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THE EFFECTS OF FERTILIZER SUBSIDY ON COFFEE PRODUCTION – AN EMPIRICAL ANALYSIS

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ABSTRACT: Coffee production plays a key role in Kenya's economy. It contributes to foreign exchange earnings, food security, household income and employment creation. Coffee is a major cash crop in many countries, and ranked third in Kenya after tea and horticulture. Coffee productivity has been declining partly due to various reasons such as low use of inputs, poor cooperatives management, and market problems. In the literature, loss of soil fertility is considered a major cause of declining coffee productivity, hence the need for planned replenishment of the depleted soil nutrients. High prices of retail fertilizer limit its use by farmers and governments has addressed the challenge by introducing fertilizer subsidy program since 2006. The program targets increased production of coffee and other crops through accessibility of cheaper fertilizer input. Despite the intervention policies, coffee productivity remains low in Mukurwe-ini sub-county. The study sought to determine the effects of fertilizer subsidy on coffee production in Mukurwe-ini sub-county. Non-experimental research design was be used where stratified random sample provided data for the study using questionnaires. The multiple regression analysis was applied to analyze the data. The results showed that fertilizer subsidy has a significant influence on coffee production. An increase in one 50kg bag of subsidized fertilizer would result to 0.191074 Kgs increase in coffee yields per bush. Most of the farmers using 1, 2 and 3 50Kgs bags of subsidized fertilizer, were harvesting 2, 3 and 4 Kgs per coffee bush respectively. This showed that increasing the amount of subsidized fertilizer used resulted to an increase in coffee yields per bush. This research concluded that fertilizer subsidy significantly determines coffee production. Therefore, the results provide some empirical ground for the collective political will of the Kenyan government through the Ministry of Agriculture to unlock the agricultural economic and social potentials through increasing subsidized fertilizers.

KEYWORDS: fertilizer subsidy, coffee production, yields, coffee farming, subsidized fertilizer
JEL CLASSIFICATION: M2, Q1, Q18, D1, D13
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1. INTRODUCTION

In the agricultural sector, coffee is a significant crop that helps developing nations achieve food security, sustainable economic growth, and poverty reduction (Obisesan, Akinlade & Fajimi, 2013). It provides a significant portion of the income for both small and large scale farmers in Kenya. Of

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all the coffee produced in Africa, Kenya produces approximately 5% of the total (MOA, 2016). According to (MOA, 2010) more than 160,000 hectares of Kenya's land is under coffee plantations. The major regions in which coffee farming is practiced include Central Kenya, Eastern Kenya, Coastal Kenya, Western Kenya, and the Nyanza region (Mwangome, 2011). However, coffee productivity has been declining in Africa, as well as in Kenya, for the past 20 years, which has led to, gradual decline in income, and resulting increase poverty rates (Akpan, Udoh & Nkanta, 2012).

Due to the continued crop's diminishing productivity and revenues, most Kenyan farmers have stopped growing coffee in order to pursue other lucrative ventures like dairy, horticulture, and farming. As well, Kenya's coffee industry has been struggling with both internal and external issues, which has resulted in decreased production (Peter & Rotich, 2013). The ineffective management of cooperatives, theft, unfavorable weather, soil deterioration, expensive fertilizers, the prevalence of diseases, and a lack of money are some of the internal obstacles and challenges experienced by the sector. High worldwide quality requirements, intense rivalry, and collapsing international prices are some of the external difficulties (Dorward & Chirwa, 2012).

Among the major reasons for the decline in coffee production is decline in soil fertility. Soil fertility is a significant internal barrier in this in coffee production (Dzung, Dzung & Khanh, 2013). The degradation of the land brought on by the loss of soil fertility is a significant barrier to increased productivity. The main input used to replace soil nutrients and increase agricultural output is fertilizer. It is provided to coffee farmers through a fertilizer subsidy scheme with the aim of increasing coffee production, and raining farmers' income (Dorward & Chirwa, 2012).

Coffee is a perennial crop, and in its initial two to three years of growth, exhausts the nutrients in the soil. To increase coffee production, continuous soil replenishment through the application of organic and/or inorganic fertilizers is necessary. However, the majority of small-scale coffee farmers are unable to pay the expensive fertilizer needed to restore the soil's fertility level (Mureithi, 2008).

The goal of Kenya's fertilizer subsidy program is to provide fertilizer to coffee farmers at a lower cost price than the market price (Mwangome, 2011). The distribution of the subsidized fertilizer is majorly carried out through cooperative associations and co-operatives for coffee farmers. To control the efficiency of coffee production, marketing, and the supply of essential inputs like fertilizers, pesticides, finance, and extension services, the coffee industry has traditionally been organized into cooperatives (Ministry of Cooperative Development and Marketing, 2011). The government distributes the cheap fertilizer through these cooperatives where the member farmers can access it.

It is anticipated that small-scale coffee producers, who produce 75% of the world's coffee, benefits from subsidized fertilizer and hence improve coffee production and output. However, coffee production has continued to decline in Kenya over time, despite the adoption of the fertilizer subsidy project since year 2006. The country's production is still below its potential. Coffee farming is the primary industry regarded as the most significant source of income for households in Mukurwe-ini sub-county. Despite the adoption of a program for fertilizer subsidies in the region, coffee production is still low, with low revenue and high levels of poverty. The issues facing the coffee industry have been attributed to a variety of factors, although it is unclear whether the fertilizer subsidy has had any impact on coffee production. Bearing this in mind, this research is focused on investigating the effects of fertilizer subsidy on coffee production, under a case study in Mukurwe-ini, Nyeri County, Kenya.

2. REVIEW OF THE LITERATURE

In Kenya, the coffee industry is divided into two structures, small-scale farming, and large-scale farming. About 75.5 percent of the land used for growing coffee is in small-scale, where the farmers are organized in cooperatives, while 24.5 percent is used by large-scale plantations (Van-Rijsbergen, *et al.,* 2016). Despite the dominance of small-scale coffee farming, just 48% of the country's overall coffee production comes from them (Republic of Kenya 2009; Gathura, 2013). Low productivity per coffee bush and decreased overall yield are two major challenges that smallholder coffee producers must contend with. In 2009, the large-scale or corporate sector's average yield per hectare was only one-third that of the large-scale or estate sector (Ministry of Agriculture, 2009). About 160,000 hectares of arable land in Kenya are planted with coffee. The High Plateaus, the areas surrounding Mount Kenya, the Aberdare Ranges, and a small portion of the Rift Valley and Nyanza region are the primary coffee-growing locations.

Kenyan coffee production has faced a number of difficulties over the years. These difficulties include a lack of finance availability, high fertilizer costs, cooperative management issues, declining coffee prices, and statutory deductions estimated at 12.8% of the auction price (Van-Rijsbergen, *et al.,* 2016). Due to rising agricultural input costs, the price of coffee has soared (Ruben & Hoebink, 2015). Over 130,000 metric tons of coffee were produced in 1989; in 2016, only over 45 metric tons were produced. The trend of Kenyan coffee production from 1961 to 2017 is seen in Figure 1.

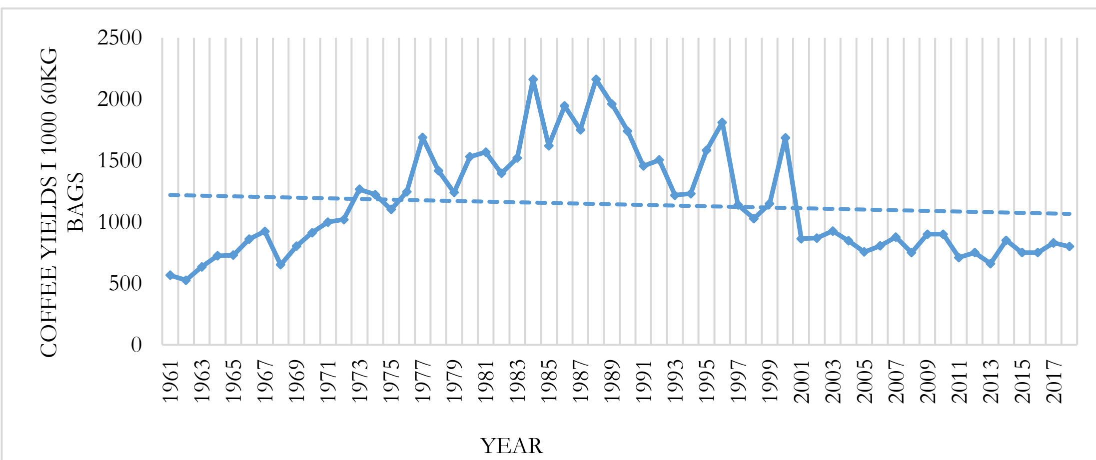

Figure 1. Coffee production and growth rate from 1961 to 2016 in Kenya

Source: Ministry of Agriculture, Livestock and Fisheries (2016).

The chart above shows that the growth in coffee production from 1961 to 1988 was increasing over time. This was before Kenya liberalized its coffee industry. In 1988, it peaked at 130,000mt overall. The production thereafter began to drop, as the chart indicates, up to date. Even though the nation's coffee production experienced a peak in 1996 and 2000 at 108,935mt and 101,412mt, respectively, the production has since dropped and as of 2016 the coffee production was just 45,000mt. After the liberalization of the coffee industry, production of coffee began to fall (Bichanga & Kabaka, 2013). The reason for this was that the amount of money paid to farmers was reduced as a result of the liberalization (Thuku, *et al.*, 2013).

Considering the area under study, the primary cash crop in the region and the main source of income for the rural inhabitants is coffee. The majority of coffee cultivation is done on a modest scale, with each household owning an average of 1.5 acres of coffee-growing land. Since the beginning of the coffee crisis in the 1980s, Mukurwe-ini coffee growers have suffered economically, resulting in declining living standards, increasing levels of poverty, and socioeconomic difficulties (Andrew & James, 2002).

Coffee and tea are the two main revenue crops in Nyeri County. Unlike areas like Othaya and Tetu and Mathira sub-counties, where tea and coffee production are combined, Mukurwe-ini farmers depend primarily on coffee farming as a source of income. Since independence, coffee farming has been practiced in Mukurwe-ini as the primary source of revenue, accounting for more than half of the county's total coffee production (Bichanga & Kabaka, 2013). Despite its low production, coffee was considered to be the most significant crop in the area for both income and food security. Over the past few decades, there has been a steady fall in the region's coffee production. The Mukurwe-ini sub-coffee county's output trend between 1997 and 2017 is depicted in Figure 2.

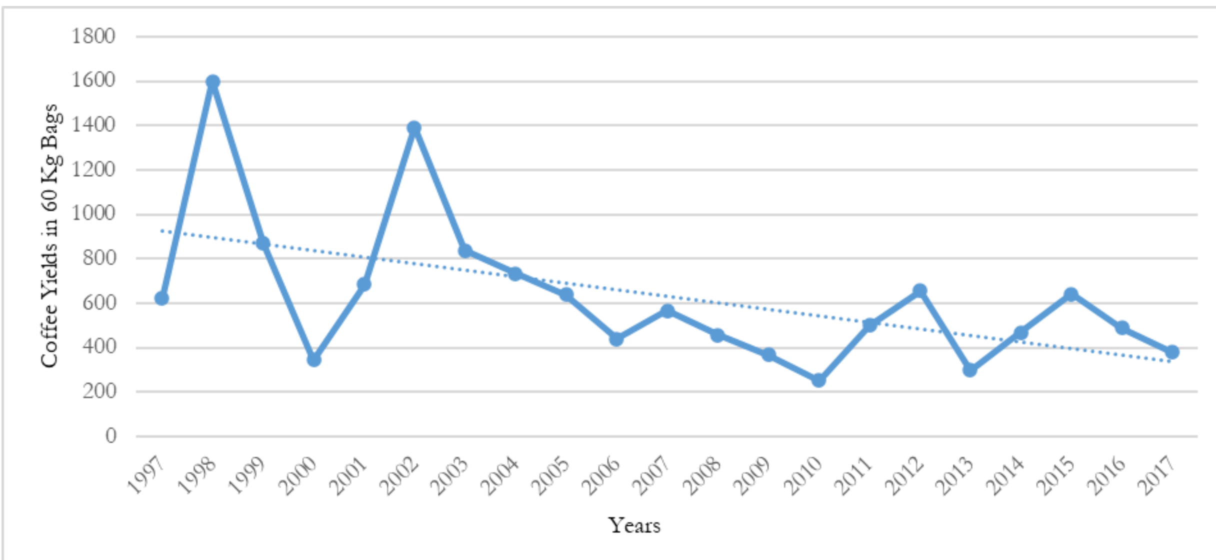

Figure 2. Coffee Production in Mukurwe-ini from 1997 to 2017

Source: Nairobi Coffee Exchange

Figure 2 demonstrates the declining trend in Mukurwe- ini's coffee production over the past two decades. This decline could either be caused by declining income from the crop, or the high cost of coffee farming. As a result, some farmers in region have uprooted their coffee trees in order to invest in other businesses, such dairy farming, as a result of difficulties like high input costs, unpredictability in coffee prices, unfavorable weather, and bad cooperatives management. The 2001 Coffee Act which permits uprooting of coffee, encourages the action (Imoru & Ayamga 2015). Through their coffee cooperative organizations, the Mukurwe-ini coffee farmers get access to the subsidized fertilizer at a reduced cost compared to the market pricing. The subsidized fertilizer is accessed through four cooperative societies in the region - Ruthaka, Rugi, Gikaru and Rumukia; and distributed through the various coffee factories under each cooperative society.

In Kenya, the fertilizer subsidy scheme was launched in 2006. The Ministry of Agriculture (MOA) oversees the program, which has two primary goals. Increasing crop yields is the main goal, and raising farmer income is the second. Initially, it sought to connect with around 2.5 million smallholder farmers (Government of Kenya, 2006). By concentrating on food crops (such as corn, rice, potatoes, and sorghum) and cash crops (such as tea, coffee, and sugarcane), the subsidy aims to promote both revenue generation and food security. We can infer that the fertilizer subsidy has an impact on households' well-being from a study by Ricker-Gilbert and colleagues (2010) on the dynamic impacts of fertilizer subsidies on household welfare.

The goal of the subsidy program is to improve agricultural input access and affordability in order to promote food security.it is also implemented in line with the Sustainable Development Goals (SDG) of eliminating hunger and raising household income (Ricker-Gilbert & Jayne, 2010). In comparison to market prices, the initiative helps farmers' access fertilizer at a lower cost. In contrast to the high market price, the government has been offering farmers subsidies on fertilizers by selling at a lower price. Even though the government has worked hard to fund the initiative, there have been certain difficulties that have delayed the projected implementation.

The program's implementation targeted the maize farmers, with the aim of boosting yields and maintaining the food sustainability. Cash crops, which make up the majority of Kenya's exports, were the second area of emphasis by the subsidy program. These crops include sugarcane, coffee, and tea. The subsidy aims to boost these crops' yields, household income, and ultimately the nation's exports (Wanyama et al., 2009). Coffee is a perennial crop, and in its first three years, it uses up all the nutrients in the soil. For good coffee production, the soil nutrients must be gradually restored. The purpose of fertilizer application is to enrich the soil with nutrients. Therefore, fertilizer is one of the fundamental input elements in coffee production that is essential to yield levels.

2.1 Theory of Production

Production theory examines how an output can be produced from a collection of inputs. The production function mentioned in equation 1 formally expresses the relation between the inputs and outputs.

$$Q = f(x) \tag{1}$$

Where x is a vector of inputs Q represents the output.

Adam Smith is credited with developing the theory of production. He clearly demonstrated how labor, land, and capital are all necessary for production. In accordance with Smith's claim, equation 2 can be extended to incorporate the inputs listed below;

$$Q = f(K, L, M \dots .) \tag{2}$$

In equation 2, Q stands for output over a certain period, K for capital employed, L for labor, and M for raw materials utilized, while the notations stand for other input factors influencing the manufacturing process. Equation 2.2 represents any imaginable combination of In equation 2, Q stands for output over a certain period, K for capital employed, L for labor, and M for raw materials utilized, while the notations stand for other input factors influencing the manufacturing process.

Any imaginable set of inputs and how they could be combined to produce outputs are represented by Equation 2. (Cobb & Douglas, 1928). The production theory makes the assumptions that technical knowledge will remain constant throughout the production process and that the production elements will be divided into the most economically viable units. The theory also makes the assumption that businesses use their inputs as efficiently as possible.

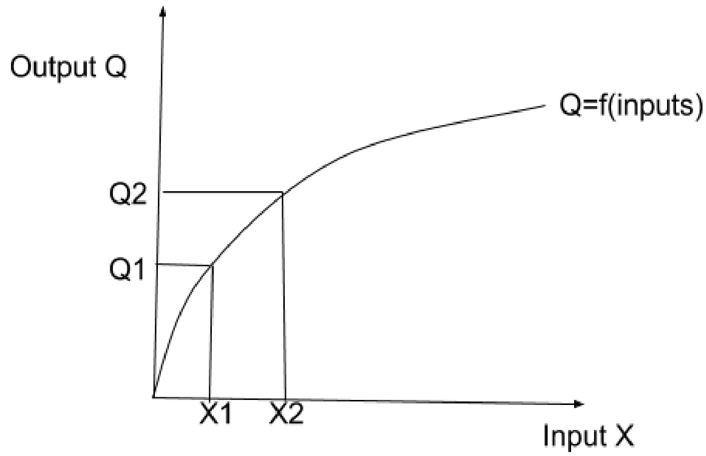

Figure 3. Graphical representation of a production function

Source: (Coelli, *et al.*, 2005)

The firm's goal is to boost profits by either enhancing the production of Q or lowering the cost of generating Q. The production function, depicted in figure 2.1, shows the greatest output that might be created by various ratios of labor (L), capital (K), and raw materials (M). The marginal physical product is the incremental unit of product that might be created using an additional input while maintaining other inputs at their current levels (MPP). The idea of returns to scale describes how output responds to an overall increase in all inputs. Scale-related returns could be rising, falling, or constant.

3. RESEARCH METHODOLOGY

3.1 Population and Sample Size

The study employed the non-experimental research design. While non-experimental research design can be categorized into time series, cross-section or panel design, this study adopted the cross-section design. The study used primary data, which was collected from the population of individual coffee farmers in the area of study. The area of study, as discussed in the literature review section was Mukirwe-ini, an area where coffee is practiced as the major source of income. The area under study is depicted in the following figure. The area has four corporative societies. From the data gained from these cooperative societies, there were a total of 958 coffee farmers.

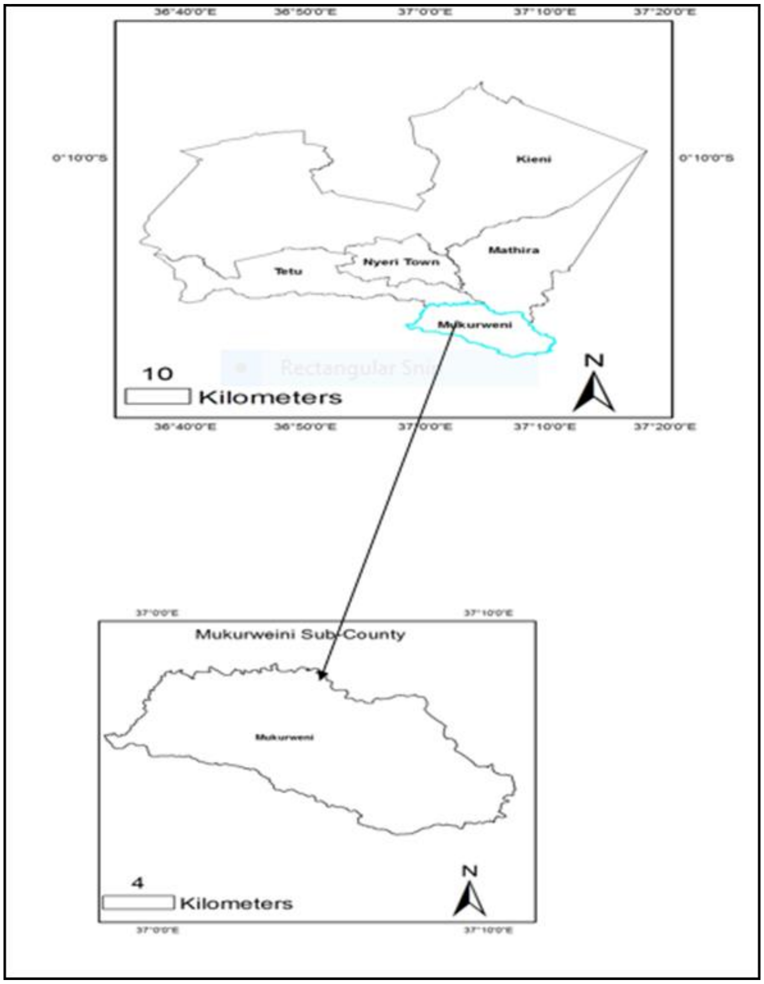

Figure 4. Map showing Mukurwe-ini Sub-county in Nyeri County

Source: Nyeri County documentations

To determine the sample size, the Krejcie & Morgan (1970) formula was adopted, considering that the coffee farmers were finite. The Krejcie & Morgan (1970) formula is represented as follows:

$$S = \frac{X^2 NP\ (1-P)}{d^2\,(N-1) + X^2 P\ (1-P)}$$

Where: S = required sample, X = Z-value (e.g 1.96 for 95% confidence interval), N = population size, P = population proportion (assumed to be 0.5), d = Degree of freedom (5%). The sample size is calculated below:

$$S = \frac{1.96^2 \times 958 \times 0.5(1-0.5)}{0.05^2\,(958-1) + 1.96^2 \times 0.5\ (1-0.5)} = 274 \text{ coffee farmers}$$

From the calculation above, it was found that the sample size is 274 coffee farmers. To select the sample respondents, stratified sampling technique was adopted. Each corporative was considered as a stratum, considering that they operate as independent units. From each cooperative, equal respondents were selected at random, making a sample size of 274 respondents.

3.2 Instruments and Data Analysis

Structured questionnaire was used to collect the data. The questionnaire comprised of two sections, the first section had demographic questions (age, gender, households, and size); and the second section comprised the questions related to coffee farming. The questionnaire comprised both closed-ended and open-ended questions. Two research assistants were used to collect the data.

The research applied the production theory, which deals with the production of a given output, given a set of inputs. The relationship between the inputs and outputs is formally expressed by the production function specified in equation 3.

$$Q = f(x) \tag{3}$$

Where Q represents the output, while x is a vector inputs. To determine the effects of fertilizer subsidy on coffee yields. The production function given in equation 1.1 was specified as a linear function presented below.

$$Y_i = \beta_0 + \beta_1 Fsize + \beta_2 Ftlzr + \beta_3 Labor + \beta_4 Hcap + \beta_5 Inc + \beta_6 Pestcd + \beta_7 OIncome + \beta_8 Trng + \beta_9 Edu + \beta_{10} Coop + \mu_i \tag{4}$$

Where Y_i, is the quantity of coffee yields (kg) per plant/bush, $Fsize$ = farm size, $Ftlzr$ = fertilizer used, $Labor =$ labor used, $Hcap$ =human capital, $Inc =$income, $Pestcd =$ pestcides, $OIncome =$ other sources of income, $Trng$ = training, Edu = education level, $Coop$ = cooperative management and β_0 is y-intercept. $\beta_1, \beta_2 \dots \dots \dots, \beta_6$ are parameters of the model and μ_i represents the error term.

4. RESULTS AND DISCUSSION

The first analysis of the study was conducting the descriptive statistics of the variables of the study. The descriptive statistics was aimed at understanding the charactersitics of the variables of the study. The results are presented in the Table 1 below.

Table 1. Descriptive Statistics analysis

Variable	Mean	Std. Deviation	Minimum	Maximum
Yields/bush	3.7	1.5	0.3	8.6
Age (years)	58.4	13.2	19.0	98.0
Household Size	6.3	2.0	2.0	14.0
Farm Size (acres)	0.5	0.3	0.1	1.0
Subsidized Fertilizer	2.4	1.4	0.5	10.0
Labour (days)	28.0	10.2	10.0	54.0
Pesticides (Ksh)	6265.3	2989.4	150.0	13000.0
Income (Ksh)	76005.6	52485.2	7020.0	301000.0
Distance (Km)	3.3	3.2	0.2	17.8
Food Crop farm size	0.7	0.4	0.1	1.5

Source: Survey data, 2018

From the results of the descriptive statistics above, it was observed that the average coffee yield per bush for the period considered was 3.6553 kgs yields per coffee bush. The results indicated that most of the farmers were quite age, with an average being 58.4 years, where the minimum coffee farmer was 19 years with a maximum age of the farmer beig at 98 years. The household size of the coffee farmers was also evaluated. It was found out that the average household size is 6 people. The farm size for the coffee farmers was evaluated and the average size was 0.5 acres, meaning that most of them, actually all of them (maximum farm size was 1.0 acres) were small scale coffee farmers. Annual income of the farmers from coffee was also evaluated. The average annual income was Ksh 76,005.6 with the maximum earner getting Ksh. 301,000.

In addition, the descriptive statistics was conducted on the four cooperative societies – Rumukia, Rugi, Ruthaka and Gikaru. The results are presented in Table 2 below. The mean of each variable for each cooperative is presented, in order to compare with other cooperative societies.

Table 2. Descriptive Statistics of Four Cooperative Societies

Variables	Rumukia	Rugi	Ruthaka	Gikaru
	Mean	Mean	Mean	Mean
Yields (Kg/bush)	3.8	4.0	3.11	3.85
Age (Years)	58.1	60.1	54.7	61.37
HH size (Members No.)	6.1	6.3	6.35	6.49
Human Capital (years)	3.96	4	3.5	3.63
Farm size (Acres)	0.59	0.67	0.48	0.44
Labour (Man -days)	29.42	30.21	24.07	29.51
Fertilizer (50 kg bags)	2.33	3.02	2.15	1.92
Pesticides (Kshs)	6545	6775	5416	6565
Income (Kshs)	64052	87646	67180	84566
Distance (Km)	3.12	5.62	3.04	1.5

Source: Survey data, 2018

The table above shows that the most productive society was Rugi with an average production of 4.00 Kgs per coffee bush, followed by Gikaru producing an average of 3.85 Kgs per coffee bush. The least productive cooperative society was Ruthaka producing 3.11 Kgs per coffee bush. Rugi was using the highest amount of subsidized fertilizer with an average of 3.02 50kgs bags, while Gikaru was using the least averaging at 1.92 50kgs bags. The cooperative society with the highest previous year's income was Rugi, with an average of Ksh 87646, which could be attributed to its high production levels. Rumukia had the lowest previous year's income averaging Ksh. 64052. Rugi had the highest expenditure on pesticides averaging Ksh 6775 per year, while Ruthaka had the lowest with an average of Ksh. 5416.892 per year. From the data, Rugi society was using the highest fertilizer and pesticides, and reported the highest average yields and income.

4.1 Diagnostics Tests

Before evaluating the effects fertilizer subsidy on coffee production using a multiple regression, the necessary diagnostic tests were conducted. The tests conducted include model specification tests, multicollinearity test, heteroscedasticity, normality and autocorrelation test. The results are discussed in the table below.

Model Specification Test

The Ramsey (1969) Regression Specification Error Test (RESET) was carried out to determine the departure from the classical linear regression assumptions. As proposed by Ramsey (1996), RESET is a general test for omitted variables alongside correlation test among the independent variables. The tests results for RESET are presented in Table 3.

Table 3. Model Specification test

Ramsey RESET test using powers of the fitted values of Y	
Ho: model has no omitted variables	
F(3, 231)	0.74
Prob > F	0.0682

Source: Survey data Mukurwe-ini, 2018

The p-value of the F-statistics was greater than 0.05. Therefore, the null hypothesis of 'model has no omitted variables' at 5% level of significance was not rejected. The results suggested that there were no possibility of misspecification in the model.

Test for Heteroskedasticity

The Breusch-Pagan test was applied tests for the presence of heteroskedasticity. Heteroskedaticity results if the variance of the residuals is not constant. The test results for Breusch-Pagan test are presented in Table 4.

Table 4. Test for Heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho: Constant variance	
Variables: fitted values of Y	
chi2(1)	1.37
Prob > chi2	0.2816

Source: Survey data Mukurwe-ini, 2018

The p-value of the test is greater than 0.05 and the Chi-square is small. As a result, the null hypothesis which assumes 'constant variance' is not rejected. The result suggested that heteroskedasticity was not a problem.

Test for Multicollinearity

The Variance Inflation Factor (VIF) was applied to test for the multicolliniearity. Multicollinearity results when more than two variables are near perfect linear combinations of one another. The VIF rule of thumb is that if VIF values are greater than 10, it may indicate presence of multicollinearity and merit further investigation. The tolerance (1/VIF) would be applied to check the level of collinearity. The VIF test results are presented in Table 5.

Table 5. Test for Multicollinearity

Variable	VIF	1/VIF
Cooperative Mgt. (Neutral)	9.75	0.10
Cooperative Mgt. (Poor)	9.18	0.11
Cooperative Mgt. (Very Poor)	3.81	0.26
Cooperative Mgt. (Good)	3.76	0.27
Farm size	1.95	0.51

Subsidized fertilizer	1.72	0.58
Labour	1.60	0.62
Pesticides	1.42	0.71
Age	1.25	0.80
Income	1.22	0.82
Education	1.13	0.89
Human capital	1.12	0.90
Other income	1.07	0.94
Training	1.05	0.96
Mean VIF	2.86	

Source: Survey data Mukurwe-ini, 2018

The VIFs and the tolerance (1/VIF) values are below the 10 and 1 respectively for the independent values considered. Therefore, the results suggest that multicollinearity is not a problem.

Normality Test

Inferring from Greene (2008), the linear regression error term should be normally distributed with a zero mean and a constant error term. The residual based test was performed to ascertain whether the estimated equation was normally distributed. The Shapiro-Wilks normality test was conducted with W being 0.9752 and the probability value being 0.07828. Since the p-value was greater than 0.05, the null hypothesis of normally distributed regression residuals was not rejected at 5 percent level of significance. These results suggested that at 95% confidence level, the regression residuals from the estimated equation do not depart from normality. According to Greene (2008), normally distributed variables exhibit normal liner function, the normal distribution of the residuals implied that the coefficients of the estimates were also normally distributed.

Autocorrelation Test

Autocorrelation is the violation of assumption 4, which states that the observations of error term are uncorrelated with each other. When the error terms from different cross-sectional observations are correlated with each other, then the error terms are said to be serially correlated. The residual test was conducted to ascertain whether the residuals were serially correlated. The results indicated that z was -0.71 and probability value being 0.48. Since the p-value was greater than 0.05, the null hypothesis no serial correlation was not rejected at 5% level of significance. Therefore, the results suggested that at 95% confidence level, there was no statistically significant evidence of serial correlation of the residuals in the model.

Empirical Results

After being satisfied with the diagnostic tests of the model, the main objective of the study was evaluated by running the multiple regression analysis specified in equation 4. The empirical results of the model are presented in Table 6.

Table 6. Empirical Results for the Study

The dependent Variable is Yields/bush			
Explanatory Variables	**Coefficient**	**t-value**	**P-value**
Age	-0.0090417	-1.43	0.154

Farm size	-0.2336878	-0.59	0.556
S. Fertilizer	0.1956219**	2.71	0.007
Labour	0.0035892	0.39	0.699
Human capital	0.0480671	0.76	0.447
Education	-0.1197475	-1.01	0.312
Income	0.0064686**	10.26	0.001
Other income	0.0127377	0.08	0.937
Training	0.1021724	1.31	0.190
Pesticides	0.0000879**	2.96	0.003
Coop Mgt (Good)	0.1318388	0.25	0.802
Coop Mgt. (Neutral)	0.572684**	1.21	0.028
Coop Mgt. (Poor)	0.4570223	0.99	0.321
Coop Mgt (V,Poor)	0.9207918**	1.89	0.040
_cons	0.5791241	0.82	0.412
No. of Observations = 243; Adjusted R-Squared = 0.6795; p-value = 0.0001			

Source: Extracted from Appendix 1

From the empirical results summarized above, adjusted R-squared is 67.95 percent, implying that the explanatory variables jointly explain 67.95 percent of the variations in coffee yields per tree. The remaining 32.05 percent could be attributed to the variables that were not included in the model. The overall model significance test has a probability value of 0.0001, which is lesser than 0.05 at 95 percent level of significance, implying that the overall model was statistically significant. The empirical results shows that there several variables that significantly influenced the coffee yields. The first variable was the fertilizer subsidy (the variable of interest in the study) which significantly and positively influenced the coffee yield. Its p-value is less than 0.05, at 5% level of significance, and the coefficient was 0.1956219 (β = 0.1956219; p = 0.007). these results implies that if farmers increase their fertilizer application by one 50kg bag of subsidized fertilizer, this would result to 0.191074 Kgs increase in coffee yields per bush.

Another variable that was found to be statistically significant was the previous year's income. The empirical results indicated that the previous year's income had a coefficient of 0.0064686 with a probability value of 0.0001 (β = 0.0064686; p = 0.0001). The previous year's income had a statistically significant influence on current year's coffee yields. Holding other factors constant, a 1Kshs rise in previous year's income would result to 0.0064686 Kgs increase in yields per coffee bush. This depicts the significance of previous year's coffee income in funding the current year's coffee production. Pesticide was also found to significantly and positively influence coffee yields. The coefficient of pesticides was 0.0000879 with a probability value of 0.003 (β =0.0000879; p = 0.003). This implies that pesticides expenditure had a statistically significant influence on coffee yields. Holding other factors constant, an additional 1Kshs expenditure in pesticide use would lead to a 0.0000878 Kgs increase in coffee yields per coffee bush. Additionally, two sub-variables of cooperative management (neutral-management and very-poor-management), which was tested as a dummy variable were found to statistically significantly influence coffee yields (β = 0.572684, p =

0.028; 0.9207918, p=0.040). This implies that holding other factors constant, an improvement in cooperative management would result to an increase in the coffee yields. Other variables labor, human capital and training, age, farm size and other incomes were found to have non-statistically significant influence on coffee yields.

4.2 Discussion

This study empirically investigated the effects of fertilizer subsidy on the on the coffee production. Agricultural inputs subsidies, especially fertilizer subsidies are adopted and implemented by the different governments, as a means of promoting agricultural output (Imoru & Ayamga 2015). For Kenya, the fertilizer subsidy was adopted as a means of boosting major cash crops and staple food crops in the country. It is considered as an effective way to boost food crop production and boost income through increased cash crop production among farmers. This research found that fertilizer subsidy has a positive and significant influence on the coffee production. The research statistics indicated that if fertilizer application increase by one unit (50kg bag), the coffee yield per bush (Kgs per coffee bush) would increase by 0.197 Kgs. These results are in line with that of Andani, *et al.*, (2020) whose research indicated that the implementation of fertilizer subsidy is significantly and positively associated with maize production in Ghana. Additionally, Ranathilaka & Arachchi (2019) indicated that there is a significant relationship between the fertilizer subsidy and paddy production. This research argues that the application of fertilizer subsidy facilitates farmers to access the required fertilizers at a cheaper and affordable prices. Therefore, the farmers are able to apply the required fertilizer quantity to their crops. This plays critical role in replenishing the soil, especially for the perennial crops. As a result the yields and production is boosted from the improved soil fertility.

The researcher also found significant relationship between income and coffee yield production. The higher the level of income, the higher the level of coffee yields. It is supported from the view that higher income farmers have extra income to hire needed labors, farm inputs as well as proper management of their crops, which translates to their higher production levels. Another important aspect is that pesticides has significant influence of coffee production. Adequate application of pesticides increase coffee yields. This is supported by the findings of Nghiem, *et al.*, (2020) the appropriate application of relevant inputs boost coffee production. Further coopertative management was foud to contribute significantly to the coffee production. This emphasizes the role of cooperative management in encouraging production through effective management of all aspects of production, including farm inputs and outputs. The significance of cooperative management was emphasized by the fact that none of the farmers rated their cooperative management to be very good. Additionally, most of the farmers who rated their cooperative management as poor and very poor were harvesting 2 and 3Kgs per coffee tree. This implies that the management had a significant impact on the effort made by farmers in coffee production. These results are consistent with the findings of Kaguru (2016) that poor governance and management of coffee cooperatives led to low production of coffee.

5. CONCLUSION

The study concludes that fertilizer is a vital and primary component in coffee farming. It has a significant influence on coffee yields per plant, the total coffee output of a farm and the resultant farmer's income. An increase in 1 50kg bag of subsidized fertilizer would result to 0.191074 Kgs increase in coffee yields per bush. Additionally, from descriptive statistics, most of the farmers using 1, 2 and 3 50Kgs bags of subsidized fertilizer, were harvesting 2, 3 and 4 Kgs per coffee tree respectively. As noted by Ricker-Gilbert & Jayne (2010), fertilizer subsidy has a contemporaneous effect on yields and life satisfaction. Their study indicated a significant evidence of increase in maize production due to the subsidy, and similarly, the government initiative of subsidized fertilizer affects coffee production. These results support the existing empirical literature, which shows that fertilizer subsidy is vital in improving agricultural production. However, several factors inhibit the farmers from realizing the full benefit of subsidized fertilizer. These include the availability and accessibility of the fertilizer during the right period. Coffee is a perennial crop that exhausts the soil fertility within the first few years of planting. Therefore, availing fertilizer in the right time is paramount for both soil replenishment and optimum coffee yields. In addition to fertilizer subsidy, other factors affecting coffee yields include coffee cooperatives management and pesticides costs.

These results provides important empirical ground for the collective political will of the Kenyan government through the Ministry of Agriculture to unlock the agricultural economic and social potentials through increasing subsidized fertilizers. Considering that coffee farming contributes to foreign exchange earnings, food security, household income and employment creation, and the fertilizer is a major input, the Ministry of Agriculture should consider enhancing fertilizer subsidy to coffee farmers as a way of reviving the declining coffee production. This study recommends that further studies could be conducted on the entire country, with inclusion of more variables not included in the current study. This would ascertain whether the study would yield the same results. To gain a bigger picture of the effects of subsidized fertilizer in Kenya, similar studies should be conducted on other crops such as maize, tea, potatoes and rice production.

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Appendix 1

Table A1. Regression Results

Source	SS	df	MS	Number of obs = 243
Model	264.699697	14	18.9071212	F(14, 228) = 14.01
Residual	307.595561	228	1.34910334	Prob > F = 0.0000
Total	572.295258	242	2.36485644	R-squared = 0.7125
				Adj R-squared = 0.6795
				Root MSE = 1.1615

	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Age	-0.0090417	0.0063195	-1.43	0.154	-.0214938	.0034104
Farm size	-0.2336878	0.3960555	-0.59	0.556	-1.014085	.5467091
S. Fertilizer	0.1956219	0.072215	. 2.71	0.007	.0533278	.337916
Labour	0.0035892	0.0092787	0.39	0.699	-.0146938	.0218722
Human capital	0.0480671	0.0631315	0.76	0.447	-.0763288	.1724629
Education	-0.1197475	0.1180851	-1.01	0.312	-.3524252	.1129302
Income	0.0064686	0.0006303	10.26	0.001	.0052266	.0077106
Other income	0.0127377	0.1604028	0.08	0.937	-.3033238	.3287992
Training	0.1021724	0.0777526	1.31	0.190	-.0510331	.255378
Pesticides	0.0000879	0.0000297	2.96	0.003	.0000293	.0001464
Coop Mgt (Good)	0.1318388	0. 5259853	0.25	0.802	-.9045748	1.168252
Coop Mgt. (Neutral)	0.572684	0.4736001	1.21	0.028	-.3605086	1.505877
Coop Mgt. (Poor)	0.4570223	0.4593412	0.99	0.321	-.4480742	1.362119
Coop Mgt (V,Poor)	0.9207918	0.4872285	1.89	0.040	-.0392545	1.880838
_cons	0.5791241	0.7050678	0.82	0.412	-.8101578	1.968406