Effect of Fertilizer Subsidy Policy on Rice Productivity: A Cross-Sectional Survey among Smallholder Rice Farmers in Western Kenya

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ABSTRACT

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| Rice farming remains an important pillar of Kenya's economy due to its positive impact on increasing household food security, raising farmers’ income, and providing employment. However, domestic rice production still falls short of demand. This study aimed to assess the effect of Kenya’s National Fertilizer Subsidy Program (NFSP) on rice productivity in Western Kenya. An analytic cross-sectional design was used to collect data from 480 randomly selected rice farmers in Kisumu and Busia counties. Rice yield per acre was used as the productivity measure. Fertilizer use was categorized into four groups: subsidized, unsubsidized, both, and none. Data were analyzed using independent sample t-tests, ANOVA, and ordinary least squares (OLS) regression. Farmers using both subsidized and unsubsidized fertilizers achieved the highest mean yield of 3.09 t/acre. In irrigated areas (n=62), this group recorded 3.17 t/acre, while in rain-fed areas (n=26), they achieved 2.91 t/acre. The combined fertilizer group had a significantly higher yield overall (mean = 3.01 t/acre; *p* < 0.05) compared to the other categories. It has been established that, combining subsidized and unsubsidized fertilizers gives higher rice yields. Enhancing fertilizer access, improving distribution systems, and promoting best practices in both irrigated and rain-fed ecosystems can boost rice productivity in Kenya. |

*Key words: Rice productivity, fertilizer subsidy, ecosystems, subsidized, unsubsidized, productivity.*

1. INTRODUCTION

The importance of rice (Oryza sativa L.) as a food and cash crop in Eastern Africa is increasing, but its value chain is becoming complex. In 2012/13, rice value chain analysis was conducted in rice farming systems of Lake Victoria region, Eastern, and Southern Highlands zones of Tanzania (Nkuba et al., 2016). The study recommended that upgrading strategies are required that can increase producers’ market share and improve the competitiveness of the rice value chain. In South Asia, an analysis of various economic and historical perspectives of rice economy and culture in the region established that self-sufficiency in rice production is paramount to its domestic food security, and thereby proposes that emphasis should be given to increased rice production, which is decelerating amid the upsurge of modern economic sectors (Bishwajit et al., 2013).

Rice production requires aggressive intervention and a holistic development approach, if its emerging pivotal role in enhancing self-sufficiency in food production is to hold. The Kenyan National Fertilizer Subsidy Program (NFSP) launched its implementation during the September 2022 short rainy season to become a foremost policy that advances food cultivation while controlling rising prices (Ricker-Gilbert et al., 2024).. The strategy recommended that the government needs to intervene with financial support programs for farmers who need reduced costs of agricultural products to boost rice production and enhance output (Njagi, Riungu, Opiyo, Mwadime, & Aloo, 2024). Rice farming remains an important concern in Kenya due to its positive impact on increasing household food security, raising farmers’ income, as well as reducing risks in the years of poor weather conditions. However, currently, the demand for rice in Kenya outstrips its production, a gap that is filled through imports(Atera, Onyancha, & Majiwa, 2018). There is a need to improve rice productivity by encouraging the increased use of modern technologies, ensuring market access and linkages, and encouraging more farmers to take up the enterprise (Nkuba et al., 2016).

Kenya has the potential to produce about 540,000 hectares of irrigable land and one million hectares of rain-fed land for rice production. Rice is grown under irrigated and rain-fed production systems, with the former accounting for 80% of rice produced in the country (Muhunyu, 2012). As a way of encouraging modern farming technologies, the Kenya Agricultural and Livestock Research Organization released New Rice for Africa (NERICA) varieties in 2009(Onyango, 2014). None of these studies have shown the effects of subsidized fertilizer on rice production in Western Kenya.

There are several agricultural policies outlined which were formulated based on the experiences with previous policy documents, such as Strategy for Revitalizing Agriculture 2004 (Poulton & Kanyinga, 2014), and Strategy for Economic Recovery (SRE 2008) and vision 2030 but there exists no information on to what extent they have contributed to increased rice production. The study is thus intended to establish whether agricultural policies are working towards enhancing the development of the rice subsector or not. Specifically, it is imperative to determine the change in production and income levels attributable to the implementation of the fertilizer subsidy policy. The main objective of this analysis was to determine the impact of subsidized fertilizer on rice productivity in Kisumu and Busia Counties.

2. METHODOLGY

**2.1 Study Design**

This study adopted a cross-sectional research design because it allowed data to be collected at a single point in time without repetition from the representative sample. The reason for the choice of such a design is that it was easier and economical to conduct, especially where there are resource constraints (e.g., labour, money, and time frame).

**2.3 Population of the study**

This study targeted rice farmers who are residents of Kisumu and Busia counties in western Kenya, and registered by the Ministry of Agriculture. The interviews were conducted at the household level. The population of the study area, Kisumu County – Nyando Sub County, was 178,246, and Busia – Bunyala Sub County was 46,320, thus totaling to 224, 566.

**2.4 Sampling technique**

Multi-stage sampling was used to select two Locations from two Wards in each selected sub-county in the target County. The target Counties (Kisumu and Busia) were purposively selected. The criteria for the selection of Kisumu and Busia were based on the existence of improved rain-fed and irrigated rice farms. A sampling frame of registered rice farmers was obtained from the Ministry of Agriculture at the Sub-County, Ward, and Location levels. Simple random sampling techniques were used to select sampling units. The sampling unit was the household.

**2.5 Sample size determination**

The sample size was determined using Glenn D Israel’s formula (2008) for cross cross-sectional survey(Israel, 2008).

n = [N/ (1+N (e2)]

The population (N) in the study area, Kisumu County – Nyando Sub County (178246) and Busia – Bunyala Sub County (46320) totaled 224, 566 which was above 100,000 farmers with a precision (e) of 5% (0.05) and 95% level of confidence according to Glenn D Israel’s formula (2008). This resulted in a sample size of 480.

The sample was distributed across the various sub-counties using the probability proportional to size (PPS) approach. Using the approach, Kisumu County accounted for a sample size of 381 while Busia County had a sample size of 99 totaling 480.

**2.6 Data Collection Methods**

A structured questionnaire was used to interview farmers who were growing rain-fed rice and irrigated rice to collect quantitative data. The interviews were conducted at the household level using the face-to-face technique. The questions were organized to gather: 1) household characteristics (such as age, level of education, sources of income and experience in rice cultivation ), 2) productivity objective variables (Quality of land preparation, seed, irrigation, planting, fertilizer utilization, weed control and pest control and yield per acre.

**2.7 Validity and Reliability of Data**

We interviewed at least 30 respondents for the pilot sample to assess internal reliability. This data was not included in the final analysis. The data were analyzed using Stata version 15. Internal reliability was assessed using the alpha estimate of 0.7. The final alpha estimate was 0.85 across the questionnaire.

**2.8 Statistical Analysis**

 Descriptive statistics such as mean, median, frequencies, and percentages were used to describe the socio-demographic characteristics of the farmers. Associations between categorical variables were assessed to test the hypothesis using the Chi-square test. An independent sample T-test was used to show if there were significant differences in rice production between farmers not using fertilizer, those applying unsubsidized fertilizer, those applying subsidized fertilizer, and those using both subsidized and unsubsidized fertilizers. Analysis of variance was employed to compare yield per acre between the four categories of fertilizer subsidy.

Multivariable Linear regression was used to establish the marginal effect of fertilizer subsidy as the main independent variable. Utilization of subsidized fertilizer was categorized into four groups: Those who used subsidized fertilizer only, those who used unsubsidized fertilizer only, those who used both, and those who did not use.

**2.8.1 Cobb-Douglas production function model.**

 This study adopted the Cobb-Douglas framework to conduct the multivariable analysis. The Cobb-Douglas production function is a widely used economic model that describes how input factors (like labor and capital) contribute to output or production. It’s especially useful in agriculture and industrial economics for measuring productivity and returns to scale. It is widely used because it has many attractive characteristics (Cobb & Douglas, 1928). The model measures the output elasticity (marginal product) with respect to changes in input use. The input variables included the fertilizer subsidy, county of residence, type of irrigation ecosystem, and type of rain-fed ecosystems.

**2.9 Measurement of productivity.**

The overall production includes measures of efficiency in using the various inputs, such as labour and capital, that are used in an economy to produce a given level of output. In this analysis, we considered the end product, which was the total yield per acre, as the dependent variable.

3.0 results and discussion

**3.1 RESULTS**

**3.1.1 Rice production ecosystem and production practices.**

Table 1 is a description of the rice environment in the study area, which was categorized broadly as irrigated and rain-fed ecosystems based on the source of water. The majority of the study participants (72%) produced rice under irrigated ecosystems, while 28% grew rice under rain-fed conditions. Conventional agronomic practices were the main rice production technologies employed by 42% of the farmers. About 29% of the respondents used Systems of rice intensification (SRI) in an irrigated ecosystem. The technology involves minimizing the quantity of inputs used per unit while increasing productivity, due to which it has gained popularity among farmers operating in the irrigated ecosystem. Sixteen percent of farmers used a combination of conventional agronomic practices and SRI, while 13% used indigenous technical knowledge (ITK). Choice of rice production practices was influenced mainly by cost effectiveness as reported by 23% of the respondents, followed by productivity and profitability at 22% and 22%, respectively. Convenience (19%), experience (13%), and peer pressure (2%), conversely, had a peripheral role in informing farmers’ choice of production practices. Nearly all the farmers (97%) used fertilizer on their farms. Farmers in the study area had different forms of land ownership. The majority (42%) had freehold land with title, followed by rented (24%), freehold without title (21%), and communal 13%.

**Table 1:** *Rice production ecosystem and production practices*

|  |  |  |
| --- | --- | --- |
| **Variable** | FrequencyN | Percentage% |
| **Fertilizer use (n=457):**YesNo | 44314 | 973 |
| **Rice production ecosystem (n=394):**IrrigatedRain-fed | 282112 | 7228 |
| **Rice production practices (n=456):**Conventional agronomic practice and SRIConventional agronomic practicesIndigenous Technical Knowledge (ITK)Systems of Rice Intensification | 7419159132 | 16421329 |
| **Choice of Rice production practices (n=428):** Convenience

|  |
| --- |
| Cost effectiveness |
| Experience |
| Peer pressure |
| Productivity |
| Profitability |

 | 80975479496 | 19231322222 |
| **Land ownership and tenure (n=454):**Freehold with titleFreehold without title RentedCommunal | 1899510960 | 42212413 |

**3.1.2 Rice grain yield by ecosystems.**

Table 3 is a post-hoc analysis, a pairwise mean comparison of yield per acre across different farming ecosystems. Letters have been used as superscripts to indicate significant results. Results with similar letters are statistically significantly different at p<0.05. Farmers (N=62) from irrigated ecosystems who used both subsidized and unsubsidized fertilizers reported a significantly higher mean yield of 3.17 t/acre compared to those who used other categories. Farmers (N = 26) operating in a rain-fed ecosystem who used both subsidized and unsubsidized fertilizer category had a significantly higher mean grain yield of 2.91 t/acre compared to other categories. There was, however interesting observation where non-fertilizer users (N=14) in rain-fed ecosystem reported slightly higher mean yield of 2.28 t/acre compared to subsidized (2.08t/acre) and unsubsidized (2.00 t/acre) categories alone. Overall, combined farmers (N=88) from irrigated and rain-fed ecosystems who used both fertilizer categories reported significantly (p<0.001) better grain yield of 3.09 t/acre.

**Table 2****:** *Analysis of variance comparing rice production across farming ecosystems*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Fertilizer category** | **Irrigated** |  | **Rain fed** |  | **Overall** |
| **N** | **Grain yield** | **SD** |  | **N** | **Grain yield** | **SD** |  | **N** | **Grain yield** | **SD** |
| Both | 62 | 3.17a | 1.21 |  | 26 | 2.91a | 1.44 |  | 88 | 3.09a | 1.27 |
| Subsidized | 62 | 2.05b | 0.64 |  | 67 | 2.08b | 0.63 |  | 129 | 2.07b | 0.64 |
| Unsubsidized | 112 | 2.08b | 0.88 |  | 42 | 2.00b | 0.75 |  | 154 | 2.05b | 0.84 |
| None | 14 | 2.35b | 0.85 |  | 4 | 2.28ab | 0.71 |  | 18 | 2.34b | 0.80 |
| **Mean** |  | **2.36A** |  |  |  | **2.21B** |  |  |  | **2.31** |  |
| **p-value**  |  | **<0.001** |  |  |  | **<0.001** |  |  |  | **<0.001** |  |
| **CV** |  | **39.1** |  |  |  | **39.4** |  |  |  | **39.0** |  |
| * *The letters represent the significance of the differences. The same letter shows non-significant results*
* *CV is the coefficient of variation; SD is the standard deviation*
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**3.1.3 Multivariable Ordinary Least Squares regression analysis to establish the effect of fertilizer subsidy on rice production**

Table 3 is a summary of multivariable linear regression analysis on predictors of rice production. The result shows a reduction in rice production of about 0.76 t/ha when no fertilizer was used, a reduction of 0.99 t/ha when subsidized fertilizer was relied upon, and a reduction of 1.03 t/ha when unsubsidized fertilizer was used. However, there was a positive effect of using both subsidized and unsubsidized fertilizer with a unit increase of 2.95 tones/per acre

**Table 3****:** *OLS Regression analysis indicating the impact of fertilizer use and demographic factors on rice productivity (yield per acre).*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Coefficients** | **Std. Error** | **t value** | **P-value** |
| Subsidized and unsubsidized | 2.95 | 0.1428 | 20.675 | P<0.001  |
| No fertilizer | -0.76 | 0.2332 | -3.265 | 0.001  |
| Subsidized fertilizer | -0.99 | 0.1275 | -7.778 | <0.001 |
| Unsubsidized fertilizer | -1.03 | 0.1207 | -8.567 | <0.001 |
| County (Kisumu) | -0.28 | 0.1042 | -2.663 | 0.008  |
| Age (18-35) | 0.40 | 0.1355 | 2.963 | 0.003 |
| Age (36-45) | 0.35 | 0.1453 | 2.395 | 0.017 |
| Age (46-55) | 0.43 | 0.1515 | 2.858 | 0.004 |

**3.1.4 Grain yield performance in t/acre by County.**

Results in Table 4 indicate that both categories of fertilizer use outperformed other categories in Busia and Kisumu counties under irrigated and rain-fed ecosystems. Farmers (N=34) in Busia using both subsidized and unsubsidized fertilizer reported a mean yield of 3.41 t/ha, which was significantly different (p<0.001) under the irrigated ecosystem. Farmers (N=28) in Kisumu County, however, reported a mean yield of 2.87t/acre, which is significantly different (<0.001) from other categories under irrigated ecosystem. In Kisumu County, farmers (N = 26) who grew rice under rain-fed conditions and used both (subsidized and unsubsidized) fertilizer reported a mean yield of 2.91 t/acre, which was significantly different (p < 0.001) from the yields of other categories. Non-fertilizer users in Busia and Kisumu reported yields that were significantly different from those of subsidized and unsubsidized Fertilizer categories under irrigated and rain-fed ecosystems.

**Table** **4:** *ANOVA analysis of Grain Yield performance in t/acre by county*

|  |  |  |  |
| --- | --- | --- | --- |
| **Fertilizer category** | Busia  | Kisumu | Overall |
| Irrigated | Rain-fed | Irrigated | Rain-fed |
| **N** | **Grain yield in tonnes (SD)** | **N** | **Grain yield in tonnes (SD)** | **N** | **Grain yield in tonnes (SD)** | **N** | **Grain yield in tonnes (SD)** | **N** | **Grain yield in tonnes****(SD)** |
| Both sub & unsub | 34 | 3.41(1.16) a | 0 |  | 28 | 2.87(1.22) a | 26 | 2.91 (1.44) a | 88 | 3.09(1.27) a |
| Subsidized | 27 | 2.05(0.73) b | 7 | 1.95(1.39) a | 41 | 2.06(0.58) b | 61 | 2.11 (0.64) b | 129 | 2.07(0.64) b |
| Unsubsidized | 24 | 2.14(0.99) b | 14 | 1.92(2.31) a | 93 | 2.06(0.84) b | 28 | 1.81 (0.72) b | 154 | 2.05(0.84) b |
| None | 2 | 2.77(0.22) ab | 1 | 2.81(-) | 12 | 2.28(0.90) ab | 3 | 2.11 (0.76) ab | 18 | 2.34(0.80) b |
| Mean |  | 2.62 A |   | 2.19 B |  | 2.22 B |  | 2.21 B |  | 2.31 |
| p-value  |  | <0.001 |  | 0.27 |  | <0.001 |  | <0.001 |  | <0.001 |
| CV |  | 37.7 |  | 32.1 |  | 39.7 |  | 40.4 |  | 39.0 |

**3.2 DISCUSSION**

The study analyzed the effect of using subsidized fertilizer on rice productivity measured as yield per acre under different ecosystems and production practices. The study has established that farmers using subsidized fertilizer were more likely to realize increased rice productivity per unit compared to those who used unsubsidized. The highest production was among those who used both (subsidized and unsubsidized) fertilizers, followed by those who used only subsidized. However, results show a non-significant difference in production levels between using subsidized and unsubsidized fertilizers. In Busia County, production in rainfed ecosystems was slightly higher compared to irrigated ecosystems. In Kisumu County, the production levels were higher in the irrigated compared to the rainfed ecosystems.

The results also showed that different rice production ecosystems affect rice productivity. Farmers who used irrigated ecosystems produced higher yields across the whole study area. The average rice yields reached 3.17 t/acre under irrigation, while being 2.91 t/acre under rain-fed conditions for farmers who used both subsidized and unsubsidized fertilizers, surpassing all other categories.

Busia County yielded 3.41 t/acre as the top producing area compared to Kisumu for farmers who utilized both (subsidized and unsubsidized) fertilizers in irrigated schemes. It is postulated that there is likelihood of that farmers using both applied optimum applied recommended fertilizer rates and received technical assistance. The yield levels in Kisumu were slightly lower than Busia County, especially when farmers used rain-fed ecosystem, that require more specialized extension operations and field training in those regions.

The statistical analysis through regression reinforces the identified trends. Using either "no fertilizer" (-0.76 t/ha) or "subsidized" (-0.99 t/ha), or "unsubsidized" (-1.03 t/ha) fertilizer alone results in a reduction of productivity when compared to combined fertilizer utilization, which can be attributed to either unavailability and inaccessibility to subsidized fertilizer or unaffordability of unsubsidized fertilizer. Combining subsidized and unsubsidized fertilizer use gives the highest rice productivity. The coefficient of variation (CV), measuring 39%, demonstrates substantial yield variability in all measured ecosystems and counties because of possible differences in management practices and input application timing, and support services accessibility. It has been noted that high fertilizer costs often discourage adequate application, thereby reducing productivity (Omiti et al., 2006).

4. Conclusion

The study found that the use of both subsidized and unsubsidized fertilizer significantly improves rice productivity in Western Kenya, holding other factors constant. In consideration of other factors, the availability of water in irrigated ecosystems produced superior results in terms of yield improvement as compared to rain-fed ecosystems because water accessibility proved essential. Rice farmers in Busia County obtained higher yields as a result of using both subsidized and unsubsidized fertilizers. Farmers' decision to use a combination of subsidized and unsubsidized fertilizer could have been influenced by the possible inaccessibility, unavailability, and inadequacy of subsidized fertilizer, based on study results. Furthermore, while the demand-driven extension model holds considerable promise, its constrained reach and perceived prohibitive cost implication indicate a disconnect between policy formulation and the realities faced by farmers. The rice sector in Kenya needs comprehensive solutions to resolve these limitations to the promotion of functional and resilient agricultural development efforts. The existing subsidized fertilizer distribution systems may not have worked in favor of smallholder rice farmers in Western Kenya, who should have benefited most from the fertilizer subsidy policy, probably leading to inaccessibility, unavailability, and untimeliness challenges.

Fertilizer subsidy policies should be designed to address affordability, accessibility and availability constraints affecting optimal fertilizer utilization. Similarly, strategic investments in irrigation infrastructure across the rice producing regions with high agroecological potential should be enhanced because this move will most likely strengthen yield stability resulting in optimal returns on investment. This can be achieved through a partnership between the public and private sectors. Investment in farmer education to ensure they understand the various ecosystems and fertilizer utilization to enhance rice production across the Country should be enforced.

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Competing interests

Authors have declared that no competing interests exist.

Authors’ Contributions

Joseph Newton O. Okech conceived the study, wrote the protocol, led the implementation, data collection and analysis, and drafted the manuscript. Vincent Were supported data analysis and review of the manuscript. Leo Ogallo, John Ojiem, Mercy Rewe and Oyata Balah conceived the study, provided supervision and guidance and reviewed the manuscript.

**Ethical Approval and CONSENT**

The study adhered to strict ethical guidelines throughout the research process. Prior to data collection, informed consent was obtained from all participants, ensuring their voluntary participation. Respondent confidentiality was protected through complete data anonymization, with all personal identifiers removed. Formal research approval was obtained Great University of Kisumu’s Scientific and Ethical Review Committee (GLUSERC) and the Kenya's National Commission for Science, Technology and Innovation (NACOSTI), confirming the study met national ethical standards for scientific research involving human subjects.

All authors declare that informed written consent was obtained from the participating farmers, who were assured of confidentiality and voluntary participation.

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