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FERTILIZER SUBSIDY PROGRAM A STRATEGY OF ADDRESSING LOW MAIZE PRODUCTIVITY IN KAKAMEGA COUNTY, KENYA

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ABSTACT: *Kakamega is one of the most populated Counties of Kenya. Due to continuous cultivation of the land and heavy rainfall received, it is prone to loss of soil nutrients through leaching. This has resulted to reduced crop productivity in the region. A number of strategies have been initiated by the government to promote soil fertility. Fertilizer subsidy program is one of the policy instruments so far implemented despite heavily criticized. The paper provides findings of a study carried out to analyze the effect of adoption of fertilizer subsidy program on maize productivity among the small scale farmers. Cross sectional data was collected from 300 respondents who were selected using multistage sampling procedure in Kakamega County. Questionnaires were used to collect primary data from randomly selected households. A probit and Tobit two stage models-controlling for programme selection bias were used to determine the probability of adoption and the effect of participation in the fertilizer subsidy program on maize productivity respectively. Maize productivity was significantly influenced by the subsidy program participation at 5% level. The average maize productivity was 2.21t/ha. Farmers who benefited from the program had an average productivity of 2.46t/ha significantly higher than non-participants who had an average of 1.97t/ha. Tobit model results showed that subsidy program participation had a likelihood of increasing productivity by 0.323t/ha. However, there is an existing yield gap between what is possible with the existing technologies and what farmers currently achieve. The cause of this is low average fertilizer usage to make an impact on productivity as compared to the national recommended application rates. Hence the study recommends expansion of the subsidy program by increasing quantities of fertilizer supplied to incorporate more farmers in the program.*

KEYWORDS: maize productivity, subsidy program, probit model, dummy variable

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INTRODUCTION

The agricultural sector continues to be a pillar for most economies in developing nations and provides livelihoods to millions of people (Geffersa, 2019). The sector is crucial to poverty reduction and socio-economic transformation globally (Akuku et al., 2019). Sustainable long-term development in both developed and developing nations around the world, is projected to be reliant on agriculture as a vital sector (Selejio, 2017). With anticipations that the global population will rise more than 9 billion by 2050, food sustainability has become an urgent issue to address especially in Africa (Debnath & Babu, 2020). Higher farm productivity would reduce both absolute as well as relative poverty among rural households (Mellor, 2019). Globally, over 67 percent of the people generate revenue from the sector, with the sector contributing 39.4% of the Gross Domestic Product while exports of agricultural products account for 43% of global total exports (Kahanna & Solanki, 2014). In addition, 65% of the African states employment is sectorial and over 75% of its domestic trade is either directly or indirectly related to agriculture (World Bank., 2016).

In specific, apart from wheat and rice, maize is the largest crop grown contributing to about 24% of the cereals produced globally (Imran et al., 2015; Rehman et al., 2016). Approximately 1.2 billion people depend on maize directly as a main food. It has been largely classified into white and yellow maize (Suri & Tanumihardjo, 2016) and the two categories are produced under similar climatic conditions (Ranum et al., 2014). The rates at which white maize is consumed in developing countries exceed many other regions (Barmao & Tarus, 2019). Most maize varieties mature in about 100-130 days, however, this varies with climatic conditions (Fisher et al., 2015). Globally, about 40% of the maize harvests is accounted for by United States as the leading producer. Country wise, the prominent producers of the crop are France, Mexico, China and Brazil. By continent, North America produces highest quantities of maize grain accounting for 38.8% of the world output. Closely, Asia follows with 28.5%, followed by South America with 11.2%. Europe only produces 11.1% of the global output, Africa comes at 6.9% higher than Central America which contributes 3.4%. Lastly Oceania only accounts for 0.07% (Barmao & Tarus, 2019).

In Africa, maize was introduced by the Portuguese in the 16th century and gradually it has become the African staple food. South Africa is the leading producer of maize in the continent, it is closely followed by Nigeria, Ethiopia and Tanzania. In addition, Egypt and Malawi produces a significant portion of the maize harvest in the continental output (DTMA, 2015). Apart from the crop being an essential food, it is a raw material for a wide

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range of industrial activities ranging from manufacturing services of explosives, plastics and glue to food processing and traded in huge quantities as animal feed crop (Kirimi et al., 2011; Greaves & Wang, 2017). Maize stover is used locally as wood-fuel and in biomass fuel production for transportation sector (Wang et al., 2015). Over 85% of maize produced is consumed as food; it can be boiled, roasted, consumed as pop corns or processed to flour before preparation of ugali, porridge among other local meals (Kirimi, 2012).

Despite a 60 % expansion in the area under maize production for the period between 2007 and 2017, across Africa, the crop productivity continues to deterioration (Mohammed, 2021; Barmao & Tarus, 2019). There is a significant crop yield gap between the developed and Sub-Sahara African countries caused by under-utilization of modern inputs and technologies in production (Diiro et al., 2015; Phakathi et al., 2020). The low average yields are further attributed to by extreme poverty, land degradation, poor soils, climate change and post-harvest losses (Raimi et al., 2017). The under-utilization of fertilizer accounting for only 3 percent of the world fertilizer use with an average use of 7kg/ha is less to increase crop yields (Druilhe & Barreiro-Hurlé., 2012 and c & Zakaria, 2019). The rate at which population is growing has overwhelmed agricultural productivity and this has put pressure on food security which has become a crucial challenge in African countries (Scheiterle et al., 2019).

Just as the majority of the developing countries, Kenyan economy is agricultural driven with the sector contributing 26 and 25 percent to the country GDP directly and indirectly respectively. Equally, the sector is the source of livelihood for the poor resource households (Akuku et al., 2019). The sector has employed 40 and 70 percent of the total and rural population respectively generating income either directly or indirectly to over 80% of the country population (Barmao & Tarus, 2019). In addition, 65 and 75 percent of the exports and raw materials for the industries respectively in the country are agricultural related (World Bank, 2018). Maize being an essential crop for many people in the country, with over 40 percent of Kenya's harvested crop area covered by the crop, it approximately contributes to 12.65% of agricultural GDP and 2.4% of the total GDP respectively. According to the MoA 2011, 51% of the staple food grown in the country is accounted for by maize. In addition, the average maize consumption in the country is higher than all the other countries in Eastern Africa (DTMA, 2015). Maize crop is extensively grown in Trans Nzoia, Nakuru, Bungoma, Uasin Gishu, Nandi and Elgeyo Marakwet Counties (Kimani, 2017). However, it is practiced in the whole country on small to medium scale. It is cultivated alongside other crops. Higher output can be realized by the use of certified seeds, however, some farmers practice production with local varieties (Schroeder et al., 2013).

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Despite the key role played by the crop in the economic development as well as food security, productivity has been on a standstill in the recent years and reported to be lower than the global and regional averages (Ochola & Fengying, 2015; Jena et al., 2021). This has brought about persistent deficiencies with annual maize yields often falling below the country's consumption levels (Kirimi et al., 2011; Barmao & Tarus, 2019). A high number of people are food insecure, highly depending on food aid in the country. During the period 2016 to 2018, over 30% of the population was undernourished (Boulanger et al., 2020). Attaining optimal maize productivity especially in Western Kenya has been major challenge for small holder farmers (KIPPRA, 2013). Among the root-cause of the low crop yields in Western Kenya is declining soil fertility which is linked to inadequate application of inorganic fertilizers (Druilhe & Barreiro-Hurlé, 2012) as the reports show that soils are already poor. In order to address this problem, fertilizer application rates should be increased (Debnath & Babu, 2020). Since majority of the farmers are resource-poor in the region with a poverty index higher than 51%, affordability of fertilizer is a challenge. This has potentially lowered usage as commercial agricultural input are expensive. The government initiated agricultural policies and strategies to counter the declining crop productivity. In effort to address the issue of low maize productivity, the government introduced subsidized fertilizer program with an aim of easing affordability of seed and fertilizer to raise utilization and improve productivity in order to attain food security (Ochola & Fengying, 2015).

However, despite the program being operational for over 10 years, productivity has not shown any significant increase. The potential productivity level has not yet been achieved. Many studies have examined effects of social demographic factors on maize production. For instance, Munialo et al. (2020) focused on social-demographic determinants of maize yield gap, Odilla et al., (2018) on technical knowledge and information gaps among smallholder farmers in production in Kakamega. However, information on if and how subsidy program participation affect productivity is scanty. The purpose of the research was to provide information on wheather input subsidy program has been effective in increasing farm input usage specifically fertilizer, to address the issues of low soil fertility and stagnating crop productivity. This study therefore sought to determine the effects of subsidized fertilizer program on maize productivity among small scale farmers in Kakamega County.

Theoretical Underpinnings

A theory of production in economics by the use of Cobb-Douglas function was adopted in the data analysis with basic form of $Y(L, K)$=$AK\alpha L\ \beta$ where; Y- Is total productivity, labor

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contribution is represented by L, capital input denoted by K, Total factor of productivity symbolized by A, output elasticity of capital is signified by α and labor is indicated by β. The association between input factors and output factor was represented by a model (Zellner, 2013).

For farmers to maximize their advantage, minimize losses and increase satisfaction, they would always want the best for self-interest as they are faced with a range of alternatives to choose from. Preference on an item depends on the utility derived relative to its alternative satisfaction (Makau et al., 2016). In Choice theory of economics, it is assumed that individuals have perfect discriminatory power and are able to rank alternatives in a well-defined manner. The decision is determined by the utility level that household derives from choosing an alternative.

RESEARCH METHODOLOGY

Study area

The study was done in Kakamega County, located in the Western region of Kenya. The County is one of the most populated in the country covering an area of 3,050.3 km^2. According to KNBS (2019), it has 1,867,579 people of which 970,406 are females and 897,133 men across its 12 Sub-Counties. The climate is majorly tropical with cool and wet condition throughout the year and average temperatures of 22°C. The area receives rainfall in two seasons, with an annual rainfall ranging between 1280 and 2214 mm per year. The long rains occur between February and July while short rains between August and December. The soils are predominantly luvisols and lixisols with moderately to slightly acidic conditions (pH 5.3–5.9) (Saalu et al., 2020). Subsistence farming is the main economic activity in the County with maize and beans leading as food crops and sugarcane as the main cash crop for income generation.

Study Design

The study adopted a descriptive survey research design in conducting the research. Primary data was collected using a semi-structured personal administered questionnaires focusing on the household head. Multistage sampling technique was employed. Purposive, clustered and simple random sampling design were used to select participants on condition that the farmer had less than 2.5 hectare of land. The required sample size was determined by formula developed by (Anderson et al., 2018). Proportional allocation was used to determine responses from each Sub-County.

$$n=\frac{z^2\ p.\ q}{d^2} \qquad \text{eqn. } 1$$

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Where n is the minimum sample required for the study, z is 1.96 at 95% confidence level, d is the margin of error acceptable which was taken to be 0.05, q is the weighting variance calculated as 1-p. Records shows that 80% of all farmers in the County engage in maize production thus p will be 0.8

$$n = \frac{1.96^2(0.8)(1-0.8)}{0.05^2} = 245.8624$$

Therefore, 245 farmers was the minimum sample size required according to the calculation above, but; this number was increased to 300 in order to increase information reliability.

Data analysis

Subsidy program adoption is a dummy situation involving two choices which are participating or failing to participate. Everyone involved in the selection process has a range of responses that are influenced by various factors. Probit regression was used to estimate factors affecting the likelihood of subsidy program participation. This model was preferred due to its potential to lessen heteroscedasticity limitations and aptitude of compelling the probability of adoption (P_i=(q=1|X) to increase or decrease only in an interval of 0 to 1 (Asante et al., 2011). Several other models could have been alternatives for approximating the nominal response of this dichotomous variable such as linear probability model. However, shortcomings such as the probabilities exceeding 1 or being less than 0 for linear probability model makes probit the finest. The decision of a household to adopt subsidy program is as a results of the utility value q*****, which is the outcome of other factors. Household's adoption rate of the subsidy program is higher when the utility value q***** is high. The latent utility index is expressed as:

$$q_* = X'\beta + \mu \qquad \text{eqn. } 2$$

$q=1$ if $q^*>0$; $y=0$ if $q^*\leq 0$,

A utility-maximizing (D^*) farm household decides to adopt, if the satisfaction derived from adopting (U_{Ai}) exceeds the benefits of not adopting at all (U_{Ni}) for the ith farmer ($D^* = U_{Ai} - U_{Ni} > 0$) (Onzima, 2017). Therefore, $U_{Ai}=X_i'\beta_1+\mu i_1$ and $U_{Ni}=X_i'\beta_0+\mu i_0$ represents the utility for accessing subsidized fertilizer and not accessing respectively. Since the farmers only decides to assume fertilizer subsidy program when the utility gained is greater ($U_{Ai}-U_{Ni}>0$).

The model that is used to estimate the probability of accessing subsidized fertilizer is $\phi(X_i'\beta) = P(D_i=1|X)$. Where ϕ(.) Is the standard normal distribution cumulative distribution function, X' represents vector of independent variables, β is a vector of parameters P is the probability that the i^{th} farmer access subsidized fertilizer.

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The functional form of probit model equation that empirically explain factors affecting decision to access or participate in the subsidy program was expressed as:

$D(0, 1) = \beta_0 + \sum_{i=2}^{13} \beta_i X_i + \mu_i$ eqn. 3

A censored linearized Tobit regression model was used to estimate the coefficients and the marginal effects for easier variable interpretation and determination of the influence of subsidized fertilizer program on maize productivity. A dummy variable *D* was introduced as a treatment on whether a farmer participated in subsidy program or not forming a modified model that tested for the effects on productivity. The generated IMR in the model stage 1 were inserted as independent factors to account for self-biasness in stage two of the Tobit model. Transformation of the function into a log linear specification form as shown below was done for easier results interpretation.

$InY_i = \beta_0 + \beta_1 . D_1 + \sum_{i=2}^{14} \beta_i InX_i + \varphi\omega + \mu_i$ eqn. 4

$InY_i^c = \beta_0 + \beta_1 . (D_1 = 1) + \sum_{i=2}^{14} \beta_i InX_i + \varphi\omega + \mu_i$ eqn. 5

$InY_i^T = \beta_0 + \beta_1 . (D_1 = 0) + \sum_{i=2}^{14} \beta_i InX_i + \varphi\omega + \mu_i$ eqn. 6

Explanatory variable D_1 is a dummy variable. In equation 5 D_1=1 when a farmer is participants, in equation 6 D_1=0 when a farmer is not a participants. In equation 5, when a farmer is a participant, then a straight line relationship is represented with an intercept $(\beta_0 + \beta_1)$ and slope coefficients $(\beta_{2....14})$ and in equation 6, when a farmer is not a participants, then a straight line relationship is represented with an intercept (β_0) and slop coefficients$(\beta_{2.....14})$.

$E(InY_i^c / D_1 = 1) = (\beta_0 + \beta_1) + \sum_{i=2}^{14} \beta_i InX_i + \varphi\omega + \mu_i$ eqn. 9

$E(InY_i^T / D_1 = 0) = (\beta_0) + \sum_{i=2}^{14} \beta_i InX_i + \varphi\omega + \mu_i$ eqn. 8

$[E(InY_i^c / D_1 = 1]$- $E[InY_i^T / D_1 = 0]$ - are the average response when an observation belongs to participants and non-participants. Thus $\beta_1 = [E(InY . D_1 = 1] - E[InY . D_1 = 0]$ which has an interception as the difference between the average values of *Y* with D_1=1 and D_1=0.

Y_i= maize productivity for i^{th}; β_0 denote unknown intercept, slope coefficients are represented by $\beta_1 .... \beta_{14}$, In is natural logarithm. X_2 Fertilizer quantities kg/ha, X_3 Farm size under production, X_4 Household size, X_5 Manure application, X_6 Seed quality quantities kg per ha, X_7 Seed quality, X_8 Age of the farmer, X_9 Farmers' education

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levels, X_{10} Household head sex, X_{11} Farmers occupation, X_{12} Credit accessibility, X_{13} Group membership, X_{14} Location, φω IMR (inverse mill ratio) and μ error term.

RESULTS

Results in Table 1 show the estimates from probit model of the selected variables influencing the likelihood of adopting fertilizer subsidy program. Having a Chi-square of 33.37, significantly at 5% level, the model was well approximated. The variation in the probability of farmers participating in the program was explained by 81.39%, since this was the model Pseudo R^2. In addition, the Log likelihood of -37.28 was highly negative indicating that the model was well specified.

When the size of the household increases by one, the likelihood of a farmer adopting subsidy program corresponds by increasing with 0.07% at 1% level. Results indicates as a farmer gets older by one year, the probability of adopting the program increased by 0.09% at 5% level. In addition, as a farmer spends an extra year in a formal learning facility, the chances of engaging in subsidy program increased by 0.124% at 1% level. Furthermore, an increase by 1000 units of credit access increased the possibility of a farmer participating in the subsidy program by 2.47%. Moreover, as distance enlarges by a kilometer from the market, the probability of one participating in the subsidy program went up by 0.329%. However, in contrary, an increase by one km away from the word agricultural office reduced the likelihood of the farmer engaging in the fertilizer subsidy program by 0.122%.

Table 1: Probit regression estimate of factors influencing subsidy fertilizer program participation

Program participation	Coefficient	Std. Error	t	P>|t|
Farm size (Area under maize production)	-3.409	0.085	-1.15	0.320
Manure quantities (KgHa^{-1})	-0.124	0.049	-1.02	0.306
Household size	0.070	0.027	2.62	0.000**
Seed quantities (Kg Ha^{-1})	0.793	0.415	1.73	0.230
Age (Years)	0.090	0.009	9.65	0.009*
Schooling (Years)	0.124	0.015	-7.84	0.000**
Gender (1. Male, 2. Female)	0.230	0.039	0.59	0.555
Occupation (1. Farming, 2. BR, 3. S)	0.009	0.015	0.63	0.529
Amount of credit (Ksh. 1000)	2.471	0.430	5.78	0.000**
Distance to market (Km)	0.329	0.540	9.98	0.000**
Distance to agriculture office (Km)	-0.122	0.141	5.91	0.000**
Group membership (1. Yes, 0. No)	0.107	0.061	-1.76	0.078
Location (1. Malava, 2. Otherwise)	0.002	0.035	0.04	0.965
Lambda	-0.083	0.220	-0.38	0.706
Rho	-0.304	waldchi^2(13)	33.37	
Sigma	0.275	Prob>chi^2	0.000	

Source: Authors' own survey data, Km, Kg, M, F, Ha^{-1}, BR, S, kilometer, kilograms, male, female, per hectare of land, business related, Salaried respectively)

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The results in Table 2 shows the estimates from a censored Tobit regression model of the selected factors that influence maize productivity. The model was correctly estimated as it had a high Pseudo R^2 of 94.14% which indicates that independent variables in model explained the variation in maize productivity by 94.14%. In addition, the Log likelihood of -58.80 was a high negative number which shows the steadiness in the model specification. The model had a significant Chi-square of 35.92 at 1% level.

Fertilizer subsidy program participation significantly increases maize productivity by 0.323t/ha at 1% level. Further, an extra kilogram applied on a hectare of land increased the maize output by 0.001 t/ha. In addition, an increase in the cultivated farm size by a hectare, intensified quantities of maize productivity by 0.229 t/ha at 1% level of significance. Moreover, as the household size increase by a member, maize productivity increased by 0.018t/ha. Using certified seeds significantly increased maize productivity by 0.037t/ha at 1% level. The quantities of maize productivity increased by 0.023 t/ha as age increases by a year at 1% level. Furthermore, increase in credit accessed by 1000 unit increased productivity by 0.077 t/ha. However, participation in farmers group decreased productivity by 0.064 t/ha at 5% level.

Table 2: Tobit regression estimates of factors determining maize productivity quantities

Maize productivity (t/ha)	**Marg. Effe**	**Std. Error**	**t**	**P>|t|**
Program participation (1. Yes, 0. No)	0.323	0.021	15.74	0.000**
Fertilizer quantities ($KgHa^{-1}$)	0.001	0.002	3.59	0.000**
Farm size (Ha under maize production)	0.229	0.079	2.84	0.001**
Household size	0.018	0.007	2.45	0.015**
Manure quantities ($CartsHa^{-1}$)	0.205	0.053	1.56	0.121
Certified seed quantities ($KgHa^{-1}$)	0.158	0.056	1.13	0.258
Seed quality (1. Certified, 2. Own farm)	0.037	0.005	6.85	0.000**
Age (Years)	0.023	0.003	6.55	0.000**
Schooling (Years)	-0.001	0.005	-0.20	0.841
Household head gender (1. M, 2. F)	0.008	0.011	0.75	0.454
Occupation (1. Farming, 2. BR, 3. S)	0.002	0.042	0.45	0.651
Group membership (1. Yes, 0. Otherwise)	-0.064	0.016	-3.85	0.003*
Amount of credit (Ksh. 1000)	0.077	0.018	4.14	0.000**
Location (1. Malava, 2. Otherwise)	-0.004	0.010	1.43	0.686
Inverse Mills Ratio (IMR)	0.059	0.041	1.43	0.153
Log likelihood	-58.80	Pseudo R^2 of	94.14%	
LR Chi^2 (15)	35.92	Prob>chi^2	0.000	

Source: Authors' own survey data, Km, Kg, M, F, $Ha^{-}1$,S, BR, kilometer, kilograms, male, female, per hectare of land, business related, Salaried respectively)

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DISCUSSION

Effect of subsidized fertilizer program on maize productivity

From Table 2, results shows that fertilizer subsidy program participation significantly increased maize productivity. This increase could be attributed to various facts. Majorly, the higher average quantities of fertilizer usage among the beneficiaries due to affordability. Also, the supply of appropriate types of fertilizer could also be increasing productivity among program beneficiaries. In addition, the availability of the subsidy inputs on time could also be contributing to higher yields.

According to the study by Dorward & Chirwa (2011), on the Malawi Agricultural Input Subsidy Program (MAISP), authors reported a considerable increase in maize production that contributed to increased food availability, reduced rural poverty as well as amplified real wages. In the study, further approximation of the subsidy program economic returns was done and reported to have been pleasing using a cost-benefit analysis. In the report by Djurfeldt et al. (2005), recommended agricultural government supported programs being a critical element in increasing food production through technology advancement among Asians. Similarly, Denning et al. (2009) and Gawamadzi & Kosura (2011) while investigating the impact of fertilizer subsidy on marketing of maize in Malawi using a two-wave Integrated Household Panel Survey (IHPS) data, the authors determined the average partial effects by analyzing linear and non-linear models through a method of correlating random effects. In their report, though the magnitude of the effects was moderately low, subsidized fertilizer increased farmers market participation levels because of increasing production quantities, agro-dealer numbers and quantities sold as well as intensified maize commercialization.

Moreover, Ricker-Gilbert et al. (2011), reports an intensification in production of maize by a range of about 1.82 kg to 3.16 kg if utilized up to the third year in a row being effected by applying a surplus kilogram of subsidized fertilizer. Congruently, Chibwana et al. (2013), reported farm input subsidy program having a positive and significant association with participation, fertilizer use intensity and yields. The author further mentions that using subsidized fertilizer and using both subsidized fertilizer and hybrid seeds increases maize output for small scale farmers by 249 kg and 447 kg per ha respectively. The author recommended the program as a mechanism to drive poor households towards food self-sufficiency and poverty alleviation. In addition, Dorward et al. (2013) evaluating adoption of FISP in the years 2012/13, basing on the simulation findings, authors reported full a package having a probability of increasing output by lowest 500kg. Equally, a 50 kg bag of subsidized fertilizer had a possibility of swelling maize harvests between 200kg to 400kg. Harmoniously, a report from Ricker-Gilbert et al. (2013), in their findings in a

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research on how maize productivity is affected by fertilizer subsidy in Zambia, additional one kilogram of the fertilizer increased output by 1.88kg among farmers.

Supporting, Ragasa et al. (2013) and Wiredu et al. (2015) on fertilizer subsidy effects on land production in Ghana, authors reported subsidized fertilizer having increased rice production by 29 kg/ha. Tallying, Smale et al. (2020) studying the results on usage of fertilizer, household harvest and crop commercialization caused by fertilizer subsidy program in Mali, employing a regression model, they conveyed a positive effect on the crops targeted. However, on millet and sorghum, though the effect was affirmative, it was weak and insignificant. They further reported inconsequential effect of subsidized fertilizer on yields when application is less than 65 kg and 87kg/ha for rice and maize respectively (Smale et al., 2020). According to Baquedano et al. (2010) and Alhassan et al. (2020), the opportunity presented by the subsidy program is very important in African countries to improve resource-poor households food production and attain food security. Equally it is a golden opportunity to raise income for small scale farmers. Substantially, Chirwa (2010) on evaluating agricultural input subsidy program using treatment models and a quasi-experimental design in econometrics controlling for selection biasness by creating control groups, reported subsidy program contributing positively to food production and family expenditures. In the reports of Bunde et al. (2019) and Theriault et al. (2018) using a survey design, they mentioned an affirmative relationship between maize productivity and input subsidies while researching on effects of government incentives on maize production in Nandi North, Kenya.

Furthermore, Magut et al. (2019) in a study on the evaluation of government subsidies in productivity of maize among farmers in Uasin Gishu, Kenya, the author mentioned an increasing relationship of production and engagement in the subsidy program. According to Ochola & Fengying (2015), using cross-sectional data and multinomial logistic analysis, reported subsidized fertilizer having played vital roles in achieving food security among rural households. Similarly, Denning et al. (2009) comments that in Malawi, maize production increased by almost doubling after implementation of the subsidy program.

According to Druilhe & Barreiro-hurlé (2012), fertilizer subsidies was supposed to be the most effective instrument to increase fertilizer usage and raise crop productivity. However, the authors reported that the subsidy program success highly depends on the policy implementation. He further recommends that in situation where the output is low due to poor inputs accessibility, a solution can be found in fertilizer subsidies program for liberation. The author justified further by giving an example of Sasakawa Global Initiative which consistently led to increase in production in Ethiopia during and after the program, in Rwanda where maize output rose from 3.8% to 7.9% after the subsidy program and in

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Mali where production of cotton enormously increased. Furthermore, Alene et al. (2008), reported that the completely removal of explicit subsidies on small holders, reduced hybrid maize seeds and fertilizer usage quantities in the Eastern and Southern regions of Nigeria. Also, population growth outpaced grain production leading to food insecurity and poor living standards. According to Dorward et al. (2008), reported increment in fertilizer usage, maize output and improvement in household food safety by the program in Malawi. With a cost benefit ratio of 0.76 to 1.36, it verified that the program yield a favorable economic returns.

However, in contrary, Kinuthia (2020) exposes the weakness of the program by revealing an initial increase in maize and rice production in only a few regions in Tanzania, however, it failed in long run. Similarly, adoption of subsidy program negatively affected rice productivity in Ghana (Azumah & Zakaria, 2019). Moreover, Morris et al. (2007) reports that when subsidies are timey, they results in an incremental productivity. However, the long term sustainability of the program in poverty mitigation alongside economic growth is yet to be realized. This agrees with the report by Chirwa (2010) who evaluated the targeted subsidies in Malawi showing that the reason why reintroduction of large scale input subsidies was done was because subsidies were not effective in reducing rural poverty and food insecurity among small holder farmers.

In support, Dorward & Chirwa (2009) and Minot & Benson (2010) reported that under any market condition, especially when output prices are low, profitability of subsidies is never certain. The author further mentions that subsidy program is beneficial only where the technical efficiency especially the quality is considered, timing and appropriate use. In agreement, as reported by Kahsay et al. (2015), only complimentary actions such as research and development can increase the returns on input subsidy program. The author attributes the failure of the program to heavy government expenditure crowding out supplement necessary actions that can lead to increased productivity. According to Leal-Filho et al. (2019) and Monke et al. (2019), who evaluated effectiveness of different policies on Kenyan agricultural targets and on Sustainable Development Goals, they reported subsidy program having no impact on agricultural productivity, poverty and under-nourishment and recommended that increase in productivity could only be achieved through mutual strategies including agriculturalists trainings and agricultural research and development. Similarly, a report by Ragasa & Chapoto (2017) suggested a more holistic approach to encourage fertilizer application and productivity to be adopted by the government of Ghana rather than subsidies which has left maize production low and unbeneficial for over two decades.

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IMPLICATION TO RESEARCH AND PRACTICE

The paper addresses the gaps in low fertilizer application causing declining soil fertility and low maize productivity. The results shows that the government initiatives to increase commercial agricultural inputs use through subsidy program strategy in addressing the issue of low maize productivity focusing on fertilizer input is very crucial and useful. Farmers participating in the subsidy program had a higher fertilizer application rates and productivity compared to those who did not participate in the program. However, they failed to attain the potential maize productivity levels since the fertilizer application rates were low to make an impact on production compared to the recommended rates.

Higher fertilizer application rates is associated with high productivity of maize among the farmers. Any strategy or policy to raise the quantity or quality of fertilizer application will effect a positive change in productivity. This calls for the government to strategies and implement policies that will increase fertilizer usage. This could be through the program expansion to involve more farmers, increase the quantities of fertilizer allocation to each farmer, prices reduction or any other policy that would be favorable to farmers.

In addition, policy makers should consider complementary socio-economic factors alongside the program such as research, innovation, training farmers and extension services which encourage appropriate fertilizer use and are directly focused on increasing fertilizer application rates in order to attain food security.

Despite subsidy program increasing productivity among farmers participating, it may not be beneficial when the fertilizer application rate is lower than the recommended rates. Just as many other regions in Sub Saharan Africa, subsidy program has not been able to achieve the potential productivity frontier. As far as the government continues to implement subsidy policies, strategies to raise application rates could be more critical.

CONCLUSION

It was established that maize productivity substantially increased by the subsidy program participation. In addition, fertilizer quantities, age, household size, seed quality and credit amount were also positively significant. However, group membership negatively affected maize productivity. The factors influencing farmers' participation in the subsidy program were household size, age, years of schooling, amount of credit borrowed and distance to market while distance to the agricultural office negatively affected program participation. The study establishes that, despite average productivity being lower at 2.21t/ha in 2020 compared to 2.26t/ha in 2017, Tobit results shows that farmers who participates in fertilizer

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subsidy program have a higher average productivity of 2.46t/ha as compared to 1.97t/h for non-participants. When priorities are given to the program, productivity has a probability of increasing by 0.323t/ha which is quite impressive. However, in Kakamega County, fertilizer subsidy program has not been able to increase yields to potential production levels since the average fertilizer usage is still low to make an impact on productivity as compared to what is recommended for the country.

In conclusion, subsidies should only be fortified where input market failure is experienced, when market is efficient, subsidies should be abolished. This should trigger the policy makers to go back and contemplate more critical and sustainable initiatives to stimulate farmers such as price stabilization and research and training. In effort to raise productivity, the government, farmers and all stakeholders should develop insight consideration on the program beside other social economic factors.

RECOMMENDATIONS

By the findings showing a higher productivity for subsidy program beneficiaries, the government should consider expansion of the program to incorporate more farmers and target other staple crops. Also focus on strategies that increase application rates of fertilizer.

AREAS FOR FURTHER RESEARCH

Despite the study focusing on the effect of participation in subsidized fertilizer program on maize productivity, other researchers may focus on assessing the impacts of leakages in the subsidy program on productivity at the County and national level and focus on authenticating the results by the use of uniform units across all types, which sets the ratio for all fertilizer types and allows for direct comparisons.

REFERENCE

Akuku, B., Derksen, H., & Haaksma, G. (2019). *Digital Farming in Kenya*.

Alene, A. D., Manyong, V. M., Omanya, G., Mignouna, H. D., Bokanga, M., & Odhiambo, G. (2008). Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. *Food Policy*, *33*(4), 318–328. https://doi.org/10.1016/j.foodpol.2007.12.001

Alhassan, A., Abdul-Hamid, B. M., & Gazali, I. (2020). Fertilizer subsidy policy and smallholder farmers crop productivity: The case of maize production in North-Eastern Ghana. *Journal of Agricultural Extension and Rural Development*, *12*(2), 18–25. https://doi.org/10.5897/jaerd2020.1138

Asante, B. O., Afarindash, V., & Sarpong, D. B. (2011). Determinants of small scale farmers decision to join farmer based organizations in Ghana. *African Journal of*

@ECRTD-UK-https://www.eajournals.org/
https://doi.org/10.37745/ijaerds.15

Vol.8, No.5, pp.44-62, 2021

Print ISSN: ISSN 2058-9093,

Online ISSN: ISSN 2058-9107)

Agricultural Research, *6*(10), 2273–2279.

Azumah, S. B., & Zakaria, A. (2019). Fertilizer Subsidy and Rice Productivity in Ghana: A Microeconomic Study. *Journal of Agricultural Studies*, *7*(1), 82. https://doi.org/10.5296/jas.v7i1.14367

Barmao, C., & Tarus, K. (2019). Maize Crisis : A Position Paper on Strategies for Addressing Challenges Facing Maize Farming In Kenya. *East African Scholars Journal of Education, Humanities and Literature Abbreviated*, *2*(3), 149–158.

Boulanger, P., Dudu, H., Ferrari, E., Mainar-Causapé, A. J., & Ramos, M. P. (2020). Effectiveness of fertilizer policy reforms to enhance food security in Kenya: a macro–micro simulation analysis. *Applied Economics*, *1*(5), 1–21. https://doi.org/10.1080/00036846.2020.1808180

Bunde, A. O., Kibet, K., Otieno, D., & Mugo, S. W. (2019). *Impact of Fertilizer Input Subsidy on Maize Production in Nandi North District , Kenya . 4531*(10), 520–540.

Chibwana, C., Jumbe, C. B. L., & Shively, G. (2013). Agricultural subsidies and forest clearing in Malawi. *Environmental Conservation*, *40*(1), 60–70. https://doi.org/10.1017/S0376892912000252

Chirwa, T. G. (2010). Program evaluation of agricultural input subsidies in Malawi using treatment effects: Methods and practicability based on propensity scores. *Munich Personal RePEc Archive*, *20878*.

Debnath, D., & Babu, S. C. (2020). *Prospects for sustainable intensification of soybean production in sub-Saharan Africa*. *15*(4), 365–371.

Denning, G., Kabambe, P., Sanchez, P., Malik, A., Flor, R., Harawa, R., Nkhoma, P., Zamba, C., Banda, C., Magombo, C., Keating, M., Wangila, J., & Sachs, J. (2009). Input subsidies to improve smallholder maize productivity in Malawi: Toward an African green revolution. *PLoS Biology*, *7*(1).

Diiro, G. M., Ker, A. P., & San, A. G. (2015). The role of gender in fertiliser adoption in Uganda. *African Journal of Agricultural and Resource Economics*, *10*(311-2016–5630), 117–130.

Djurfeldt, G., Holmen, H., Jirström, M., & Larsson, R. (2005). *The African food crisis: Lessons from the Asian green revolution.* CABI publishing.

Dorward, A., & Chirwa, E. (2011). The Malawi agricultural input subsidy programme: 2005/06 to 2008/09. *International Journal of Agricultural Sustainability*, *9*(1), 232–247.

Dorward, A., Chirwa, E., Kelly, V. A., Jayne, T. S., Slater, R., & Boughton, D. (2008). *Evaluation of the 2006/7 Agricultural Input Subsidy Programme, Malawi: Final Report*. *March*, 1–131.

Druilhe, Z., & Barreiro-hurlé, J. (2012). *Fertilizer subsidies in sub-Saharan Africa*. *12*.

DTMA. (2015). Maize in Kenya: Chance for Getting Back to Former Glory? *A Quarterly*

Vol.8, No.5, pp.44-62, 2021

Print ISSN: ISSN 2058-9093,

Online ISSN: ISSN 2058-9107)

Bulletin of the Drought Tolerant Maize for Africa Project, *4*(3), 4.

Fisher, M., Abate, T., Lunduka, R. W., Asnake, W., Alemayehu, Y., & Madulu, R. B. (2015). Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: Determinants of adoption in eastern and southern Africa. *Climatic Change*, *133*(2), 283–299.

Gawamadzi, S. B., & Kosura, W. (2011). *the Effects of Input Subsidies on Maize Productivity in Malawi*. *44*(5), 1–38.

Geffersa, A. G. (2019). Technology adoption and technical efficiency in maize production in rural Ethiopia. *African Journal of Agricultural and Resource Economics*, *14*(3), 184–201.

Greaves, G. E., & Wang, Y. M. (2017). Yield response, water productivity, and seasonal water production functions for maize under deficit irrigation water management in southern Taiwan. *Plant Production Science*, *20*(4), 353–365.

Jena, P. R., De Groote, H., Nayak, B. P., & Hittmeyer, A. (2021). Evolution of Fertiliser Use and its Impact on Maize Productivity in Kenya: Evidence from Multiple Surveys. *Food Security*, *13*(1), 95–111.

Kahanna, N., & Solanki, P. (2014). Agricultural & Horticultural Sciences. *Agricultural & Horticultural Sciences*, *2*(4), 1–16.

Kahsay, W. S., Koroto, S., Masrie, B., Dechassa, N., Tana, T., Alemayehu, Y., Abebie, B., Rosen, C. J., Kelling, K. A., Stark, J. C., Porter, G. A., Ariga, J., Jayne, T. S., Oseko, E., Dienya, T., Linus, M. M., Irungu, J. W., Sarkar, A., … Usman, M. (2015). Fertilizer consumption and fertilizer use by crop in Kenya Study Conducted For Africafertilizer. *American Journal of Potato Research*, *5*(1), 1–23.

Kinuthia, B. K. (2020). *WIDER Working Paper 2020 / 149 Agricultural input subsidy and outcomes for farmers in Tanzania Bethuel Kinyanjui Kinuthia* .

Kirimi, L. (2012). History of Kenyan maize production, marketing and policies. *Kenya: Tegemeo Institute of Agricultural Policy and Development Nairobi*.

Kirimi, L., Sitko, N. J., Jayne, T. S., Karin, F., Muyanga, M., Sheahan, M., Flock, J., & Bor, G. (2011). *A farm gate-to-consumer value chain analysis of Kenya's maize marketing system*.

Kirimi, L., Sitko, N., Jayne, T. S., Karin, F., Sheahan, M., Flock, J., & Bor, G. (2011). A Farm Gate-to-Consumer Value Chain Analysis of Kenya's Maize Marketing System. *Agricultural Economics*.

KNBS. (2019). Kenya Population and Housing Census Volume 1: Population by County and Sub-County. In *2019 Kenya Population and Housing Census: Vol. I* (Issue November). https://www. knbs.or.ke/?

Leal Filho, W., Tripathi, S. K., Andrade Guerra, J. B. S. O. D., Giné-Garriga, R., Orlovic Lovren, V., & Willats, J. (2019). Using the sustainable development goals towards a

@ECRTD-UK-https://www.eajournals.org/
https://doi.org/10.37745/ijaerds.15

better understanding of sustainability challenges. *International Journal of Sustainable Development and World Ecology*, *26*(2), 179–190. https://doi.org/10.1080/13504509.2018.1505674

Magut, I., Mwenda, L., & Wachira, A. (2019). Effects of Government Input Subsidy Program on Maize Production in Uasin-Gishu County. *Journal of Public Policy and Administration*, *4*(1), 45–57.

Makau, J. M., Irungu, P., Nyikal, R. A., & Kirimi, L. W. (2016). An assessment of the effect of a national fertiliser subsidy programme on farmer participation in private fertiliser markets in the North Rift region of Kenya. In *African Journal of Agricultural and Resource Economics*. *11*(4).

Mavuthu, A. K. (2017). *Effect of the National Accelerated Agricultural Inputs Access Subsidy Program on Fertilizer Usage and Food Production in Kakamega County , Western Kenya (Doctoral dissertation)* [Walden University]. https://scholarworks.waldenu.edu/dissertations

Mellor, J. W. (2019). *Core requirements for rapid agricultural growth and poverty reduction in Sub-Saharan Africa 1*. *14*(3), 219–224.

Mohammed, M. (2021). Empirical Analysis of the Factors that Affecting Maize Production of Farmers among Smallholders : The Case of Eastern Oromia , Ethiopia Turkish Journal of Agriculture - Food Science and Technology Empirical Analysis of the Factors that Affecting Maize Pro. *Turkish Journal of Agriculture -Food Science and Technology*, *9*(1), 137–145.

Monke, E. A., Argwings-Kodhek, G., Avillez, F., Mukumbu, M., Pagiola, S., Sellen, D., & Winter-Nelson, A. (2019). Agricultural Policy in Kenya. *Agricultural Policy in Kenya*, *March*, 20–22.

Morris, M. L., Kelly, V. A., Kopicki, R. J., & Byerlee, D. (2007). *Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines. Washington DC: The World Bank*.

Munialo, S., Dahlin, A. S., Onyango M., C., Oluoch-Kosura, W., Marstorp, H., & Öborn, I. (2020). Soil and management-related factors contributing to maize yield gaps in western Kenya. *Food and Energy Security*, *9*(1), 1–17. https://doi.org/10.1002/fes3.189

Odilla A, G., Mwiti G, R., & NyongesaNato, G. (2018). Technical Knowledge and Information Gaps among Smallholder Farmers in the Production, Kakamega County, Kenya. *International Journal of Agricultural Science, Research and Technology in Extension and Education Systems*, *3*(4), 199–207.

Ochola, R. O., & Fengying, N. I. E. (2015). Evaluating the effects of fertilizer subsidy programmes on vulnerable farmers in Kenya. *Journal of Agricultural Extension and Rural Development*, *7*(6), 192–201.

Onzima, B. (2017). *The effect of climate change adaptation strategies on bean yield in central and northern Uganda*. *14*(4), 279–291.

Phakathi, S., Sinyolo, S., Fraser, G. C. C., & Marire, J. (n.d.). Heterogeneous welfare effects of farmer groups in smallholder irrigation schemes in South Africa. *African Journal of Agricultural and Resource Economics Volume*, *16*(1), 27–45.

Ragasa, C., & Chapoto, A. (2017). Moving in the right direction? The role of price subsidies in fertilizer use and maize productivity in Ghana. *Food Security*, *9*(2), 329–353.

Ragasa, C., Dankyi, A., Acheampong, P., Wiredu, A. N., Chapoto, A., Asamoah, M., & Tripp, R. (2013). Patterns of Adoption of Improved Rice Technologies in Ghana. *IFPRI Working Paper N 35, July*.

Raimi, A., Adeleke, R., & Roopnarain, A. (2017). Soil fertility challenges and Biofertiliser as a viable alternative for increasing smallholder farmer crop productivity in sub-Saharan Africa. *Cogent Food & Agriculture*, *3*(1), 1400933. https://doi.org/10.1080/23311932.2017.1400933

Ranum, P., Peña-Rosas, J. P., & Garcia-Casal, M. N. (2014). Global maize production, utilization, and consumption. *Annals of the New York Academy of Sciences*, *1312*(1), 105–112.

Ricker-Gilbert, A. J., Jayne, T. S., Chirwa, E., American, S., Economics, A., January, N., Ricker-gilbert, J., Jayne, T. S., & Chirwa, E. (2011). Agricultural & Applied Economics Association Subsidies and Crowding Out : A Double-Hurdle Model of Fertilizer Demand in Malawi. *American Journal of Agricultural Economics*, *93*(1), 26–42. https://doi.org/10.1093/ajae/aaql22

Ricker-Gilbert, J., Mason, N. M., Jayne, T. S., Darko, F., & Tembo, S. (2013). What are the Effects of Input Subsidies on Maize Prices ? Evidence from Malawi and Zambia. *Indaba Agricultural Policy Research Institute Working Paper*, *75*(6). http://onlinelibrary.wiley.com/doi/10.1111/agec.12081/pdf

Saalu, F. N., Oriaso, S., & Gyampoh, B. (2020). Effects of a changing climate on livelihoods of forest dependent communities: Evidence from Buyangu community proximal to Kakamega tropical rain forest in Kenya. *International Journal of Climate Change Strategies and Management*, *12*(1), 1–21.

Scheiterle, L., Häring, V., Birner, R., & Bosch, C. (2019). Soil , Striga , or subsidies ? Determinants of maize productivity in northern Ghana. *The Journal of International Association of Agricultural Economists*, *50*(1), 479–494. https://doi.org/10.1111/agec.12504

Selejio, O. (2017). Economic analysis of the adoption of inorganic fertilisers and improved maize seeds in Tanzania. *African Journal of Agricultural and Resource Economics*, *12*(11), 142–157.

https://doi.org/10.37745/ijaerds.15

Vol.8, No.5, pp.44-62, 2021

Print ISSN: ISSN 2058-9093,

Online ISSN: ISSN 2058-9107)

Smale, M., Amidou A., Theriault, V. (2020). *Effects of the Fertilizer Subsidy Program on Fertilizer use, Farm Productivity and Crop Sales in Mali* (Issue May).

Suri, D. J., & Tanumihardjo, S. A. (2016). Effects of different processing methods on the micronutrient and phytochemical contents of maize: from A to Z. *Comprehensive Reviews in Food Science and Food Safety*, *15*(5), 912–926.

Theriault, V., Smale, M., & Haider, H. (2018). Economic incentives to use fertilizer on maize under differing agro-ecological conditions in Burkina Faso. *Food Security*, *10*(5), 1263–1277.

Wang, M., Han, J., Dunn, J. B., Cai, H., & Elgowainy, A. (2015). Well-to-wheels energy use and greenhouse gas emissions of ethanol from corn, sugarcane and cellulosic biomass for US use. *Efficiency and Sustainability in Biofuel Production: Environmental and Land-Use Research*, 249–280.

Wiredu, A. N., Zeller, M., & Diagne, A. (2015). Impact of fertilizer subsidy on land and labor productivity of rice-producing households in Northern Ghana. *Centre for the Study of African Economies (CSAE) Annual Conference, Oxford, UK*, *3*, 22–24.

World Bank. (2018). Investing in opportunity, ending poverty. *Annual Report 2018*, 35.

Zellner, A. J. Menta, K and Dreze, J. (2013). *Specification and Estimation of Cobb-Douglas Production Function Models Author (s): A . Zellner , J . Kmenta and J . Drèze Reviewed work (s): Published by : The Econometric Society Stable URL : http://www.jstor.org/stable/1910099 . 34*(4), 784–795.

@ECRTD-UK-https://www.eajournals.org/
https://doi.org/10.37745/ijaerds.15