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Analysis of the factors affecting farm-level output of mangoes among small-scale farmers in Mwala Sub-County, Kenya

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Abstract The factors affecting farm-level output of mangoes among small-scale farmers in Mwala Sub-County, Kenya were examined. The first stage of regression analysis resulted that family and hired labour, amount of pesticides and manure had positively significant affected on mango farm-level output. The results on the second stage of the factor affecting mango output was household size, farming income, area allocated to mango farming (farm size), amount of credit, and extension contacts which exhibited positively affected on mango output, while cost of pesticides and manure precipitated had negatively affected. The study recommended that relevant authorities should strengthen the extension contact for encouraging farmers to practice the best and recommended management practices on mango farming to improve production. Furthermore, small-scale mango farmers accessed to functional input markets would enhance farm-level mango output.

Keywords: Mango production, Small-scale farmers, Regression Model

Introduction

Mango is the second most important fruit in the tropics and subtropics after banana. It is commercially grown in more than 90 countries worldwide and consumed in both fresh and processed forms (Mujuka *et al*., 2020). Globally, India is the largest producer of mango, accounting for 50% of the total output. Kenya is among the leading producers of mangoes in Africa (United States Agency for International Development, 2018). Mango production has targeted for fresh fruit markets and the processing industry. Additionally, flavor and high nutritional value is placed it in a great position as a source of income to farmers, international markets and traders (Bundi *et al*., 2020).

Diversification into horticultural produce has become more attractive to small-scale rural farmers across the globe. Due to worldwide production of fruits has faster grown with a total value of horticultural crops which is traded at present more than double that of cereals (Mariyono, 2020). As a result, farmers involved in horticultural production are usually earned much higher farm income, and per capita income for five times higher than cereal producers (Ayalew, 2015). Mango tree has been classified as a permanent

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horticultural crop which is occupied the field for a long period without replanted for several years after each harvest (Horticultural Crop Directorate, 2018). Despite, its potential has not fully exploited due to constraints such as pest and diseases, poor agronomic practices and glut during peak seasons.

In Kenya, the area under mango cultivation has been increasing over the years to 46,364 hectares (Ha) in 2017 and 49,098 Ha in 2018, respectively (Horticultural Crop Directorate, 2018). Statistics from the Ministry of Agriculture Livestock and Fisheries, (2018) indicated that mango cultivation is contributed approximately 5% of the Agricultural Gross Domestic Products (GDP) and 2% of the national GDP, employing a significant number of the seasonal labour force. Kenya is dominated by two types of mango varieties; the local and the exotic or improved varieties (Githiomi *et al*., 2019). The latter is usually grafted on local mangoes and grown for consumption and processing. Most of the local varieties are tended to high fibre content which made them unpopular for processing. In addition, the local varieties grow naturally without much application of modern production technologies. Research on mango production in Kenya has concentrated on varietal introduction of high yielding varieties which have differed in qualities that suitable for either fresh consumption or processing (Gichungi *et al*., 2020). Despite the adoption of these mango varieties by small-scale farmers, the farm-level output is declined (MoALF, 2018), and the factors leading to this remain unknown.

Mango farming is faced by numerous challenges ranging from lack of clean planting materials, poor agronomic practices to price fluctuations which leading to low harvest and resulting to food security and low income for the small-scale farmers. In Machakos County, the ecological conditions are suitable for good growth and development of mango tree, however the production in the area is under-utilized with only 5,593 (Ha) (MoALF, 2018). The county has also experienced in a lack of improved mango varieties and advanced cultural management. Hence, production of mangoes for domestic consumption and market supply are low. Therefore, failure to address these problems would lead to loss of livelihoods, enhanced poverty and food insecurity in the area. The study focused on identifying the factors that affected farm-level output of mangoes among small-scale farmers in Machakos County.

Materials and methods

The study was carried out in Mwala Sub-County, Machakos County, Kenya (Figure 1). The Sub-County is located on latitude 0°45′S and longitude 36°45′E. It covers an area of 1,047km^2 and has a population of 181, 896 (Kenya Bureau of Statistics, 2019). The rainfall pattern is bimodal, with the long rains occurring between March to May, while short rains are

received between October and November. The average annual rainfall ranges between 500 to 1300 mm per annum while temperatures range between 18 ̊C to 25.7 ̊C (Government of Kenya, 2018). These conditions are suitable for mango farming.

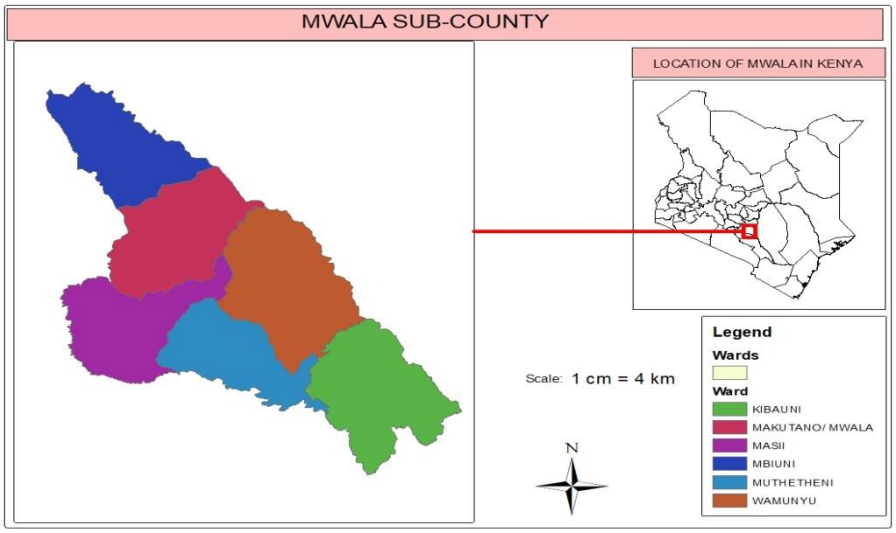

Figure 1. Map of the study area

Two-stage stratified sampling was applied to collect data from 352 mango-farming households in Mwala Sub-County. Firstly, purposive sampling was used to select the six major mango producing wards in Sub-County (Mbiuni, Makutano/Mwala, Masii, Muthetheni, Wamunyu, and Kibauni). Secondly, a location was randomly selected from each of the six wards for the purpose of the study. Further, a sub-location was then selected from each location and finally a village was selected from each sub-location. Probability proportionate to size technique was used to obtain the number of mango farming households to be interviewed in each village. In this case, in every village the total number of mango-farming households was obtained and divided by the total number of households in the selected villages then multiplied by the sample size (Table 1).

Table 1. Summary of mango farming households interviewed

Wards	Location	Sub-location	Village	No.of farmers	Sample size
Kibauni	Ikalasaa	Kamuthwa	Kyeni	47	39
Makutano	Mwala	Mathunthini	Misuuni	70	59
Mbiuni	Mbiuni	Kabaa	Kabaa	53	44
Masii	Masii	Mbaani	Kawaa	109	91
Muthetheni	Miu	Kikulumi	Makulumu	78	65
Wamunyu	Wamunyu	Kaitha	Kaitha	65	54
Total	6	6	6	422	352

Source: Ministry of Agriculture Livestock and Fisheries (2018)

The quantitative relationship between the selected factors and the level of mango output were based on production theory. In economics, this theory explains the technical relationship between the inputs used and output obtained. According Daniel and Afofum (2019), a production function represents the relationship between the resources used and the output obtained. The general production equation adopted is shown in equation 1.

$Y = f(X) = AX_1\beta_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4, \beta_1 \ldots \beta_4 > 0$…….....……1

Where Y is the quantity of mangoes produced (kgs); X_1 is the active family labour (man-days), X_2 is hired labour (man-days), X_3 is the amount of manure applied (kgs) and X_4 is the amount of pesticides applied (litres).

Considering the natural logarithm of the above equation, the production function was expressed as;

$\ln Y = A + \beta_1 \ln X_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \varepsilon$…….....……2

Apart from the above measurable inputs used in mango production, there were other factors that influenced the amount of output obtained and were included in the model and presented as;

$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 \ldots + \beta_n \ln X_n + \alpha_1 z_1 + \cdots \alpha_1 z_n + \varepsilon$…....3

Where Y is the amount of mango output, β_0 is the vertical intercept, $X_1\ to\ X_n$ represents the inputs used. $\beta_1\ to \beta_n$ are the multiplier effect or input coefficient. α_1 is the marginal effect or coefficient and shows the elasticity of production and $z_1\ to\ z_n$ are the selected factors. ln is natural logarithm and ε is the composite error term.

Results

Descriptive statistics of the sampled respondents

The farm and farmers' characteristics indicated that majority (73%) of the mango farming households were male (Table 2). The mean age of household head was 57.82 years indicating that mango farming activities in the study area were highly practiced by elders. In addition, the average household size was 6. On average, the number of years spent in school by the respondents was 10. These farmers experience in mango farming was 16.66 years and they owned an average land of 1.29 Ha, devoted for mango production. Their mean income derived from mango farming was USD 232.72 per month. Moreover, they had contacted with extension officers twice a year. Farmers in the study area grew four mango varieties that included Apple, Tommy, Kent and Van dyke varieties but majority (80%) of them grew the Apple Variety.

Table 2. Descriptive statistics

Variables	Mean	Std. Dev
Gender (1=male, 0=female)	0.73	0.02
Age (years)	57.82	11.65
Household size	6.00	1.65
Education (years)	10.00	2.29
Farming experience(yrs)	16.66	9.09
Total farm size (hectares)	1.29	0.55
Household income (USD)	232.72	110.56
Extension contact (visits)	2.00	1.20
Quantity produced (kgs)	3011.20	1833.50
Mango varieties (Yes)		
Apple	0.80	0.12
Tommy	0.56	0.47
Kent	0.29	0.46
Van dyke	0.10	0.30

I USD Dollars= 110 Kenyan Shillings

The stochastic Cobb-Douglas maximum likelihood estimates regression analysis

The regression analysis was done using Cobb-Douglas production function model. Results showed the effects of input application on mango farm-level output (Table 3). The results showed that active family labour and hired labour had positively significant affected on mango output at 5% level of significance. The results also indicated that an increase in family and hired labour by one man-day increased the mango output by 0.1272 and 0.0860 units respectively. The results further indicated that the amount of pesticide and manure applied had positively significant influenced on mango output at 1% level of significance. It was observed that an increase in the amount of pesticide and manure used in mango farming increased the amount of output by a factor of 0.1818 and 0.0684 units respectively.

Table 3. Effect of input application on mango output

Variable		Coef.	Std. Err.	Z	P-value
Constant	β_0	6.8241	0.1331	1.2800	0.0000
Family labour	β_1	0.1272	0.0650	1.9600	0.0500**
Hired labour	β_2	0.0860	0.0390	2.2100	0.0270**
Pesticides(litres)	β_3	0.1818	0.0236	7.6900	0.0000***
Manure (Kgs)	β_4	0.0684	0.0118	5.7900	0.0000***
Log-likelihood		-221.3531			
Wald chi2(4)		276.1900			
Lambda		6.4092	0.0403	158.8800	0.0000
Sigma squared σ^2		0.0600			0.0000

Factors affecting farm-level output of mangoes among small-scale farmers

Results showed the effects of the selected factors on mango farm-level output (Table 4). After the model estimation, multicollinearity test was done among the independent variables. Multicollinearity problem arised due to a strong linear relationship among the independent variables, which made it difficult to identify their effects on the dependent Multicollinearity occurred when the variance inflation factor (VIF) of the explanatory variable exceeded 10 or less than one. In this study, none of the explanatory variables had VIF values of less than 1 or greater than 10, implying absence of multicollinearity problem (Table 4). The value of R-square was 0.862, signifying that the expounding variables explained about 86% of the total variations in the mango output while the remaining 14% may due to uncontrollable factors in the model.

Table 4. Factors affecting mango farm-level output among small-scale farmers

Variable	Parameter	Coef.	Std. Err.	Z	P-value	VIF
Gender(1=male,0=female)	α_1	-0.0748	0.0809	-0.9200	0.3550	1.09
Household age(years)	α_2	0.5410	0.3386	1.6000	0.1100	4.13
Household size	α_3	0.3875	0.1807	2.1400	0.0320**	2.29
Level of education (years)	α_4	0.3161	0.2329	1.3600	0.1750	3.05
Mango farming income	α_5	0.1851	0.0639	2.9000	0.0040***	1.04
Annual household income	α_6	0.0625	0.0301	2.0700	0.0780	1.53
Farm size (Ha)	α_7	0.9170	0.1664	5.5100	0.0000***	2.15
Amount of credit used	α_8	0.1191	0.0405	2.9400	0.0030***	1.24
Cost of pesticides	α_9	-0.1888	0.0607	-3.1100	0.1220	5.95
Cost of manure	α_{10}	-0.0934	0.0333	-2.8000	0.0050***	6.07
Extension contact(visits)	α_{11}	0.4726	0.0911	5.1900	0.0000***	1.05
Constant	α_0	-5.5208	1.8275	-3.0200	0.0030	

The results indicated that household size had positively affected and significantly influenced the level of mango output at 5% level. The results revealed that an increase in household size by one person increased the amount of mango output by 0.3875 units. In addition, an increase in the

amount of mango farming income by one unit increased the farm-level output by 0.1851 units. The area of land allocated to mango farming activities by the farmers (farm size) that had a positive effect on the amount of output obtained. The results also showed that an increase in farm size by one acre increases the amount of mango output by 0.9170 units.

The amount of credit allocated to the mango farming activities had positively significantly affected on the amount of output. The results indicated that an increase in the amount of credit by one-unit increased mango farm-level output by 0.1191 units. As expected, an increase in the cost of pesticides and manure decreased the mango farm-level output by a factor of 0.1888 and 0.0934 units respectively. Besides, extension contact had positively significant affected on mango output at 1%. The results thus indicated that an increase in the extension contact by one visit increased the amount of mango output by 0.4726 units.

Discussion

The family and hired labour had positively significant affected on mango farm-level output. The credible explanation in mango farming involved labour intensive activities and requires extensive management practices; hence, it requires available and active labour. This is collaborated with the findings of Dessale (2018), Kloss and Petrick (2018), Ombuki, (2018) that increased in labour by one-man day was positively influenced agricultural produce among smallholder farmers. The amount of pesticide and manure used in mango farming exhibited positively affected on mango produce. Majority of farmers in the study area were applied farm yard manure for better-quality produce and increased production by improving soil fertility while pesticides used to control pest and diseases which destroyed mango fruits. Similarly, Ntakayo *et al.* (2016) found that both organic fertilizer (manure) and chemical fertilizer applied in apple and mango production influenced the amount of output among the small-scale farmers.

The household size was determined family labour which required to carry out mango farming and management activities, which in turn surges the output level. Similarly, Abubakar and Sule (2019) found that the size of household influenced the agricultural output among small-scale farmers. In the contrary, Muyanga and Jayne (2019) established that the larger household size, higher the competition of resource resulting to land fragmentation., hence, reducing the quantity of output in agricultural sector. The income obtained through mango farming determined the farmer's proficiency to access imperative resources which was crucial in agricultural production. It showed positively affected on mango farm-level output. The income obtained from horticultural fruits such as mangoes that precipitated

a positively affected on the amount of output among small-scale farmers (Alam *et al*., 2017).

Farm size had positively affected on the amount of output which obtained by the farmers. Farmers in the study area were considered mango farming as an income generating activities and allocated more land to the enterprise. In addition, farmers considered mango as an essential commercial crop and interested to increase the area under mango for high yield varieties. Similarily, Alam *et al.* (2017) indicated that farm size had affected on mango output among small-scale farmers. In the contrary, holding all other factors constant, studies projected that small farm size were more efficient and effective to manage by the poor resource constrained farmers compared to large ones resulting to inverse relationship between farm size and amount of output (Desiere, 2016; Daudi and Omotayo, 2018). However, for the case of the perennial crops like mangoes, it is not concerned in applicable as they occupied large space and farmers would require large bigger land that can take more trees in order to increase yield.

The credit is used by the farmer in mango farming that affected on the level of output. The amount of credit accessed is considered as a crucial in financing of agricultural based inputs which necessary increased the chances for higher levels of output. Similarly, access to agricultural credits is boosted the ability of small-scale farmers to secure agricultural farm inputs and enabled the farmers to increase the level of agricultural output (Mohammed *et al*. 2016; Udoka *et al*. 2016).

As expected the cost of pesticides and manure are exhibited negatively significantly affected on mango output. The information obtained from the farmers revealed that the cost of pestcides were higher and beyond their capacitiy to access. This is contributed to enormous destruction of mango fruits by fruit-fly insect leading to declining farm-level output. Mrema (2017) found that small-scale farmers experienced a lot of challeges in purchasing agricultural inputs such as chemical pestcides due to their high cost which contributed to reduce agricultural output. In addition, the cost of manure had negatively affected on mango farm-level output. Furthermore, the cost associated with manure had high cost for the farmers without livestock and contributed to decline soil fertility. Other studies have shown that an increase in the cost of organic fertilizer (manure) reduced the amount of agricultural output (Tun *et al*., 2020).

The number of extension contact had positively significant affected on mango farm-level output. Extension contact is an important aspect in agricultural production because it enables small-scale farmers to adopt the improved production practice. Contrary, Ntakayo *et al.* (2016) established that the number of extension contact had no significant effect on agricultural production among small-scale farmers. The reason was the farmers did not

appropriately apply the modern production technologies which is trained by the extension officers.

The study concluded that family and hired labour, amount of pesticides and manure had positively significant affected on mango farm-level output. In addition, household size, farming income, area allocated to mango farming (farm size), amount of credit, and extension contacts exhibited positive effect on mango output, while cost of pesticides and manure precipitated a negative effect. The study recommended that relevant authorities must strengthen the extension contact with mango farmers so as to encourage them to practice the best and recommended management practices on mango farming for improved production. Furthermore, small-scale mango farmers are encouraged to access functional input markets as this enhanced farm-level mango output.

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