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Effects of Adoption of Agricultural Technologies on Irish Potato Yield in Ol Kalou Sub-County Kenya: Application of Endogenous Switching Regression Model

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ABSTRACT

Population growth has increased demand and diversified use of Irish potato which have increased its demand. The crop has become a major source of food and income for many households across the world. However, despite the high potential of about 30 tonnes per hectare (ha), smallholder farmers in Kenya realize low Irish potato yields ranging from 4-8 tonnes per ha due to limited uptake of agricultural technologies. The low yields calls for a profound understanding of the factors influencing the uptake agricultural technologies. The study analyzed the effects of the adoption of agricultural technologies on Irish potato yield in Ol Kalou Sub County. The study considered chemical fertilizer, certified seeds, fungicides, and farm machinery as the four main agricultural technologies that that affect yield. A descriptive cross-sectional research design was used to obtain data from a study population of 21,942 smallholder Irish potato farmers in Ol Kalou Sub County. A multiple-stage sampling technique was employed to generate a sample size of 385 respondents who provided primary data. Data collected was analyzed using endogenous switching regression model using STATA version 17. The study found that the average treatment effect on treated (ATT) was 10.21 bags per acre. In addition, the Endogenous switching regression model showed that the expected yield for the adopter increased by 51.83%. Out of the four technologies, the use of chemical fertilizers had the highest effect of 37% on yield. The study concluded that the adoption of agricultural technologies increases the yield of Irish potatoes. The study recommends that national and county governments should develop policy regulations such as training and extension services, market access, price support and public-private partnerships encouraging farmers to uptake agricultural technologies. The study also recommends that both levels of government should subsidize agricultural technologies, hence reducing the cost of adoption.

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Introduction

Irish potato is an essential food crop recommended by the United Nations as a vital food security crop produced in over 100 countries globally (Djaman et al., 2021). Irish potato originated from Ireland, thereby gaining the term "Irish", and later spread to other parts of the world during the movements of the Britons (Hassan et al., 2020). Potato is a primary food crop produced in the majority of developing countries. It is the fourth most-produced food crop globally at about 314 after corn at 822, wheat at 689 and rice at 685 million metric tonnes (Wang et al., 2020). In most parts of the world, especially Africa, Asia, Europe, and Southern and Northern America, Irish potato production is a fundamental economic activity both for small-scale and large-scale farmers who aim at increasing food security (Thuo & Maina, 2024). The Irish potato produced in the world does not meet the global demand, which calls for improvement in production technologies (Karashchuk & Fedonenko, 2020).

The global Irish potato production is over 300 million metric tonnes annually, and over one billion people consume potato globally (Setiawan & Inayati, 2020. The high number of individuals consuming potato shows the importance of the crop to most households in different parts of the globe. Before the 1990s, the major potato producers and consumers were North America, Europe, and most members of the Soviet Union (Muriithi et al., 2020). Since 2017, there has been a drastic increase in potato demand in developing countries, including Latin

America, Africa, and Asia, which requires producers to improve their production practices (Richards & Rickard, 2020). China's production surpasses that of any other country globally, and approximately a third of the world's production is done in China and India, with the production of about 22 percent Irish potato produced annually in the world (Wang et al., 2020).

In most of the countries in the world where agrarian transformation has occurred, improvement in Irish potato productivity has been facilitated by improved technologies such as fertilizers, clean seeds, use of machineries and fungicides (Evelyne et al., 2021; Muriithi et al., 2020; Setiawan & Inayati, 2020). Since 2010, there has been an increase in potato production in China and India, which can be attributed to the adoption of irrigation technology among potato farmers especially regions that did not grow potato previously (Muriithi et al., 2020). The increase in potato production could also be attributed to population growth and the need for food (Evelyne et al., 2021). Lack of application of technology in agricultural production results in low agricultural yields (Akoto et al., 2020 and Wei & Lu, 2024).

The average Irish potato production in Africa is about 14.2 tonnes per hectare (ha) (Djaman et al., 2022). There is a significant gap in the production other continents, such as America, producing 25.9 tonnes per ha, Europe at 21.1 tonnes per ha, and Asia at 18.3 tonnes per Ha (Barasa, 2019). The difference in Irish potato production between Africa and other countries is attributed to differences in the application of agricultural technologies (Evelyne et al., 2021). Despite Africa lagging behind, FAO statistics showed that potato production has tripled from 8 to 24 million metric tonnes from 1994 through 2011, which is attributed to increased cropping area and the application of agricultural technology (Hossain, 2016). A study by Richards & Rickard (2020) established that the current level of Irish potato production could rise by 140 percent if farmers embrace application of the available technology. Fitz-Koch et al. (2018) alluded that entrepreneurs in sub-Saharan Africa have established that the uptake of agricultural technologies is key in increasing the yield of different crops, including the Irish potato.

In Kenya, just as in other parts of the world, Irish potato demand has risen in the past decade due to increasing urbanization, where it is ranked second among town dwellers consumers (Thuo & Maina, 2024). Kenya has a potential yield of between 4 and 8 tonnes per hectare compared to a world potentiality of 30 tonnes per hectare (Evelyne et al., 2021). Barasa (2019)) reported that Kenya's acreage of Irish potato production is gradually reducing from 192,341 hectares in 2007 to about 109,614 hectares in 2017, which is associated with land fragmentation. If the farmers are to overcome the decline in Irish potato production, the uptake of advanced practices would increase ease and efficiency at the farm level and in marketing. Kenya has a high potential for potato production, which has remained underutilized for many years due to the lack of uptake of agricultural technologies in different parts of the country (Barasa, 2019). The Kenyan government has come up with structures in agricultural research that are geared toward enabling the agriculture sector to be responsive to low production (Thuo & Maina, 2024).

Adoption of agricultural technology has resulted in increased yield among adopters (Far & Rezaei-Moghaddam, 2018), Donkoh et al., 2019), and Shita et al., 2020). The uptake of innovations in the agricultural sector has been a game-changer in both yield and income for the farmers (Shita et al., 2020). There is a significant difference in yield between the non-adopters and adopters of agricultural technologies (Donkoh et al., 2019. There have been intense studies in developed countries about the impact of the adoption of agricultural technologies on yield and income; Therefore, there is a need to establish the effect adoption of agricultural technologies in Ol Kalou. Ol Kalou Sub County lies in Nyandarua County, which is a top potato producer, contributing approximately 33% of total potato production in Kenya, which is below its potential (Muriithi et al., 2020). Mwangi et al. (2015) argued that the sector supports the potato value chain directly or indirectly with over 131,697 farm families. Despite, Irish potato being the second most-produced agricultural product in the County, after dairy, there is low adoption of agricultural technologies (Nyagaka et al., 2010). Irish potato production in Ol Kalou is, on average, 4-8 tonnes per hectare, which is below the average potentiality of about 30 tonnes per hectare produced in developed countries (Mumia et al., 2018). There is a need to establish the influence of the adoption of agricultural technologies on yield.

Materials and Methods

Study Area

The study was carried out in all five wards of Ol Kalou Sub County in Nyandarua County in June and October 2022. The five wards include Kaimbaga, Ruria, Karau, Kanjuire Ridge and Mirangine, which covers a total area of 384.9 km^2 and has a population of 75,262 (County Government of Nyandarua, 2018). The area was selected because it had was among high Irish potato producers in Kenya where government had invested in agricultural technologies in the past 10 (Mumia et al., 2018). Ol Kalou is located on the west slopes of the Aberdare Ranges, and it is one of the five sub-counties of Nyandarua County. The majority of the land in Ol Kalou Sub County is arable due to the fertile soils in the area (Mumia et al., 2018).

Research Design

The study applied a descriptive cross-sectional research design. The research design described the state of adoption of agricultural technologies among Irish potato farmers. Blazy et al. (2009) stated that a descriptive cross-sectional research design is one of the approaches that utilize and gain an accurate profile of effects of adoption of agricultural technologies on yield. The use of descriptive research design catered for the collection of mixed techniques involving qualitative and quantitative data. Finally, the design was useful in the determination of the impacts of the adoption of agricultural technologies on yield.

Target Population and Sample Size

The study targets smallholder Irish potato farmers in Ol Kalou sob-county. The total study population was 21942 (County Government of Nyandarua, 2018) households practicing Irish potato production in Ol Kalou Sub County. The major qualification for one to qualify to be a respondent is that they must be a smallholder Irish potato producer. Additionally, one had to be an Irish potato farmer continuously for the past five years from 2018 to 2022. The continuous ensured that there were no new entrants in Irish potato production since they may lack adequate knowledge about the available agricultural technologies and their impact on yield. A sample size of 385 was obtained using Cochran formula and multiple stage sampling technique was applied to select the respondents.

Data Collection

The study adopted the use of primary data, which was collected through a structured questionnaire that captured various variables of the study. The questionnaire was installed in Open Data Kit (ODK) and later downloaded in SPSS. The questionnaires were administered with the assistance of enumerators who understand the local language. In addition, data on effect of adoption of agricultural technology on yield and income of smallholder Irish potato was collected in two Irish potato seasons namely June-August and August-October, 2022. The production schedule administered by the five enumerators were to record the total output for adopters and non-adopters.

Data Analysis

The primary data collected was first checked and sorted for consistency and completeness before analysis. Checking and sorting were done with the aim of making sure all elements of the questionnaire were answered. The study used descriptive statistics like frequencies and percentages to present and summarize data collected from smallholder Irish potato producers in Ol Kalou Sub County. The study also employed Pearson correlation analysis to establish any significant association between different study variables. The study applied independent sample test to establish the yield difference between the adopters and non-adopters of agricultural technologies. Endogenous Switching Regression (ESR) was used to determine the impact of yields.

Endogenous Switching Regression Model

The Irish potato farmer's decision to uptake a given technology was under the condition of the different variables. A farmer expects to maximize yield which is their utility function subject to different variables that forms the constraints. The use of the ESR model to analyze the potential yield for non-adopters and adopters of agricultural technologies was justified since the model accounted for bias associated with unobserved variables.

$$R = W_A - W_{NA} > 0 \quad (1)$$

where R represents the dummy observed variable that is 0 for the non-adopters and 1 for adopters of agricultural technology. W represents the benefits a farmer obtains from the adoption of agricultural technologies, such as crop productivity, increased income and food security. The subscripts (A) denote the adopters of technologies, and (NA) is for non-adopters of agricultural technologies, respectively. The extent of adoption of agricultural technologies can be specified as follows;

$$\log R_i = \max(0, R_i^*) + \beta' X'_{\mathrm{i}} + Ui \quad (2)$$

The ESR model involved two stages. The model started by adoption behaviour using the constrain variable. The first step was followed by estimation of productivity discretely for non-adopters and adopters of combined technologies conditional on their decision to uptake agricultural technologies. Therefore, an ordered probit model was utilized to model the adoption behaviour of Irish potato farmers, and separate regression models were used to model the production function conditional to the specified criterion function.

The decision of a farmer to uptake a given technology can be modelled in a utility maximization framework (Läpple & Kelley, 2013). Utilities difference between the adopters U_{Ai} and the non-adopters U_{Ni} of agricultural technologies (AGs) of Irish potato was denoted as $G*$ such that the i^{th} farmer was likely to adopt given technologies if U_{Ai} was greater than U_{Ni}. That is, a farmer would adopt a bundle of AGs when G*= U_{Ai} - U_{Ni} >0. G* was unobservable and hence the study expressed it as a function of observable issues in the latent variable (probit model) as follows:

$$G^*_1 = \beta X_i + ui \text{ where } G_1 = \begin{cases} 1 \text{if } G^*_1 > 0 \\ 0 \text{ if } G^*_1 \leq 0 \end{cases} \quad (3)$$

where G is dichotomous taking value of 0 for non-adopters and 1 for adopters of agricultural technologies on Irish production, X is the vector of independent variables; β is the vector of unknown constraints while u is the stochastics random term with mean and variance σ^2 of 0. The maximum likelihood estimation procedure was applied to determine the vector of probit coefficients β.

$$Y_{1i} = \alpha_1 J_{1i} + \epsilon_{1i}, \text{if } G_1{:}\ 1 \quad (4)$$

$$Y_{0i} = \alpha_0 J_{0i} + \epsilon_{0i}, \text{if } G_1{:}\ 0 \quad (5)$$

Y_1 and Y_0 represent Irish potato yield with agricultural technologies and without agricultural technologies, respectively. For a given Irish potato farmer, Y_1 or Y_0 were observed based on the values of criterion function in equation (2). The model made an assumption that the error terms had a trivariate normal distribution with non-singular covariance matrix and mean of 0 as expressed below;

$$COV(\epsilon_{1i}\epsilon_{0i}, u_i\epsilon) = \begin{pmatrix} \sigma^2{}_{\epsilon 1} & \sigma_{\epsilon 1e0} & \sigma_{\epsilon 1u} \\ \sigma_{\epsilon 1e0} & \sigma^2{}_{\epsilon 0} & \sigma_{\epsilon 0u} \\ \sigma_{\epsilon 1u} & \sigma_{\epsilon 0u} & \sigma^2{}_u \end{pmatrix} \quad (6)$$

where the $\sigma^2{}_u$ represent variance of the error in the criterion equation (6) $\sigma^2{}_{\epsilon 1}$ and $\sigma^2{}_{\epsilon 0}$ are the variances of the errors α_1e1 and e0in the yield outcome function in eq 1 are the covariances respectively of the error terms u , ϵ_1, and ϵ_0. The outcome functions equations were not observed concurrently as expressed by equations 6 and 7:

$$E|\epsilon 1i|\ G_i = \sigma_{\epsilon 1u} \frac{\phi(\beta X_i/\sigma)}{\Phi(\beta X_i/\sigma)} = \sigma_{\epsilon 1u}\lambda_{1i} \quad (7)$$

$$E|\epsilon 0i|\ G_i = -\sigma_{\epsilon 0u} \frac{\phi(\beta X_1/\sigma)}{1-\Phi(\beta X_i/\sigma)} = \sigma_{\epsilon 0u}\lambda_{0i}\,. \quad (8)$$

where;
ϕ -is the standard normal probability density function
Φ-is standard normal cumulative density function
λ_{1i} and λ_{0i} Estimated ratio evaluated at βX_i

The study also used full information maximum likelihood (FIML) to estimate the endogenous switching regression model. The FIML estimated concurrently the conditional equation (probit model) and the yield functions to give standard errors that were reliable. The equation was given as:

$$Ln\ L = \sum_{i=1}^{n} G_i \left(ln\phi\left(\frac{\epsilon 1i}{\sigma_{\epsilon 1}}\right) - ln\sigma_{\epsilon 1} + ln\Phi(\phi_{1i}) \right) + (1 - G_i)\left(ln\phi\left(\frac{\epsilon 0i}{1\sigma_{\epsilon 0}}\right) - ln\sigma_{\epsilon 1} + \ln\left(1 - \Phi(\phi_{1i}\right) \right) \quad (9)$$

The study assumed that production, financial and marketing factors had differential effects on productivity where separate yield outcome functions for adopters and non-adopters had to be specified, while at the same time accounting for endogeneity. Therefore, the econometric problem involved sample selection and endogeneity.

Results

Level of Adoption

The study sought to categorize the farmers into either adopters or non-adopters of agricultural technologies in the Ol Kalou sub-county. It was found that that majority (52.20%) were adopters of agricultural technologies while 47.80% were non-adopters in production of Irish potato (Table 1).

Difference in Yield Between Adopters and Non-Adopters

The study sought to determine whether there was a significant difference between the adopters and non-adopters of agricultural technologies on Irish potato yield. Independent samples *t*-test was used to establish whether there was a difference in yields between adopters and non-adopters. The equality of variances test showed an F value of 43.09 and a significant value of 0.00, indicating that there was significant variability in yield between the adopters and non-adopters (Table 2). The study findings showed a significant difference in yield obtained from Irish potato production between adopters and non-adopters, with a *t*-value of 5.32 and a p-value of 0.00 (Table 2).

The study findings showed that there is a difference in farm productivity per acre between the adopters and non-adopters of agricultural technologies (Table 2). The findings of this study suggest that adoption of different agricultural technologies among Irish potato farmers had a measurable impact on yield. Additionally, the findings of the study implied that the use of agricultural technologies in the Irish potato sub-sector was likely to contribute to changes in yield per acre. The study findings are consistent with those of Shita et al. (2020), who found a significant difference in crop production between the adopters and non-adopters of agricultural technologies. However, further analysis was done using the ESR model to establish which group had more output.

Estimation of Yields Using the Endogenous Switching Regression Model

The study sought to determine the impact of the adoption of agricultural technologies on yields using the endogenous switching regression model (ESR). The ESR model was used to compare the expected yield of adopters and non-adopters of agricultural technologies. The study compared the yield of the actual situation (adopters if they do not adopt) and the counterfactual condition (yield of a farmer without technologies if they adopt). To determine if there was a significant effect upon adoption of agricultural technologies on yield, the following hypothesis was formulated;

H_0: There is no statistically significant effect of the adoption of agricultural technology on the yield of smallholder Irish potato farmers in Ol Kalou Sub County.

The findings indicated that the expected yield of the farmer who adopted agricultural technologies was 40.22 bags per acre, while the expected yield of the farmer who did not adopt was 30.01 bags per acre under the counterfactual condition (Table 3). The findings of the study found that the average treatment effect on treated (ATT) was 10.21 bags per acre (p=0.01<0.05), indicating that adopters of agricultural technologies had a possibility of decreasing their expected yield by 25.39% per acre (Table 3) if they failed to adopt the technology.

Table 1. Adopters and Non-adopters of agricultural Technologies.

Level of Adoption	Frequency	Percent
Adopters	201	52.20
Non-Adopters	184	47.80

Table 2. Independent Samples *t*-Test for Output Variation

Variable	Category	F	Sig	t	Df	Sig (2-tailed)
Output	Equal Variances Assumed	43.09	0.00	5.21	383	0.00
	Equal Variances not Assumed			5.32	332.79	0.00

Note: *** significant at 1% level, ** significant at 5% level, *significant at 10% level

Table 3. Average Treatment Effect of Treated and Average Treatment Effect of Untreated the in Irish Potato Yield

Outcome	Mean Outcome		ATT	ATU	Effect (%)
	Adopters	Non-Adopters			
Total Yield (bags/acre)	40.22(0.02)	30.01(0.02)	10.21**(0.01)		25.39
	42.02(0.06)	20.24(0.05)		21.78**(0.01)	51.83

Note: *** significant at 1% level, ** significant at 5% level, *significant at 10% level

Table 4. Effects of Different Agricultural Technologies on Yield of Farmers: Estimates by ESR Model

Category		Mean Outcome		ATT	ATU
		Adopters	Non-Adopters		
Fertilizer	Yes	3.69(0.05)	3.33(0.05)	0.37**(0.03)	
	No	5.28(0.04)	3.40(0.03)		1.88**(0.03)
Certified Seeds	Yes	4.02(0.06)	3.65(0.05)	0.35***(0.03)	
	No	5.78(0.02)	3.94(0.02)		1.84***(0.02)
Fungicides	Yes	3.49(0.07)	3.20(0.06)	0.29*(0.04)	
	No	4.08(0.06)	3.05(0.05)		1.03*(0.03)
Farm Machinery	Yes	4.13(0.05)	3.81(0.05)	0.32*(0.03)	
	No	4.09(0.06)	3.75(0.05)		0.34*(0.03)

Note: *** significant at 1% level, ** significant at 5% level, *significant at 10% level

Furthermore, the findings of this study showed that if the farmers do not actually adopt agricultural technologies, the average treatment effect on untreated (ATU) was 21.78 bags per acre (p=0.01<0.05), implying that the expected yields increased by 51.83% per acre (Table 3).

Effect of Agricultural Technologies on Yield

The study also sought to establish whether the four technologies (use of chemical, certified seeds, farm machinery and fungicides) under investigation had differences in the impact of the yield of Irish potato. The findings of the study indicated that use of chemical fertilizer technology had the highest impact on the yield indicating a 37.00% increase for adopters of Irish potato at a 5% significant level. The outcomes of the study indicated that the application of certified seeds had the second-highest yield-increasing effect of 35.00% at a 1% statistical level (Table 4).

The adoption of farm machinery was significant at a 10% statistical level. The uptake of farm machinery had the third highest effect on yield at 32.00%. The adoption of fungicides had the least impact, indicating that the adoption increased yield by 29.00%. The adoption of fungicides had a positive and significant impact at 10% statistical level (Table 4).

Discussion

The difference between the actual yields and the counterfactual condition yields reflected the average treatment effect associated with the adoption of agricultural technologies (yield increasing effect brought by the application of agricultural technologies) [Table 3]. The study also found that the farmers who did not actually uptake agricultural technologies had a more significant yield increase if they adopted more agricultural innovations shown by ATU>ATT. The finding suggests that the uptake of agricultural technologies in Irish potato production improves farm-level productivity. Therefore, these findings do not support the null hypothesis that there is no statistically significant effect of adoption of agricultural technology on yield of smallholder Irish potato. The findings from this study may also indicate that the farmers who do not uptake the available technologies are likely to reduce their output due to the dynamic nature of the agricultural sector that is characterized by seasonality, infestation from pests and diseases and loss of soil fertility (Table 3). The findings of this study are in agreement with those of Wu (2022) and Fuglie & Echeverria (2024), who found that the adoption of agricultural technology has an impact on increasing output.

The findings imply that applying chemical fertilizers provides crop nutrients and encourages vegetative growth, which renews soil organic matter, which is essential in increasing yields (Table 4). In addition, the application of chemical fertilizer technology, especially if it is a biofertilizer, may improve soil biological activities and promote its properties, hence increasing soil fertility. The findings of this study concur with those of Tilahun et al. (2022), and Haris et al. (2023), who found that the usage of chemical fertilizer technology forms a source of essential plant nutrients, which increases crop yield. Further, the findings of this study are in agreement with those presented by Wu (2022), who postulated that the application of chemical fertilizer technology ensures soil fertility that assists in increasing crop yields.

The findings of the study imply that the adoption of certified seeds can increase a farmer's productivity per unit area. Additionally, the use of certified seeds is associated with a reduction in incidences of transfer of insect pests and diseases from one farm to another or from one season to another, which may increase the yield. The findings of the study are in consonance with those of Fuglie & Echeverria (2024), who established that the use of certified seed increases yield compared to the where the farmers recycle the seed. Similar findings are presented by Zilberman et al. (2018), who established that usage of certified seeds improves yields since the seeds are resistant to pests and tolerant to herbicides and drought.

The findings indicated that the adoption of farm machinery could promote farm productivity, hence increasing yields (Table 4). The findings of this study may also show that the adoption of farm machinery can save agricultural labour and increase the area in which a farmer operates, thereby increasing yields. The adoption of farm machinery technology may imply that farmers increase efficiency and assist in growing more crops in less time. The findings of this study agree with those of Wei & Lu (2024), who established that adopting farm machinery reduces the farmer's labour input cost, allowing them to concentrate on improving productivity. The outcomes of this study are in consonance with Liao et al. (2022), who postulated that the adoption of farm machinery reduces labour costs and increases the yields per unit area. However, the findings of the study are against the one presented by Mohammed et al. (2023), who found that the adoption of farm machinery technology had the least impact on yield and income, which was associated with limited usage and a low degree of mechanization among farmers.

The findings imply that the adoption of the fungicide technology could have been higher in the study area, although their usage did not affect the final yield. The study findings are against Kassaw et al. (2021), who established that the impact of fungicide technology among Irish potato farmers had immense benefits on yield due to the presence of late and early blight. On the other, the findings are against those of Periakaruppan et al. (2023), who reported that the adoption of the fungicide technology is a major driver towards the reduction of potato late blight, which is a major constraint to productivity.

Conclusion

The study concluded that there is significant variability in yield between the adopters and non-adopters of agricultural technologies among Irish potato farmers. In addition, there was a significant difference in productivity per acre between the two levels of adoption. The difference between the actual yields and the counterfactual condition yields showed the average treatment effect on treat (ATT) which was associated with adoption of agricultural technologies. The ATT concluded that adopters of agricultural technologies had a possibility of decreasing their expected yield if they failed to adopt the innovations. The average treatment effect on untreated (ATU) showed that if a farmer that had not actually adopted did adopt, there was an increase in yield by almost 50%. Finally, out of the four technologies under investigation (use of chemical fertilizers, certified seeds, farm machinery and fungicides), the use of chemical fertilizer (37%) had the highest impact on yield, followed by certified seeds (35%), farm machinery (32%), and lastly, the use of fungicides (29%). The study recommends that national and county governments should develop policy regulations such as training and extension services, market access, price support, and public-private partnerships to encourage farmers to uptake use of chemical fertilizers, certified seeds, farm machinery, and fungicide. The study also recommends that both levels of government should subsidize agricultural technologies, hence reducing the cost of adoption.

Declaration

Ethical Approval Certificate

The research procedure of this study was approved by Ethics Committee of Chuka University prior to data collection (Approval date: 24th May, 2022, Ref No: CUIERC/NACOSTI 288). Moreover, the study acquired research permit from the National Commission for Science Technology and Innovation (NACOSTI) [Approval date: 15th September, 2022, Ref No: 399336].

Author Contribution

David Mwangi Kihoro: Writing the original draft, methodology and formal analysis.

Geofrey Kingori Gathungu: Supervision, conceptualization, review and editing.

Rael Nkatha Mwirigi: Supervision, conceptualization, review and editing.

Vicky Nyambura Wairimu: Data collection, conceptualization and editing.

Conflict of Interest

The authors declare no conflict of interest

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