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Adoption of Improved Maize Seeds and Production Efficiency in Rivers State, Nigeria

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Abstract: Maize is an important staple food in Nigeria. Declining yields of maize as a result of several environmental and biological factors have necessitated technological innovations focusing on maturity time, disease resistance and palatability of the crop. This study therefore assesses the adoption of improved seeds and efficiency levels of farmers in River state, Nigeria. The data were obtained from 150 farmers that were randomly selected using two-stage sampling procedures. The Probit model and production function analysis were the analytical methods. Results show that education, farming experience, mono-cropping, minimum tillage and use of fertilizer significantly influence adoption ($p<0.1$). Also, use of hybrid seeds significantly reduces inefficiency ($p<0.1$) along with other factors like age, experience, crop rotation, minimum tillage, fertilization. It was recommended that efforts to increase adoption of improved maize seeds for enhanced farm efficiency should focus on farmers' education, farming experience and access to fertilizers.

Key words: Efficiency · Maize · Production function · Probit model

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crop in sub-Saharan Africa (SSA). Along with rice and wheat, maize is one of the three most important cereal crops in the world. According to FAO data, the land areas planted to maize in West and Central Africa alone increased from 3.2 million in 1961 to 8.9 million in 2005. This phenomenal expansion of the land area devoted to maize cultivation resulted in increased production from 2.4 million metric tonnes in 1961 to 10.6 million metric tonnes in 2005. While the average yield of maize in developed countries can reach up to 8.6 tonnes per hectare, production per hectare in many SSA countries is still very low (1.3 tonnes per hectare) [1].

In Nigeria, maize is a staple food of great socio-economic importance. Ironically, the demand for maize as a result of the various domestic uses sometimes outstrips supply [2]. Similarly, the unfolding performance of maize can be attributed to the fact that, bulk of the country's farm, over 90 percent is dependent on smallholder farmers with rudimentary farming system, low capitalization and low yield per hectare. Additionally, other factors like price fluctuation, diseases and pests, poor storage facilities have been associated with low maize production in the country [3]. In view of this, national and international bodies have developed interest in promoting maize production for households' food security and poverty alleviation. Some of these efforts have been channelled through biological and agronomic research into the development of high-yielding varieties along with best cultural practices. The agricultural extension arms of several government parastatals have therefore been saddled with the responsibility of ensuring that farmers use the hybrid varieties in order to increase production. This is important if the research-extension-farmer linkage will be strengthened for maximum impact.

This study derives its justification from the fact that maize is one of the main staple food among rural households in Nigeria. However, there has been a fluctuating trend in maize production over the last decade, which threatens household food security and income sources. Secondly, in the last two decades, maize has yielded compelling success stories with the adoption of new technologies that has increased smallholder maize production. The diffusion of new technologies in Africa has been more widespread for maize than for other food crops. This implies that this success can provide lessons for further increasing food production. Assessment of farmers' efficiency in maize production resulting from technological innovations also has some food security implications. Policy makers will therefore be advised on socio-economic variables that influence adoption in order to channel agricultural development process in a manner that takes care of every segment of the population.

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Scholars have undertaken several studies on adoption of an innovation. Adoption had been defined as the decision to apply an innovation and to continue to use it [4]. No doubt, the importance of farmers' adoption of new agricultural technology has long been of interest to researchers [5]. Precisely, researchers across the globe have identified several parameters believed to be influencing farmers' decision to adopt a technology or not. Lawal *et al.* [6] examined the adoption and assessment of improved maize varieties by farmers in Institute-of-Agricultural-Research-&Training-adopted villages in Southwest Nigeria. The findings showed that adoption of improved maize seed was 56.7 percent. Empirical evidence reveals that age, household size, education and varietal attributes were the most important factors that influenced the adoption of improved maize seeds. Saka *et al.* [7] analyzed the factors influencing adoption of improved rice seeds in south western Nigeria. The study showed that farm size, frequency of extension contact and the yield rating of the improved rice varieties are the significant factors influencing both the decision of farmers to adopt the improved rice varieties.

Sserunkuuma [8] examined factors responsible for poor adoption of production-enhancing technologies in the production of maize in Uganda. It was found that farmers do not pay proper attention to soil fertility management, which acts as a major constraint to increase yields. The analysis also indicates the need for vibrant rental market for land to provide access to landless tenants who are found to be the economically efficient. Kaliba *et al.* [9] examined the factors influencing the adoption of improved maize seeds and the use of inorganic fertilizer for maize production by farmers in the intermediate and lowland zones of Tanzania. The results indicate that availability of extension services, on-farm field trials, variety characteristics and rainfall were the most important factors that influenced the extent of adopting improved maize seeds and the use of inorganic fertilizer for maize production. The farmers indicated to prefer those varieties which minimize field loss rather than maximizing yields.

This study intends to determine household socio-economic factors that affect adoption decision of improved maize seeds, as well as evaluating the efficiency differentials across the different groups of farmers. In the remaining parts of the paper, section 2 discusses the materials and methods, section 3 itemized the results and discussion, while section 4 concluded with some policy recommendations.

MATERIALS AND METHODS

Study Area: The study was carried out in Ken-Khana local government area of Rivers state, Nigeria. The local government is located in Ogoni land, which is situated in an area of about 100,000 km², east of Port-Harcourt, the state capital. Because of their involvement in farming and increasing population, most of the rainforest vegetations have been cleared for farming activities. This area was once the food basket for the Niger Delta and beyond. However, Ken-Khana's agricultural production has now been severely hampered due to loss of farmlands to oil pollution and persistent decline in soil fertility.

Source of Data: The data used for this study were collected with the aid of structured questionnaire that were administered to food crop farmers. The data collected include socio-economic factors (like age, household size, farming experience, education level, farm size), adoption of improved maize seed, use of land management practices, input use and output. A multi stage sampling procedure was adopted for this study. The first stage involved the random selection of fifteen villages from the list of the villages in the local government area. The second stage involved a random selection of an average of twelve farmers per village. Therefore, a total of one hundred and eighty (180) responses were envisaged. However, due to missing information and non-return of questionnaires, a total of one hundred and fifty (150) responses were considered good for use in the study.

Methods of Data Analysis

The Probit Model: Factors influencing adoption of improved maize seed were estimated using some socio-economic, demographic and farm-level agronomic variables of the farmer. The Probit regression method was used due to the fact that we were dealing with a binary dependent variable with values being 1 if adopted and 0 otherwise. The model is stated as:

$$Y_i = \eta + \beta_i \sum_{i=1}^{16} Z_i + e_i \tag{1}$$

The independent variable (Z_is) were age (years), sex (dummy variable – male =1 and 0 otherwise), marital status (married = 1, 0 otherwise), family size, years of farming experience, years of education, mono-cropping (yes =1, 0 otherwise), proportion of maize plot mulched, proportion of the land areas occupied by maize crops, proportion of maize plot with clean clearing, proportion of maize plot under organic manures, proportion of the maize plot under zero tillage, proportion of the maize plot under crop rotation, proportion of the maize plot under slash and burn, proportion of the maize plot covered by crop residues, proportion of the maize plot covered by house refuse, fertilizer application rate (quantity/land areas), number of extension visits and error term. $\eta\ \beta_i$ are the parameters to be estimated.

Stochastic Frontier Production Function Analysis: In order to determine the impact of improved maize seeds on production efficiency, we employed the stochastic frontier model which was estimated using FRONTIER 4.1 statistical software developed by Coelli [10]. The stochastic production frontier as an econometric method of efficiency measurement in production systems is built round the premise that a production system is bounded by a set of smooth and continuously differentiable concave production transformation functions for which the frontier offers the limit to the range of all production possibilities. It has the advantage of allowing simultaneous estimation of individual technical efficiency of the respondent farmers as well as determinants of technical efficiency [11, 12]. The stochastic production function is of the form:

$$Y_i = \alpha_0 + \alpha_i \sum_{i=1}^{5} LnX_i + u_i + v_i \qquad (2)$$

The subscripts i and j refer to the ith farmers and jth observation respectively while, Y is total farm output of maize (kg), X_1 is cultivated land area for maize (ha), X_2 is sum of family labour (man days), X_3 is sum of hired labour (man days), X_4 is quantity of seed planted (kg), X_5 is quantity of fertilizer used (kg), v_i is a random error term with normal distribution N(0, δ^2), u_i is a non-negative random variables called technical inefficiency effects associated with the technical inefficiency of production of farmers involved. *Ln* is the natural logarithm (i.e. to base e). The α_0 to α_6 are the parameters to be estimated.

An inefficiency model was specified to examine the effect of these variables (z) on the technical inefficiency (u_i) of the farmers in maize production. The model assumes that the inefficiency effects are independently distributed having N (0, σ_u^2) distribution and mean u_i [13]. The general form of the model is specified as:

$$u_i = \delta_o + \delta_i \sum_{i=1}^{11} Z_i + d_i \qquad (3)$$

Where Z_is are already defined in equation 1 and d_i is the error term.

RESULTS AND DISCUSSION

Socio-Economic Characteristic of the Farmers: Table 1 shows that 21.3 percents of the respondents were between the ages 20-39 years, 58 percent of the respondents were between ages 40-59 years while 20.7 percent of the respondents are older than 60 years. The average age of the farmers is about 48 years, while the variability index is 33.47 percent.Also, 48.7 percent of the respondents were male, while 51.3 percent were female. This does not go with the expectation that the males dominate agricultural production in some Nigerian states. Several studies have indicated that women in Africa are responsible for up to 60 percent of African agricultural workforce. Damisa *et al.* [14] reported that Nigerian women contribute a lot to food production, although their contributions have often been under-valued. Therefore, as the homemakers, more women than men may be involved in farming in order to supplement the food needs of their households.

Similarly, 26.7 and 28.7 percent of the respondents had no formal education and primary education respectively, while 28 and 16.7 percent of the respondents had secondary and tertiary education, respectively. The average year of formal education is 8 years, with variability index of 87.5 percent. This low level of education will no doubt affect the level of technology adoption and skill acquisition. Agricultural extension experts point out that farmers with higher educational qualification are more likely to adopt agricultural technological innovations more than those without or with lower educational qualification. Data in Table 1 show that 47.3 percent of the respondent's had between 1-15 years of experience in agricultural production, while 52.7 percent had above 16 years experience. The average years of farming experience is 20 years, with variability index of 75 percent. This indicates that most of the farmers have been practicing farming for long. The accumulated years of experience may help farmers in crop selection and enable them to evolve the farming practices that are most suitable to their fragile environment.

Table 1: Age Distribution of Farmers

Socio-economic groups	Frequency	Percentage (%)
Age (year)		
20-39	32	21.3
40-59	87	58.0
60 and above	31	20.7
Sex		
Male	73	48.7
Female	77	51.3
Educational level		
No formal education	40	26.7
Primary education	43	28.7
Secondary education	42	28.0
Tertiary education	25	16.7
Year of farming experience		
1-15	71	47.3
16-30	56	37.4
Above 30	2	15.3
Year of planting maize		
1-15	99	66
16-30	31	20.7
Above 30	18	13.3

Table 2: Factors influencing adoption of improved maize seeds

Variables	Coefficient	Standard error	t-statistics	Mean value
Constant	-7.3985***	2.129	-3.4750	
Age	-0.0129	.01685	-.767	47.8333
Sex	0.3037	0.5442	0.558	0.4867
Marital status	-0.7252	0.5152	-1.408	0.6267
Household size	0.0444	0.1476	0.301	5.1467
Farming experience	0.1002***	0.0352	2.846	20.5133
Education	0.2024***	0.0630	3.210	8.0533
Primary occupation	1.0223	1.0115	1.011	0.9267
Mono-cropping	2.4869***	0.8652	2.874	0.1467
Amount of renting land	0.00001	0.000006	1.630	8830.0667
Use of mulching	0.4274	0.6934	0.616	0.6149
Use of crop rotation	1.0004	0.6336	1.579	0.1667
Use of organic manure	0.0009	0.5503	0.002	0.7100
Use of zero tillage	2.2674***	0.8336	2.720	0.2667
Use of fertilizer	1.4151*	0.7684	1.842	0.6533
No extension visit	-0.9636*	0.5716	-1.686	0.7466
Log likelihood function		-31.86787		
Restricted log likelihood		-67.58418		
Chi-squared		71.43263***		

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Furthermore, 4.5, 66 percent of the respondents had cultivated maize for between 1-15 years, while 20.7 and 13.3 percent had cultivated maize for between 16-30 years and above 30 years, respectively. The average years of farming experience in maize production is 16 years, with variability index of 81.25 percent. From this we can deduce that most of the farmers were well experienced in maize production.

Factors Influencing Adoption of Improved Maize Seeds: Table 2 shows the estimated parameters for adoption of improved seeds in Rivers state of Nigeria. The chi square of the log likelihood function is statistically significant ($p<0.01$). This shows that the estimated model fits the data very well. The parameter of farming experience reveals that probability of adoption significantly increase ($p<0.01$) as farmers' experience increases. This goes in line with the finding of Rao and Rao [15]. It is also expected that experienced farmers may be able to understand the nature of risk associated with each of the technologies, having practiced or seen some of them used over time.

Also, probability of adopting improved maize seeds significantly increased ($p<0.01$) as the years of education of farmers increase. Some studies [6, 16] have reported similar findings. Ideally, educated farmers are expected to display better adoption of a technology because of their ability to understand the benefits from such technology and thrust in extension officers. It is however not surprising that while adoption rate was as low as 20 percent, average years of formal education was as low as 8 years, depicting a generally non-completion of the junior secondary school.

Furthermore, the practice of mono-cropping significantly increases the probability of adoption ($p<0.01$). This also goes in line with expectation because a major advantage of the maize hybrid seed is early maturity. However, when farmers do not grow sole crops, especially where crops like cassava and yam are inter-cropped with maize, the tendency to ignore early matured varieties may increase.

Also, out of the included cultural factors, only the use of zero or minimum tillage and application of fertilizers are statistically influencing adoption ($p<0.10$) of improved maize seeds. This shows that as farmers' access to fertilizer is being guaranteed, hybrid seeds will be grown. Also, the practice of minimum tillage will be encouraged as a farmer has access to fertilizer and grows a maize variety that mature early. The farmers that indicated not to have access to extension agents have significantly lower probability of growing improved maize seeds. This goes in line with the finding of Igodan *et al.* [17]. This is expected because contacts with extension agents facilitate adoption because these guarantees high level of awareness.

Table 3: Results of Maximum Likelihood Estimates (MLE) of the production function

Variables	Coefficients	Standard error	t-statistic
Constant	9.7780	0.2661	36.7425***
Land area	-0.1159	0.1709	-0.6781
Family labour	0.0116	0.0099	1.1734
Hired labour	0.0270	0.0056	4.8182***
Seed	0.0048	0.0022	2.1945**
Fertilizer	0.0042	0.0022	1.9303*
Sigma-squared	10.8523	2.2161	4.8971***
Gamma	0.9731	0.0073	133.9674***

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 4: Parameter of technical inefficiency of farmers

Inefficiencies variables	Coefficients	Standard error	t-statistic
Constant	1.6492*	0.9678	1.7039
Age	-0.2631***	0.0716	-3.6769
Experience	-0.1437**	0.0584	-2.4633
Family size	-0.0347	0.3061	-0.1132
Mulching	1.7143	1.1239	1.5253
Crop rotation	-11.8941**	4.1510	-2.8652
Organic manure	-1.0177	1.0013	-1.6230
Education	-1.0177	1.0013	-1.0162
Zero tillage	-4.2736**	1.6559	-2.5807
Fertilization	-3.7554**	1.2884	-2.9147
Cover crop	3.4386**	1.5419	2.2300
Hybrid seeds	-1.8133*	-1.0369	1.7487

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Maize Production and Inefficiency Analysis: This study used the Maximum Likelihood Estimates (MLE) for efficiency estimation and the results are in Table 3. The estimated coefficients for seed, family labour and hired labour were all positive, which conform to *a priori* expectation and significant. The positive coefficients of these variable inputs imply that increase in quantities of these inputs would result in increased output. The estimated coefficients for land is negative, which does not conform to *a priori* expectation. The negative coefficient imply that increase in quantities of these inputs will result in decreased output. This may be connected to the fact that most of the lands in the study area have been polluted due to oil spillage, gas flaring, acid rain and dumping of toxic waste in the environment. So an increase in land area will not have any significant effect on the level of efficiency that will be achieved. Fertilizer is with positive sign, implying that increasing its quantities will increase maize output.

Table 4 shows the results of the inefficiency model. The coefficient of the inefficiency variables with the exception of cover crops and mulching have the expected signs. Since the dependent variable of the inefficiency function represents the mode of inefficiency a negative sign on an estimated parameter implies that the associated variable has a positive effect on efficiency and a positive sign indicates that the reverse is true. Hence, age, experience, family size, crop rotation, organic manure, education, zero tillage, fertilization, use of hybrid seed and farm income have positive influence on the technical efficiency of the maize farmers. The coefficient of age is estimated to be negative as expected and statistically significant ($p<0.01$). The implication is that older farmers tend to be more efficient in maize production. This conforms with the findings of [18] who reported that a negative production elasticity with respect to farming experience for farmers in two villages in India. Ogundari [19] also reported that age significantly reduced profit inefficiency of some rice farmers in Nigeria. Similarly, increasing farming experience will statistical significantly reduce inefficiency ($p<0.05$). This is also expected because as farmers gain more experience in maize production, it is expected that their efficiency level will increase. Oyekale [20] reported similar finding for some food crop farmers in the rainforest belt of Nigeria.

Some of the land management variables that were included show some statistical significance. Precisely, use of crop rotation reduces inefficiency significantly ($p<0.01$). This is expected because crop rotation ensures appropriate management of soil nutrient. Also, Oyekale [21] reported similar result for some food crop farmers in southwest Nigeria. Zero tillage or minimum tillage significantly reduces inefficiency ($p<0.01$). This goes with expectation because with zero tillage, soil nutrients are able to be conserved and efficiently utilized for crop's growth and development. Also, those farmers that were using fertilizer have significantly lower level of inefficiency ($p<0.01$). Fertilizers are necessities for growing maize in areas where fertile lands are rare to come by. However, those farmers that were using cover crop have significantly higher level of inefficiency ($p<0.05$). This is expected because most of the farmers were using planting melon as cover crop. The implication is that it will take a longer time to weed such farms because of the patience demanded if the cover crops will not be destroyed. Finally, those farmers that were using hybrid seeds (yellow maize) have significantly lower level of inefficiency ($p<0.1$). This is expected and shows that because of its early maturity, planting of hybrid seeds is bound to reduce the level of inefficiency in maize production.

CONCLUSION

Maize occupies a central position in the diets of Nigerian rural and urban households. It importance can also be gauged by its being affordable to the poor, majority of whom are found in rural areas. The emerging declining trends of maize yields necessitate a study of the factors influencing adoption of hybrid seeds and technical efficiency in a soil degradation prone area of Rivers state. The policy implications of the findings of the study are hereby discussed.

First, farmers' education is a top priority if their response to technological innovation will improve. This study found that educated farmers have higher probability of using improved maize seeds. This should be addressed by the policy makers in a way that will be attractive because the general behaviour of the people in the study area is that of encouraging business ventures for children without completing their normal education. This may not be unconnected with the average years of schooling that is as low as 8 years for the respondents.

Secondly, the introduction of maize hybrid seeds to farmers should target those with ample experience in farming. This is because they are able to appreciate technological innovation better than new entrants. Similarly, the extension arms of the Agricultural Department in Rivers state should be strengthened for effective dissemination of technological innovation. We found that those farmers with access to extension have higher probability of adopting the use of maize hybrid seeds. It should also be noted that many of the farmers who reported extension contacts also do so once in a while.

Thirdly, inefficiency in maize production can be reduced by promoting soil management practices like use of fertilizers, crop rotation and zero tillage. The fragile nature of the soil in the Niger Delta, where this study was conducted requires that appropriate conservation methods be used for sustainable crop production. It should be noted that access to fertilizer not only reduces inefficiency, it also increases the probability of using improved hybrid seeds.

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