Upper

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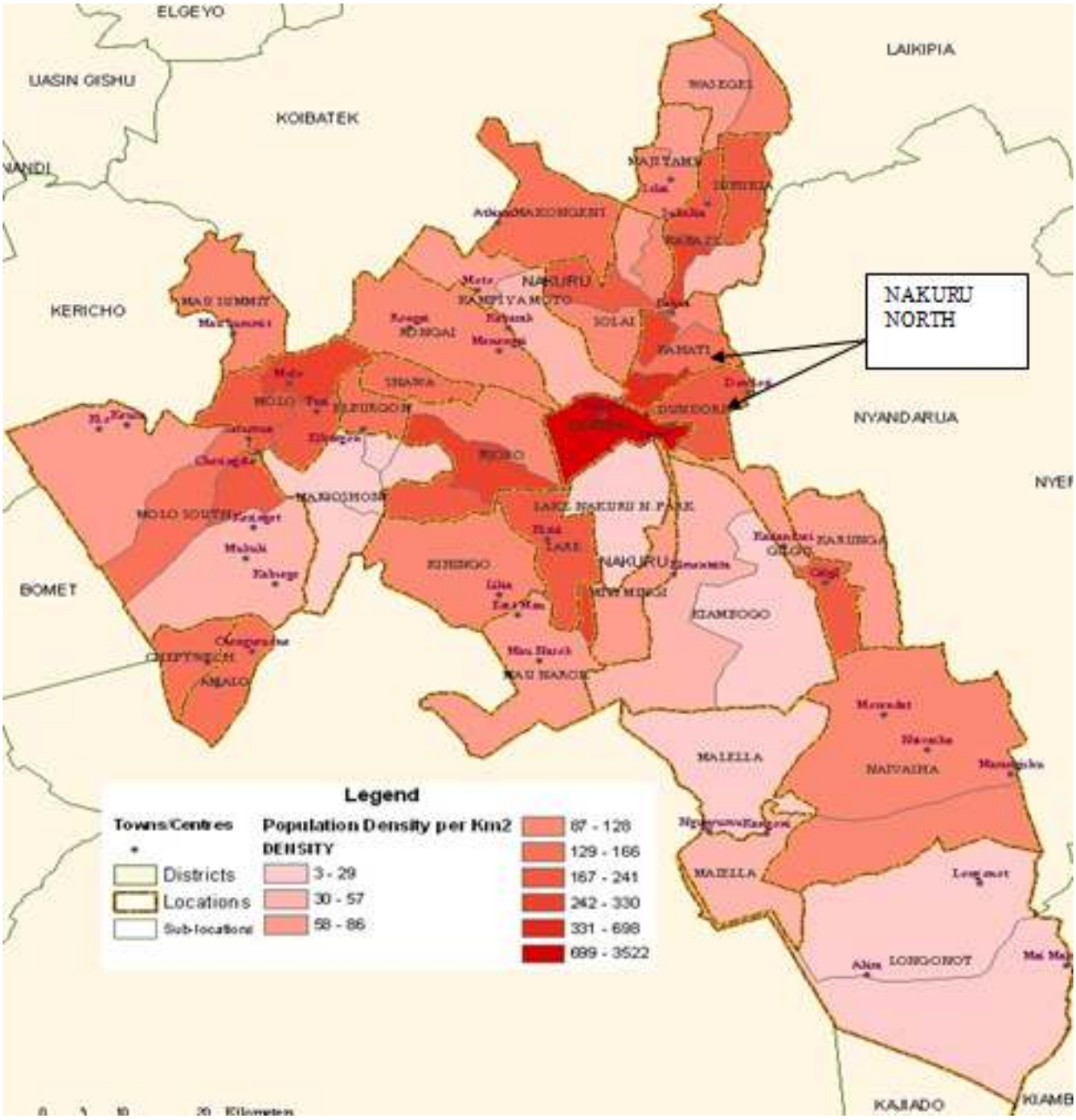

Fig. 1: Nakuru county map (Nakuru District Strategic Plan (2005-2010))

Highlands-1 (UH1), Lower Highlands-2 (LH2), Lower Highlands-3 (LH3), Upper Midlands-3 (UM3) and Upper Midlands-4 (UM4) and has an average rainfall of between 800 and 1,600 mm/annum. It lies at an altitude of between 1,700 and 2,500 m above sea level. Figure 1 is a map of the study area.

Sampling design and sample size: The study used multistage sampling technique, which started with purposive sampling of Nakuru North district as the study area. Both Bahati and Dundori divisions were covered during the study. The target population included all the small-scale tomato farmers. The unit of research was the farm household. The sampling frame consisted of two strata: -the first being those farmers practising open-field tomato production system; and the second being famers growing greenhouse tomatoes. Farmers interviewed from the open-field tomato growers' stratum farmers were randomly selected. For the greenhouse tomato stratum, as the expected number of farmers was small, a census survey was done.

Since this was a disproportionate stratified sampling design, it was deemed necessary to carry out data weighting so as to make the sample be representative of its population. Data weighting involved computation of weighting factors that were

obtained as the population proportion of the stratum divided by the sample proportion of the number of farmers in that stratum (Deaton, 1997; Johnson, 2008; Van Turnhout *et al*., 2008) and determined as:

Weight factor = (% in population/ % in sample)

For the open-field stratum, a sample size of 120 randomly selected farmers was used. This was a sample size that had been used in many previous similar studies like by Desta (2003), Jamala *et al*. (2011) and Shinde *et al*. (2009). Since the greenhouse sub-population census realized a total of 96 farmers, there was a resultant of 216 farmers for the entire study. The study mainly used primary data that were gathered from respondents with the help of structured interview schedules which were administered by enumerators.

Empirical model: Gross margin and Net Profit analyses were used to determine and compare the profitability levels for both greenhouse and open-field tomato production systems. The gross margins were calculated by subtracting total variable costs from gross revenue as:

$$GM_i = TR_i - TVC_i \quad (1)$$

where,
GM = Gross margin
TR = Total (Gross) Revenue
TVC = Total variable costs

(For i = 1, 2) either the open-field or the greenhouse system.

Net profits were calculated by subtracting total production costs from gross (total) revenue as:

$$\pi_i = TR_i - TC_i \quad (2)$$

where,
π = Net profit
TR = Total revenue
TC = Total cost

Gross (total) revenue was calculated by multiplying stated tomato price by quantity of tomato yield as reported by the respondents. The only direct and measurable revenue was obtained from the production of tomato. Quantity of production included total amount of tomato output and was either, marketed, consumed at household level, or gifted out. The value of tomato consumed at household level or gifted out was determined by assuming that it would have been sold at the prevailing price. The study used current season's (2010/2011) prices and labour costs.

Variable costs comprised of inputs and labour costs at production, harvesting and marketing stages. Such inputs included seeds/seedlings, fertilizers, chemicals and water. Labour costs consisted of greenhouse construction, nursery work, land preparation, planting, watering, weeding, training, pruning, de-suckering, harvesting, sorting, packing, transportation and marketing. In the case of family labour, the opportunity cost concept was applied where average wage levels in the locality was adopted.

The main fixed costs were: interest on total initial investment costs, interest on total variable costs, depreciation and administrative costs. Land was assumed to be owned by the farmer and not rented, although cost of land renting was established and treated as a fixed cost where land hiring was the case. Interest on investment and variable costs was calculated by charging a simple interest rate of 1.63%, which was the average annual saving deposits interest rate for commercial banks in 2010, according to Kenya National Bureau of Statistics (2011). Administrative costs were estimated as 3% of total variable costs. This method has been applied in most previous studies (Engindeniz and Tuzel, 2006) that involved economic analysis of agricultural enterprises. Depreciation was estimated using the straight-line method. A 10% allowance or salvage value was taken from the assets' initial cost and then divided by the assets expected economic life, to determine the depreciation (Chaudhary, 2006). In our study, depreciation for greenhouse structures and equipments was calculated using Eq. (3):

Depreciation = (Purchase Price - Salvage Value) /Number of Years of Life (3)

Gross margin per meter squared and net profit per meter squared were then calculated by dividing gross margin and net profit by the area in meters squared, respectively. In addition, a t-test was carried out to determine the statistical difference of computed gross margins and net profits per meter squared between the open-field and greenhouse tomato growers.

LITERATURE REVIEW

Greenhouse tomato growing: The tomato sub-sector is among the rapidly evolving sub-sectors worldwide (Odame *et al*., 2008), due to increasing population, decreasing land sizes and changing climatic conditions. Consequently, various tomato production technologies have been developed to ensure adequate supply, good quality and the achievement of various farmers' objectives. Growing of tomatoes in greenhouses is one such technology. Estimated tomato yields and corresponding costs of different sizes and types of greenhouses have been documented by Odame (2009).

The national average tomato yield in Kenya is 30.7 tons/ha (GoK, 2009). One greenhouse plant has a potential of giving up to 15 kg at first harvest, going up

to 60 kg by the time it has completed its full cycle mostly in 1 year (Makunike, 2007). Farmers can get 10 times more yield with greenhouse production system than with the open-field system of production (Seminis-Kenya, 2007).

Profitability and economic analysis of technologies: Profitability is the perception that a crop would reward the producer with surplus income and it is often considered as the basis for a viable business (Lukanu *et al*., 2009). In economic analysis, profitability is a relative term derived from profit, where profit is total revenue minus total costs (Lipsey, 1975). Total costs, can be classified into variable costs and fixed costs.

Variable costs are those associated with production including all inputs like labour, fertilizer, pesticide, seed-seedling, transport, among others (Engindeniz, 2007). To determine variable costs, market input prices and labour costs are used.

Fixed costs are costs that don't vary with production and they include administrative costs, interest on total initial investment costs, annual initial investment costs, interest on total variable costs and land rent (Engindeniz and Gül, 2009). Administrative costs have been estimated to be 2-7% of total gross production value or 3-7% of total costs (Kiral *et al*., 1999). Besides, in their respective studies, Engindeniz (2002, 2007), Engindeniz and Tuzel (2006) and Engindeniz and Gül (2009) estimated administrative costs to be 3% of variable costs.

According to Chaudhary (2006), interest is defined as a sum paid for the use of capital and is calculated in terms of a rate or percentage. Various interest rates have been used in past economic analysis studies to calculate interest as a component of fixed costs. For example, Engindeniz (2007) used 6%, Engindeniz (2002) used 14%, Engindeniz and Gül (2009) used 12%, while Engindeniz and Tuzel (2006) used 11% as the interest rate charged on total variable costs and total initial investment costs. These interest rates were justified by the annual saving deposits interest rates on US$.

Depreciation, also considered as a fixed cost, is defined as the loss in value of an asset over time, mainly as a result of obsolescence (Chaudhary, 2006). In computing depreciation, a 10% allowance or salvage value is deducted from the purchase price of assets before dividing by their estimated economic life in years (Chaudhary, 2006).

Gross margins have been calculated by subtracting total variable costs from gross revenue (FAO, 1985) and specified as:

$$GM_i = TR_i - TVC_i \quad (4)$$

where,

GM = Gross margin
TR = Total (gross) revenue
TVC = Total variable costs

The net profit has been calculated by subtracting total production costs from gross (total) revenue (Lipsey, 1975) and expressed as:

$$\pi_i = TR_i - TC_i \quad (5)$$

where,

π = Net profit
TR = Total revenue
TC = Total cost

Although gross margin has been used as a proxy for profitability in many studies, because it provides an estimate of the returns of a particular enterprise, it however, has the weakness of using only the variable costs, thus not including fixed costs and capital costs like equipments and buildings, capital interests and depreciation (Sullivan and Greer, 2002). To calculate profitability and productivity of greenhouse tomato production, Bayramoglu *et al*. (2010) used Gross margins per hectare combined with Net Incomes in a comparative analysis between certified and uncertified greenhouse tomato producers. In their study, the gross margin was calculated as Gross Product Value (GPV) minus Variable Costs. The Farm Net Income from tomato production was calculated as Gross Product Value (GPV) minus production costs. The t-test was used to determine significant differences in mean values of variables across the producer groups. Their findings showed that certified tomato producers had a higher net income per unit area compared to uncertified tomato producers.

RESULTS AND DISCUSSION

Socio-economic characteristics of tomato growers: This section starts with results on the socio-economic characteristics, followed by results on the profitability analysis using gross margins and net profits of the open-field and greenhouse tomato growers.

The results show that a high percentage of tomato farmers were falling in the 40-50 years age bracket. It implies that tomato farming in the study area was mainly a middle-aged farmers' activity. No statistically significant difference was observed in age between the open-field and greenhouse farmers. Table 1 summarizes the age comparison results for the tomato farmers.

Table 2 summarizes results on gender, access to credit and land tenure characteristics of the producers. Gender was not found to be significantly different between the two systems as shown by the Chi-square value. However, over 80% of tomato growers were males while the rest were females. Within the two tomato production systems, very similar results were obtained, with only 17.6 and 1% of the tomato growers

Table 1: Age comparison of the tomato farmers

Age of household head		Open-field	Greenhouse	Total	Chi-square value	Sig.
20-30 years	Number	12	0	12	3.959	0.555
	% within stratum	5.8%	0.0%	5.6%		
	% of sample	5.6%	0.0%	5.6%		
30-40 years	Number	52	1	53		
	% within stratum	25.2%	11.1%	24.7%		
	% of sample	24.2%	0.5%	24.7%		
40-50 years	Number	79	5	84		
	% within stratum	38.3%	55.6%	39.1%		
	% of sample	36.7%	2.3%	39.1%		
50-60 years	Number	34	1	35		
	% within stratum	16.5%	11.1%	16.3%		
	% of sample	15.8%	0.5%	16.3%		
60-70 years	Number	19	2	21		
	% within stratum	9.2%	22.2%	9.8%		
	% of sample	8.8%	0.9%	9.8%		
Above 70 years	Number	10	0	10		
	% within stratum	4.9%	0.0%	4.7%		
	% of sample	4.7%	0.0%	4.7%		
Total	Number	206	9	215		
	% within stratum	100.0%	100.0%	100.0%		
	% of sample	95.8%	4.2%	100.0%		
		95.8%	4.2%	100.0%		

Survey data (2011); The small discrepancy in totals is as a result of SPSS rounding off the decimals to the nearest integer due to weights

Table 2: Gender, credit and land tenure analysis of the farmers

Socio-economic characteristic		Open-field	Greenhouse	Total	Chi^2	Sig.
Gender of farmers						
Females	Number	38	2	40	0.085	0.770
	% within stratum	18.4%	22.2%	18.5%		
	% of total	17.6%	0.9%	18.5%		
Males	Number	169	7	176		
	% within stratum	81.6%	77.8%	81.5%		
	% of total	78.2%	3.2%	81.5%		
Total	Number	207	9	216		
	% within stratum	100.0%	100.0%	100.0%		
	% of total	95.8%	4.2%	100.0%		
Applied for credit						
No	Number	148	7	155	0.168	0.682
	% within stratum	71.5%	77.8%	71.8%		
	% of total	68.5%	3.2%	71.8%		
Yes	Number	59	2	61		
	% within stratum	28.5%	22.2%	28.2%		
	% of total	27.3%	0.9%	28.2%		
Total	Number	207	9	216		
	% within stratum	100.0%	100.0%	100.0%		
	% of total	95.8%	4.2%	100.0%		
Land tenure						
Without title	Number	45	0	45	2.471	0.116
	%	21.7%	0.0%	20.8%		
With title	Number	162	9	171		
	%	78.3%	100.0%	79.2%		
Total	Number	207	9	216		
	%	100.0%	100.0%	100.0%		

Survey data (2011); The small discrepancy in totals is as a result of SPSS rounding off the decimals to the nearest integer due to weights

being females for open-field and greenhouse tomatoes systems, respectively. This implies that tomato farming was predominantly a male activity. For access to credit, only 28.2% of tomato growers who had indicated interest in credit use while the rest 71.8% did not apply. In addition, more open-field growers applied for credit compared to greenhouse tomato growers at 28.5 and 22.2%, respectively. However, access to credit was not observed to be statistically different between the producer groups. The results suggest that, the tomato growers relied more on other sources of income like farm income than credit.

With regard to land tenure, 79.2% of the farmers owned the land and had title-deeds. Within the tomato production systems, 100% of greenhouse tomato farmers owned the land and had title deeds compared to 78.3% in the case open-field system farmers. Although results show that the difference in land tenure between

Table 3: Comparison of other farmers' socio-economic characteristics

	Type of farmer							
	Open-field			Green house				
Characteristic	Mean	Min.	Max.	Mean	Min.	Max.	t-ratio	Sig.
Farm size (m^2)	7917.08	450	28,000	7072.50	500	64,000	0.333	0.747
Tomato land size (m^2)	2384.79	225	18,000	256.41	60	1216	11.230	0.000
Household size	5.43	1	12	5.21	2	11	0.299	0.772
Education level (years)	11.20	0	16	13.06	8	16	-3.210	0.009
Experience (years)	11.57	2	40	6.47	1	31	2.303	0.046
Market distance (km)	13.05	0.5	32	12.36	0.5	30	0.230	0.823
Extension (number)	1.92	0.5	18	3.79	0.5	36	-1.040	0.327
Income (KES)	188,591.67	9,000	680,000	345,920.83	17,000	1,070,000	-1.760	0.099

Survey data (2011); Min.: Minimum; Max.: Maximum

the farmers of both systems was not statistically significant, there is the implication that greenhouse tomato growing was only practicable on owned land.

Table 3 shows results of a comparison of other socio-economic characteristics between the open-field and greenhouse small-scale tomato farmers. It was observed that the average farm size was 7917.08 m^2 (1.96 acres) and 7072.50 m^2 (1.75 acres) for open-field and greenhouse farmers, respectively. The mean tomato land was 2,384.79 m^2 (0.59 acres) and 256.41 m^2 (0.063 acres) for open-field and greenhouse farmers, respectively. Although farm sizes were not found to be significantly different, the tomato land sizes between the two groups of producers were found to be statistically different at 1% significance level. These results indicate that the land sizes would not be a key barrier towards the uptake of greenhouse tomato technology.

The average household size was 5.43 and 5.21 for open-field and greenhouse farmers, respectively and no statistical significant difference existed in terms of the household sizes between the two tomato growing systems. The results indicated that greenhouse tomato farmers were significantly more educated ($p = 0.009$) than open-field producers. The open-field tomato growers had a mean of 11.20 years of education (equivalent of secondary school) compared to 13.06 years of education (equivalent of diploma/certificate college level) attained by the greenhouse tomato farmers.

The mean number of farming years of experience was 11.57 and 6.47 years for open-field and greenhouse farmers, respectively. This implies that open-field farmers had more years of farming than greenhouse tomato producers. The difference in experiences between the two groups was significantly different at 5% level of significance. The distance to the tomato market was 13.05 and 12.36 km for open-field and greenhouse farmers, respectively. However, the difference in market distances between the two groups of tomato growers was not statistically significant.

In the year 2010, the number of extension contacts received either from the government, research or non-governmental institutions were 1.92 and 3.79 for open-field and greenhouse farmers, respectively. The numbers of extension contacts were, however, not found to be statistically different between the two groups of tomato growers.

The results showed that greenhouse tomato farmers had a higher level of income with a mean annual total income of KES 345,920.83 against KES 188,591.67 for the open-field tomato growers. In addition, the two income levels were statistically different at 10% level of significance.

Comparing the profitability of greenhouse and open-field tomato production: The results on the profitability analysis are shown in Table 4. Results of this study revealed that the mean variable costs as KES 9.16/m^2 for open-field production system and KES 134.94/m^2 for the greenhouse systems. The fixed costs averaged KES 1.93/m^2 and KES 119.23/m^2 for open-field and greenhouse systems respectively, while the mean total costs were KES 11.09/m^2 and KES 254.18/m^2 for open-field and greenhouse systems, respectively. The differences between the total costs were statistically significant at 1% significance level. These results imply that, greenhouse tomato production system was more costly and requiring more working capital compared to the open-field tomato production system.

The mean gross margins were KES 14.92/m^2 and KES 288.34/m^2 for the open-field and greenhouse tomato production systems, respectively. The differences between the gross margins were statistically significant at 5% significance level. The results indicate that although both production systems had varying levels of variable costs, returns were high enough to offset those costs associated with production. The mean net profit was KES 12.99/m^2 and KES 169.11/m^2 for open-field and greenhouse tomato, respectively. The differences between the net profits for the two systems were statistically significant at 10% significance level. These results reveal that, the net profit for greenhouse tomato growers was thirteen times higher that of their open-field counterparts. On top, the results show that both systems were able to recover all the total

Table 4: Profitability analysis of the tomato production systems

Parameter	Type of farmer	Mean	S.D.	Min.	Max.	t-ratio	Sig.
Yield (kg/m^2)	Open-field	0.95	0.5840	0.00	3.46	-4.144	0.003
	Greenhouse	10.53	6.9890	0.33	29.13		
Average price (KES/kg)	Open-field	26.02	12.2670	0.00	62.50	-3.039	0.015
	Greenhouse	41.78	15.4730	15.63	75.00		
Total variable costs	Open-field	9.16	5.4110	2.84	50.56	-5.442	0.001
(KES/m^2)	Greenhouse	134.94	69.9380	15.08	314.50		
Gross margin (KES/m^2)	Open-field	14.92	14.3760	-12.92	56.77	-3.067	0.015
	Greenhouse	288.34	269.7860	-23.30	1143.83		
Fixed costs (KES/m^2)	Open-field	1.93	2.8710	0.20	28.92	-6.417	0.000
	Greenhouse	119.23	55.3170	12.85	344.53		
Total costs (KES/m^2)	Open-field	11.09	7.8597	3.32	79.48	-6.864	0.000
	Greenhouse	254.18	107.1630	27.93	540.79		
Net profit (KES/m^2)	Open-field	12.99	14.6920	-36.81	49.50	-1.864	0.099
	Greenhouse	169.11	253.4110	-134.97	917.54		

Survey data (2011); S.D.: Standard deviation; Min.: Minimum; Max.: Maximum

production costs in terms of variable as well as fixed costs. These results are consistent with various past studies. The tomato greenhouse system has been shown to have a higher profitability than the open-field system as shown by the private and social profits and is more efficient which compensates its extra costs (Atiya, 2006).

CONCLUSION AND RECOMMENDATIONS

This study's results show that greenhouse tomato production technology is more profitable than open-field production system. The results further revealed that tomato farming in the study area was practised mainly by middle-aged farmers who were predominately males. Farmers involved in tomato production showed little interest in credit use.

The implication of these findings is that since greenhouse tomato production is more profitable than open-field production, this study recommends that the system should be promoted since its increased production would contribute greatly in boosting the farmers' income. In addition it would play a key role in alleviating poverty as well as increasing employment opportunities and especially for the middle-aged persons. Increased tomato production could also indirectly enhance the food security situation since the accruing income may be used to acquire food. Moreover, it has a potential for diversifying sources of foreign earnings through exportation. It is also worth noting that greenhouse tomato farming is coupled with other advantages including being more climate change friendly.

Following these results, the study suggests the need for further research to establish reasons as to why tomato growing is predominantly a males' activity and why greenhouse tomato growers indicated less interest on credit use. Further research is also suggested on how consumers' preferences as regards to tomatoes grown in the greenhouse compare to those grown in the open-field and how this may influence on the adoption of greenhouse tomato production. In addition, a value chain analysis study is suggested as it could open up more avenues for improving the performance of this important sub-sector.

ACKNOWLEDGMENT

Authors wish to express special thanks to Collaborative Masters of Agricultural and Applied Economics/Africa Economic Research Consortium, for funding the study. Our other thanks go to the Egerton University, the host institution for the study and the enumerators, Ministry of Agriculture staff and the tomato farmers for their contribution during the data collection exercise.

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