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Comparing productivity of rice under system of rice intensification and conventional flooding: A switching regression approach

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This paper examined the factors influencing rice productivity in Mwea Irrigation Scheme using the System of rice intensification (SRI) and conventional flooding (CF). Stratified sampling was used to obtain 364 smallholder rice farmers for interviewing. Data collection was done with the aid of a semi-structured questionnaire and analyzed using the Endogenous Switching regression Model (ESRM). The results of ESRM revealed that factors such as household size, access to extension services, involvement in off-farm work, distance from the canal, farm size, labour use, access to credit services and years spent in rice farming were found to be significant in explaining variations in rice productivity. Furthermore, the gross margin analysis showed that the returns of SRI outweigh the returns of CF, thus making SRI more profitable than CF. The study therefore recommends that Kenya government should enhance engagement with development partners to pay attention to all significant factors which are important in making decisions in the two practices of rice production.

Key words: System of rice intensification (SRI), rice, Mwea irrigation scheme, productivity.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important food crops for more than 50% of the world population (Atera et al., 2018). Globally, about 160 million hectares are estimated to be under rice production with an annual production of approximately 500 million metric tons (Kirby et al., 2017). The demand for rice has increased steadily over the years, thus playing a major role in many countries in terms of strategic food security planning policies.In recent years, rice crop yield has slowed considerably therefore failing to keep up with the population growth thus leading to shortages and higher prices that have adversely affected smallholder rice

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farmers (Denkyirah, 2015; Lee and Kobayashi, 2017)

Paddy rice is one of the commodities whose demand is rapidly increasing in Sub-Saharan Africa as a result of increased urbanization, growing importance of the crop and the challenges of attaining food security (Amos, 2014). Therefore the consumption of rice is expected to increase tremendously (Kirby et al., 2017). The current paddy rice production in Kenya is estimated at 150,000 metric tons. The output meets only about 20% of the total demand (Omondi and Shikuku, 2013). The gap between production and consumption is filled by importation to meet the domestic demands (Ndirangu, 2015). For Kenya to attain self-sufficiency in rice production, the domestic production must increase at the rate of 9.3% per year (Amos, 2014). To achieve self-sufficiency in rice production, innovative practices that reduce water use need to be put in place to enhance sustainable rice farming.

Various methods have been used to reduce water usage in rice production (Denkyirah, 2015). One of the most tried methods was the Green Revolution in Asia, which involved a series of research and technology transfer initiatives (Kassam et al., 2011). This innovation involved the development of high yielding varieties of cereal grains and modernization of farmland management techniques (Rahman, 2017). The Green Revolution was very effective and successful in Asia whereby many farmers were able to adopt the technology (Thakur et al., 2015). However, the innovation was not able to help many African countries farmers due to limited infrastructure and financial constraints (Ndiiri et al., 2013). The other innovation is the System of Rice Intensification (SRI). From the farmers' perspective, SRI is the use of existing assets differently yet increasing the outputs and reducing water use while maintaining the quality of the grain (Katambara et al., 2013). It can be inferred from Stoop (2003) that SRI is a concept on the manipulation of agronomic practices to attain higher rice yields with the use of minimal resources such as agrochemicals, seeds, and water (without continuous flooding in SRI as compared to traditional methods). The SRI is gaining popularity in all rice-growing areas of the world and that farmers can grow more rice with less water (Karki, 2010).

The key components of SRI include: water management, practiced by keeping the soil drained and saturated rather during the vegetative growth period. Furthermore, it includes flooding and drying of the fields for alternating periods of 3-6 days each (Namara et al., 2003). The second component is the planting method which involves spacing configurations and age of seedlings. In SRI, seedlings are transplanted 8-15 days after germination (Thura, 2010). Some studies suggest a line spacing of 30 cm × 30 cm. The spacing could be based on the local edaphic conditions but it has to facilitate weeding (Uphoff and Thiyagarajan, 2005). The third component is weed control which is best done ten days after transplanting and then weeding every ten days until canopy closure (Uphoff and Thiyagarajan, 2005). The fourth component entails soil fertility management. Most farmers use compost or organic manure but the amount applied varies in terms of its availability and also because there is no fixed recommended rate to follow (Ndiiri et al., 2013). The traditional method of rice growing involves continuous flooding during the vegetative growth with draining of the water during the grain ripening stage, which is a common practice in all rice-growing schemes in Kenya (Omwenga et al., 2014). The Conventional Flooding (CF) method is thus associated with higher water demand and occasioned by high losses through percolation, seepage, and evaporation (Paredes et al., 2017).

There exist various socioeconomic factors that influence the level of rice productivity in the two systems of rice farming in Sub-Saharan Africa, Kenya included. Many empirical studies have investigated the issue of crop productivity and profitability (Denkyirah, 2015). However, alternative production practices such as SRI and CF have not yet been fully investigated especially on productivity and profitability of rice. Previous studies on SRI in Mwea Irrigation Scheme include (Ndiiri et al., 2013). Authors such as Ndirangu (2015) focused on the constraints and the returns associated with SRI. Additionally, their studies focused on the perceptions of SRI. On profitability, authors such as Denkyirah (2015) focused on cash flow projections for SRI for a period of five years using the Benefit Cost Ratio (BCR) and Net Present Value (NPV) approaches. However the study did not focus on the use of other approaches in determining profitability. In Ghana, the application of gross margin approaches was done for paddy production (Bwala and John, 2018). However the study did not make a comparison of rice practices instead it focused costs and returns thus creating a research gap.

There is a need to understand what to increase or decrease in productivity of rice among smallholder farmers. Therefore the main objective of this study was to compare the productivity of rice under SRI and CF. Against this background, this study came in hardy to provide research-based information on determinants of rice productivity under SRI and Convectional flooding in Mwea irrigation scheme, Kenya. From these studies, little has been done or investigated on productivity of rice using the SRI and CF methods of crop establishment in Mwea Irrigation Scheme. ESRM have been applied to examine the impacts of technology adoption on farm outcomes when self-selection is an issue. The model accounts for selection bias making it the most appropriate in analyzing the productivity of rice under SRI and CF. This, therefore, provides a strong case of argument of using SRI to generate information on rice productivity with a view of driving policy recommendations and filling the information gap in Kenya.

MATERIALS AND METHODS

Description of study area

This research was carried out in Mwea Irrigation Scheme (MIS) in Central Kenya. MIS was selected since the first field experiments on SRI in Kenya, were conducted at Mwea Irrigation Agricultural Development (MIAD) Centre. The scheme occupies the lower altitude zones of the region with expansive low marshy areas. The altitude ranges from 1,000 - 2,200 m above the sea level, with temperatures ranging between 15 and 30°C. The rain seasons in the region are usually two, the long rains occur between March and May, while the short rains occur in October/December. The main agricultural activity is mono-cropping of rice. The crop is grown in paddies that are irrigated for six months. The main sources of water to the scheme are River Nyamindi and River Thiba which are tributaries of river Tana. There are currently over 52 villages with approximately 7320 households within the scheme (GoK, 2008).

Sampling procedure

The respondents were selected using two stage stratified random sampling. This was done with the aid of the major blocks/villages which include Karaba, Tebere, Wamumu, and Thiba. In total, 364 smallholder farmers were selected (that is 91 from each study location and each 45 from SRI and CF per block). The four study blocks were purposively selected based on their prevalence of SRI farmers. Additionally, the sampling frame was obtained from the National Irrigation Board.

Theoretical framework

Smallholders Farmer's perception is to maximize on their perceived utility. The study was based on the subjective expected utility framework. The individual expected utility of innovation can be approximated in Equations 1 and 2.

$$SEU(\pi) = \sum_i p_i^t \, U(\pi i) \quad (1)$$

$$U(\pi) = \frac{\pi^{1-RRA}}{1-RRA} \quad (2)$$

Where pi is the probability of state of nature i for the profit (π_i); RRA is the relative risk aversion coefficient and SEU is the subjective expected utility. It is expected that farmers choose the alternative with the highest utility (Equation 3). Based on the random utility theory, the global utility of a system is composed by the utility of each characteristic of the cropping system. Although profit could be one of the characteristics, farmers also maximize their utility based on other factors such as agronomic and technical.

$$U_k > U_j \quad (3)$$

Where $= U(t_1, t_2, \ldots, t_r) + \varepsilon$ (4)

$t_1, t_2 \ldots t_r$ Corresponds to the r characteristics of innovation while the error term (ε) depicts the individual determinants.

Testing for heteroscedasticity- White Man-test

White test is used to test the presence of heteroscedasticity. The null hypothesis indicates that the error variances are all equal (homoscedasticity), whereas the alternative hypothesis indicates that the error variances are multicative function of one or two variables (heteroscedasticity).

Analysis of gross margin

In order to compare profitability of SRI and conventional flooding, the gross margins were computed. The variable cost was summed to derive the total cost of production per hectare basis. Variable cost used includes hired labour, fertilizer, pesticides, and machinery operating costs. The gross margins are the difference between the gross returns and the total variable costs.

Descriptive analysis

The data was analyzed using descriptive and inferential statistics. For the socio-economic characteristics, t-test and Chi-test was used to determine the variables that were significant. The t-tests was applied for continuous variables and Chi-tests for dummy variables used in comparisons of the SRI and CF farmers.

Analysis of factors influencing rice productivity among smallholder farmers

The main approach employed in the analysis of rice productivity for the two practices is mainly the econometric approaches that use the Endogenous Switching Regression Model (ESRM). Smallholder farmers take into account the net benefits when deciding on the technologies to adopt. Thus, the technologies employed by farmers should take into account the outcomes such as yields and profits. The selection biasness may occur if they fail to take into account of the outcomes. The biasness occurs because of the smallholder farmers who would obtain less than average returns from the new technology. The selection biasness occurs when the unobservable factors influence the technology choice equation and the outcome (Abdulai, 2014). The factors may include the technical abilities of the farmers in understanding the new technologies such as SRI; while evaluating the impacts of new agricultural technologies it becomes difficult to attribute the differences on yields and returns to adoption and non-adoption. Thus in ESRM approach, the smallholder farmers are classified as both adopters and non-adopters. Therefore the model becomes the most appropriate to use since it captures the responses of the two groups.

The ESRM was used to compare the rice productivity of the farm households who participated in SRI and CF. Switching regression consists of two stages. The first stage is based on a dichotomous choice criterion function. The farmer evaluates whether or not to adopt SRI practices based on resource endowment. The adoption, I_{SRI}^* is compared to the expected utility of using CF practices I_{CF}^*.

The farmers will adopt SRI if, $I_{SRI}^* > I_{CF}^*$ and will not adopt if $I_{SRI}^* \leq I_{CF}^*$. This model was appropriate for this study since it allows for analysis of the outputs in the two rice farming practices. The first stage equation can be written in a simplified form as:

$$I^* = S' \alpha + \varepsilon_v \quad (5)$$

I = 1 if $I^*_{SRI} > I^*_{CF}$. (6)

I = 0 if $I^*_{SRI} \leq I^*_{CF}$ (7)

Where vector S includes farm and household characteristics, α is a vector of parameters to be estimated, and ε_v is a random error term with mean zero and variance σ^2 .

In the second stage, two regime equations can be specified by explaining the results of the estimated criterion function. The relationship between variable X and Y can be represented as $Y = f(X)$ and specified for each regime as:

$Y_{SRI} = X' \beta_{SRI} + \varepsilon_s$ If I = 1, (8)

$$Y_{CF} = X' \beta_{CF} + \varepsilon_C \; if \; I = 0 \quad (9)$$

β_{SRI} and β_{CF} are parameters to be estimated. The variables in X' and S' are allowed to overlap, identification requires some variables in S' that does not appear in X' Therefore the function is estimated based on the exogenous variables specified in equation. The counterfactual outcomes (observed and unobserved) for the adopters and non- adopters can be estimated using the endogenous switching regression model (Lokshin, 1977). SRI plots with adoption (observed):

$$E(Y_{SRI} \; l \; I = 1) = X' \beta_{SRI} + \sigma_{Sv} \lambda_S \quad (10)$$

SRI plots with no adoption (Counterfactual):

$$kE \; (Y_{CF} \; l \, I = 1 \,) = X' \beta_{CF} + \sigma_{cv} \lambda_S \quad (11)$$

CF plots without adoption of SRI practices (observed):

$$E \; (Y_{CF} l \, I = 0 \,) = X' \beta_{CF} + \sigma_{cv} \lambda_c \quad (12)$$

CF plots with SRI (Counterfactual):

$$E(Y_{SRI} \; l \, I = 0 \,) = X' \beta_{SRI} + \sigma_{sv} \lambda_c \quad (13)$$

Therefore Equation 14 will determine the average treatment effects (ATT) and control for observed and unobserved heterogeneity (Noltze, 2012).

ATT= $E(Y_{SRI} \; l \; I = 1)$ - $E \; (Y_{CF} \; l \, I = 1 \,)$ (14)

RESULTS AND DISCUSSION

Heteroscedasticity test

The white test was used to test the presence of heteroscedasticity. The null hypothesis indicates that the error variances are all equal (homoscedasticity), whereas the alternative hypothesis indicates that the error variances are multiplicative functions of one or two variables (heteroscedasticity). The results showed that the probability value of the chi-square statistics is less than 0.05. Therefore the null hypothesis of the constant variance can be rejected at a 5% level of significance. This implied the presence of heteroscedasticity in the residuals. The heteroscedasticity test had a significant chi-value indicating that the heteroscedasticity problem was present; however, correction of this problem was achieved by generating the robust standard errors after the regression.

Characteristics of the respondent according to SRI and CF productivity

The socio-economic characteristics of the smallholder rice farmers in the two practices were analyzed and the findings are presented in Table 1. The results indicated that the mean age of the respondent under SRI was 42 years while for CF was 41 years. The results were significant implying that young farmers are actively involved in farm operations. The results further showed that the male headed households dominate rice farming in MIS. This is understandable since rice farming is labour intensive and the tedious activities are required in the farm operations. Regarding education status, 79.17% of SRI farmers had obtained secondary education while 43.67% of CF farmers had primary education. This analysis further showed that more educated households are likely to record increased output since they have the ability to process information regarding the most productive practices in rice farming.

The mean household size for the SRI farmers was 4.12 and for the CF farmers were 5.12. These results revealed that farmers with relatively large-sized households have advantageous to rice farming since it enables farmers to use family labor for rice production. On average farmers in CF had large farm size (2.1 Ha) as compared to those practicing SRI (1.5 Ha), indicating that farm size has a bearing on rice output produced in these practices. Although farmers under CF had an advantage of land size, their income was relatively low (KES 33,761.90) in relation to SRI (KES 40, 374.52). Furthermore, findings indicated that farmers practicing CF had more farming experience in years (8.1 years) than their counterparts doing SRI (6.2 Years).

With regard to the access of extension services, 92.66 and 69.52% of farmers practicing SRI and CF had access to extension respectively. These results implied that SRI farmers relatively had higher access to extension services. The findings also showed that 88.42% of SRI farmers were doing casual works as an off-farm income, while 91.43% of CF farmers were doing the same, showing that many CF farmers were undertaking off-farm activities to increase their income. Results indicated that 91.43% of farmers doing CF had access to credit services and only 33.98% of farmers practicing SRI had access to this service. The distance from the canal for SRI farmers was 5.4788 km and that of CF was found to be 4.1714 km, implying that long distance from canal called for water management practices (Table 1).

Table 1. Demographic and socio-economic characteristics of the respondents.

Variable	SRI	CF	Pooled mean	
	n=259	n=105	n=364	t/*Chi* value
Age (Mean age)	42	41	41	52.40(0.00***)
Gender				
Female (%)	22.39	31.43	38.1	3.25(0.001***)
Male (%)	77.61	68.57	73.09	
Education level				
Primary	56.33	43.67	43.41	
Secondary	79.17	20.83	46.15	159.60 (0.00***)
post-secondary	97.37	2.63	10.44	
Household size	4.12	5.2	5	48.08 (0.00***)
Farm size (Ha)	1.5	2.1	1.8	15.85 (0.00***)
Monthly Income (KES)	40374.5200	33761.9000	37,068.21	47.70 (0.00***)
Years in paddy farming	6.2	8.1	7.1	27.08 (0.00***)
Access to extension services	92.66	69.52	81.09	33.21 (0.00***)
	7.34	30.48	18.91	
Casual work	88.42	91.43	89.93	
Livestock keeping	3.86	7.57	5.72	11.36 (0.00***)
Others	7.72	1	4.36	
Credit access	33.98	51.43	42.71	98.65 (0.00***)
	66.02	48.57	57.3	
Distance to canal	5.4788	4.1714	4.83	3.59 (0.07 **)

***,** denote significance at 1 and 5%.

Analysis of gross margins for SRI and CF

The profits of the SRI and the CF farmers were determined. To determine the profitability levels of the two groups, attempts were made to estimate the gross margins from the rice farming. This is due to the fact that the fixed costs of the smallholder farmers were negligible. The mean cost of production in one hectare of rice was calculated as listed in Figure 1.

The SRI farmers used KES 1,282.83 on purchase of seeds for planting one hectare compared to CF farmers who used KES 2,276.66. Therefore, the SRI farmers saved KES 993.83 per hectare over CF with the application of fertilizer. SRI recorded the highest cost of KES 6,026.27 compared to conventional flooding where it was KES 2,639.49 therefore CF farmers saved KES 3386.78 per hectare. The cost of ploughing for the SRI farmers was KES 4797.16 while in CF it was KES 5797.16. The difference in the cost of ploughing was KES 1,000. The difference on cost of ploughing between the SRI and CF farmers was positively significant and therefore it had a positive influence on profitability.

In the CF method, the Cost of Agrochemicals was KES 300.61, while in SRI the cost was KES 613.50 per hectare. The CF farmers saved herbicides cost of KES 312.89 over the SRI farmers. The difference in the cost of herbicides was significant and this implied that herbicide cost had a positive influence on the profitability of rice farming.

Analysis of gross margins (Table 2) revealed that the average variable cost per hectare for the adopters of SRI was KES 54,564.07 and the gross revenue was KES 118,408 with gross margins of KES 63,843.93 per hectare per season. On the other hand, the variable cost for the CF was 44,252.42 with gross revenue of 74,784 and gross margins of KES 30,351.58 per hectare. The results revealed that SRI technology is more profitable by KES 41, 843 compared to CF in the study area. The result is in agreement with findings of Denkyirah (2015) who reported that SRI was more profitable than CF in Ghana.

Endogenous switching regression results for the factors influencing rice productivity

The coefficients of years spent in farming and marital status were negative but statically significant in influencing

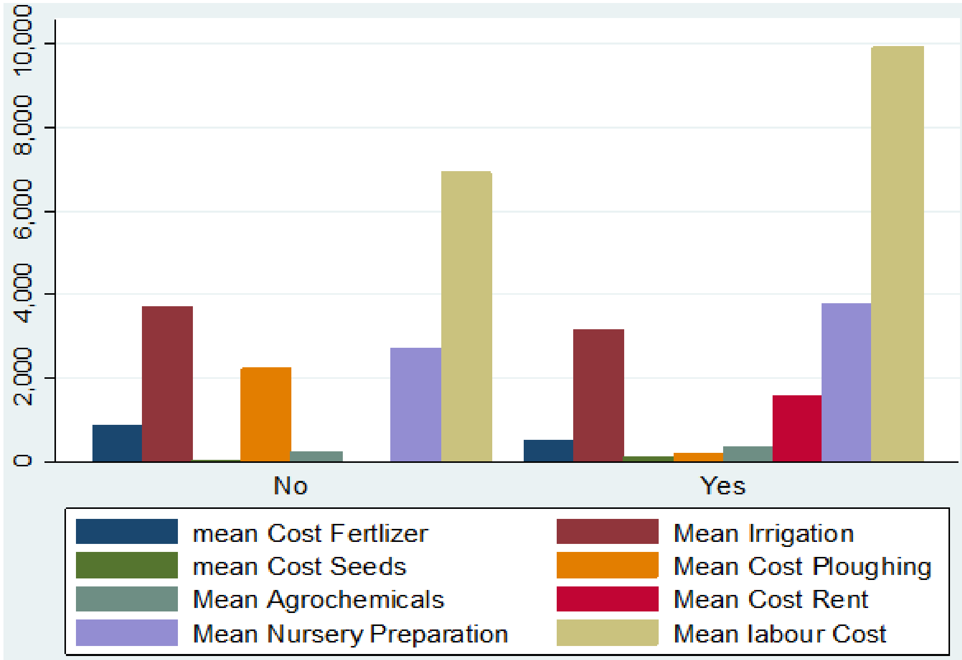

Figure 1. Mean of variable cost for CF and SRI.

Table 2. Gross margin analysis for SRI and CF.

Variable	SRI	CF	T test	P value
Bags harvested	19	12	-16.68	0.00***
Farm gate price(per bag)	6,232	6,232	-0.02	0.00***
Gross revenue	118,408	74,784	**121.56**	0.00***
Total variable cost (KES)	54,564.07	52,710.39	**21.23**	0.00***
Gross Margins Per Season (KES)	63,843.93	22,073.61	**20.23**	0.04**

rice productivity (Table 3). The plausible explanation for the negative relationship between years in rice farming and rice productivity is that experienced farmers were more satisfied with CF methods and thus finding it difficult to adopt SRI. Myint and Napasintuwon (2016) to the contrary reported that Paw rice adoption can be accelerated by promoting it to farmers with higher experience. Furthermore, Paudel et al. (2019) indicated that experience in rice farming positively has effects on rice productivity of adopters of improved technologies.

It was found that household size had a positive coefficient and statistically significant at 1% level. This shows that large households with labor endowment are important in increasing rice yields. Thus, more family labour is likely to be engaged in farm activities. This implies that an increase in household size increases output. These can be attributed to the fact that the production of rice requires more labor that is supplied from the family. Similar findings were reported by Amare et al. (2012) who found a positive relationship between the size of household and productivity of farmers in various technologies.

The results found that off-farm work was statistically significant at 1% level. The results showed that off-farm work positively affects rice productivity. This implies that the household's heads whose main job is farming are less likely to obtain more yields than the part-time farmers. This may be related to access to frequent contacts through off-farm activities and therefore access to information flow. Besides, the risky perceptions of farmers who entirely depend on farm incomes may be hesitant to adopt new technologies such as SRI. Similar results were reported by Poornima (2017) that farm activities have positive effects on rice yield and household income.

Access to credit by the smallholder farmers had a positive coefficient and significant at 1% level. Credit is an important factor in agricultural production. Farmers

Table 3. Endogenous switching regression results for rice productivity.

Variable	Selection equation		SRI Regime		CF Regime	
	Coeff	P>z	Coeff	P>z	Coeff.	P>z
Age	0.051	0.009***	-0.133	0.241	-0.005	0.919
Education	-0.179	0.501	2.266	0.175	-1.388	0.041
Marital status	-2.546	0.001***	5.197	0.090**	-4.352	0.001***
Household size	0.854	0.000***	0.639	0.583	1.709	0.000***
Average monthly income	-1.4E-05	0.434	0.0002	0.011**	5.83	0.083
Off- farm work	1.428	0.000***	-7.544	0.00***	3.782	0.000***
Farm size	0.336	0.231	0.627	0.662	1.602	0.004**
Years in rice farming	-0.144	0.014**	1.153	0.003**	-0.496	0.003**
Distance from the canal	0.740	0.00***	-2.292	0.003**	0.666	0.038
Extension services	2.639	0.00***	-5.704	0.096	3.832	0.008**
Credit access	4.024	0.00***	-13.299	0.000***	2.672	0.063
Labor use	3.901	0.00***	0.0003	0.000***	4.74	0.058
Wald Chi2 (13)	613.520					
Prob> chi2	0.000					
Log likelihood	-1250.870					
Rho1	-0.231					
Rho 2	0.210					
Sigma	7.5318					
Lambda	-1.7449					

LR test of indep. eqns. (rho = 0): chi2(1) = 2.06 Prob > chi2 = 0.1509,*** 1% level of significance, **5% level of significance.

with access to credit have a high likelihood of increasing production. Credit is accessed by having membership in co-operative or any other financial organization. The results agrees with the findings of Abdulai and Huffman (2014) who noted that access to credit has a positive relationship with the productivity of rice farmers. The distance from the canal influences rice production positively. It is significant at 10%. As the distance increases from the canals, farmers are keener to use resources efficiently such as water in the production of rice. Similar findings were found by Kamoshita and Dinh (2018) that increased distance from water sources affected rice productivity positively. Pede et al. (2018) further showed that the location of the farmer to water source affects the level of productivity.

Access to extension services has a positive coefficient and is statistically significant at 1% for the selection equation; the results imply that the value of providing farmers with skills and new production techniques improves on yields. Access to extension services positively affects rice productivity. This implies that farmers with access to extension services can acquire training on methods of rice production. In addition, farmers are usually informed of the existence and the effectiveness of new technologies such as SRI. The extension agents act as the links between the innovators and the users of the new technology. This helps to reduce the cost of a transaction when training on the new practices. Similar findings were reported by Kinuthia (2015), that access to extension affects the productivity of new varieties. Varma (2017) also reported that access to extension services positively affects rice productivity and income consecutively. Furthermore, Abdulai and Huffman (2014) indicated that access to extension positively affects the productivity of adopters and non-adopters of the new technologies.

The farm size is statistically significant at 5%. An increase in the farm size increases the probability of adopting water-saving technology and thus enhancing rice production. The small landholdings hinder the practice of new technology compared to large farm holdings. Farmers with large holdings can afford to devote their lands to try new practices such as SRI unlike those farmers with less farm size. Distance from the canal affects rice productivity positively. These results imply that farmers closer to the water source have better yields than farmers far from the canals. Farmers in far distances from water sources have the likelihood of experiencing water shortages which on the other hand reduces the output. Similar findings were found by Kamoshita et al. (2018) that distance from water sources negatively affected rice productivity. Pede et al. (2018) further showed that the location of the farmer to water source affects the level of productivity. Labour is statistically significant at 1%. Rice farming is regarded as labor intensive. Therefore labor is an integral variable to determine the productivity of the technology. The findings are consistent with the findings of Canon et al. (2018), Adesina and Zinnah (1993), Karki (2010) and Karubanga et al. (2019).

Conclusion

The study assessed the factors influencing rice productivity under SRI and CF. The results of econometric modeling showed that household size, involvement in off-farm work, farmer experience, distance from the canal, access to extension services, credit access and labor use affect rice productivity significantly. These findings suggest that paying attention to these factors is a good strategy to enhance rice productivity under SRI among smallholders in Mwea Irrigation Scheme. Additionally, the study compared the profitability of SRI and CF using Gross Margins (GM). It was established that both CF and SRI had higher returns than costs. Therefore it makes it profitable to use either SRI or CF. However, the returns of SRI outweigh the returns of CF thus making SRI more profitable. However, it was noted that SRI is more labour intensive as compared to CF. The labour requirement of SRI is high during the initial stages of land preparation and weeding.

Recommendations

(1) To improve rice productivity in Kenya, the government and development partners should work together to improve access to suitable agricultural credit. This can be realized by the formation of more farmer cooperatives in the study area.

(2) The government of Kenya together with research organizations should also play a role in providing training on SRI components and strengthen the field demonstration process for better adoption of SRI and improved returns.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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