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Full Length Research Paper

Determinants of adoption of improved maize varieties in Osun State, Nigeria

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The paper examines the level of awareness and identified the various improved maize varieties (IMVs) cultivated in Osun state, Nigeria. It also analyzed the socioeconomic factors influencing the adoption and intensity of use of improved maize varieties. A multistage sampling design was used to select 360 farming households that were interviewed using structured questionnaire. Data collected included demographic and socioeconomic characteristics of respondents such as age, household size, gender, farm size and other improved maize production related activities. Descriptive statistics and double hurdle model were used as analytical tools. Results showed that the level of awareness of improved maize varieties was 97.8%. About 91% of these estimates were adopters while 8.8% were non adopters. The double hurdle model estimates showed that age (t=4.50, p<0.05), level of education (t=3.33, p<0.05), farming experience (t=4.33, p<0.05), household size (t=2.18, p<0.05), farm size (t=4.02, p<0.05), and household's distance to market (t=2.26, p<0.05) were significant determinants of adoption of IMVs while age of respondents (t=2.31, p<0.05), level of education (t=2.27, p<0.05), household size (t=2.79, p<0.05), farm size (t=2.51, p<0.05), frequency of contact with extension agent (t=10.46, p<0.05), off farm income (t=2.19, p<0.05), and membership in association (t=2.46, p<0.05) determined use intensity of improved maize varieties. The study concluded that policies that increase farmers' level of education and effectiveness of extension services contact will facilitate adoption and use intensity of improved maize varieties.

Key words: Adoption, use intensity, improved maize varieties; and double hurdle model.

INTRODUCTION

For most developing countries, agriculture provides a leading source of employment and contributes large fractions of their national income. In addition, provision of adequate food for an increasing population and supplying of adequate raw materials to and providing markets for the product of a growing industrial sector have been identified as part of the major roles of agriculture in the economy of Nigeria. However, for agriculture to perform its roles towards economic development depends largely on agricultural productivity. High yielding seed varieties that are fertilizer responsive, tolerant to drought and resistant to pest is one of the key elements that constitute the pivot on which increased agricultural productivity per unit of land is rested (Idachaba, 1994). As noted by Duflo et al. (2006), the rapid population growth has made countries in Africa to be no longer viewed as a land-abundant region where food crop supply could be increased by expansion of land used in agriculture. Demographic and environmental pressures have made arable land to become scarce and increasingly marginal for food production in Africa.

Maize is one of the major cereal crops grown and consumed across all agro ecological zones of Nigeria. It currently accounts for approximately 20% of domestic food production in West and Central Africa. It has also achieved the highest growth rate of the major crops since the 1970s (Kamara et al., 2006). Despite the high yield potential of maize; its production is faced with numerous constraints. Studies (Babatunde et al., 2008, Kudi et al., 2011) have shown that maize average yield is still low compared to its potential yield. Thus, enough maize has not been produced in Nigeria to meet both the food and industrial needs of Nigeria. The International Institute of Tropical Agriculture (IITA) has developed extra early maturing, decreasing susceptibility to drought, disease tolerant and high yielding maize varieties that are adapted for growth in West Africa. All these positive attributes of improved maize varieties will reduce the chronic food shortages, stabilizes rural income and lessening the risk of farming.

The importance of farmers' adoption of new agricultural technology has long been of interest to agricultural economists, extensionists and rural sociologists. It is believed that an effective way to increase productivity is broad based adoption of new farming technologies (Minten and Barret, 2008). This hypothesis is supported by the substantial improvement in productivity of cereal crop in mid-1990's following extensive promotion of improved technologies by Sasakawa Global 2000, an international NGO working to improve productivity of smallholder agriculture (Tura et al., 2009). Adoption of agricultural technologies refers to the decision to apply a technology and to continue with its use. The adoption decision is divided into three phases: acceptance, actual adoption, and continued use. It is generally a multistage process undertaken most often sequentially and being influenced by a wide range of economic, social, physical and technical aspects of farming (Paudel and Thapa, 2004; De Graff et al., 2005). The low productivity levels have been attributed to low yield potential of seed cultivars, susceptibility of seeds to biotic and abiotic stress, low adoption rate and other recommended management practices (Asnake et al., 2005).

The objective of this paper is to assess the level of technology (IMVs) adoption, identify IMVs cultivated in the study location, and analyze the socioeconomic determinants of adoption and intensity of use of IMVs. By understanding farming households' adoption pattern of improved maize varieties (IMVs), extension programmes can be better designed. Hence, the outcome of this study will enable agricultural policy makers to design policies that will address factors determining the adoption of IMVs.

STUDY AREA AND SAMPLING TECHNIQUE

The study was conducted in Osun State, southwestern part of Nigeria and lies between latitude 05° 58'N and 08° 07'N and longitude 04° 00'E and 05° 05'E. It covers a total land area of approximately 14,875 km^2 with total population of 3,423,535 with sex distribution of 1,740,619 male and 1,682,916 female and population density of 238.1/km^2.The state has three Agro Ecological Zones (AEZs) namely rain forest (Ife/Ijesa), derived savannah (Osogbo), and savannah (Iwo) zones.

The climate is tropical and characterized by bi-modal rainfall pattern with the annual rainfall ranges from 800 mm in the derived savannah to 1500 mm in the rain forest while the mean annual temperature varies from 21.1 to 31.1°C (OSSG, 2004). The state's soil type is of the highly ferruginous tropical red soil and the vegetation is mostly rain forest.

The people of the State are mostly farmers, traders and artisans with larger percentage being farmers. The farmers cultivate permanent crops such as cocoa (*Theobroma cacao*), kolanut (*Cola nitida and C. acuminata*), plantain and bananas (*Musa spp*), Oil palm (*Elias guinensis*) and citrus (*Citrus Spp*). They also cultivate arable crops especially maize (*Zea mays*) with different varieties widely cultivated. Other arable crops cultivated include yam (*Discorea spp*), cassava (*Manihot esculenta*), rice (*Oryza sativa*) and cocoyam (*Colocasia spp).*

Multi-stage random sampling technique was used to select sample of 360 maize farmers. The first stage involved purposive selection of four Local Government Areas (LGAs) noted for maize production in each of the three agro-ecological zones (AEZs) in Osun State, based on the classification of the state's Agricultural Development Programme (ADP). The second stage also involved purposive selection of three high maize producing villages in each of the LGAs. In the third stage, stratified random sampling was used to categorize maize farmers into adopters and non adopters of improved maize varieties in each of the village. The fourth stage involved simple random selection of five maize farmers in each of the two categories making a total of 360 respondents for the study.

Data collected include the socioeconomic variables such as: Age, sex, farming experience, level of education, frequency of contact with extension service, credit availability, market access and farm size. The data also included the level of awareness and IMVs cultivated in the study area.

Data analysis

Descriptive statistics was used to assess the level of awareness and adoption of IMVs as well as identifying IMVs cultivated while double hurdle model was used to analyze socioeconomic factors determining adoption and intensity of use of improved maize varieties.

Specification of double-hurdle model

The underlying assumption in the double-hurdle approach is that a farmer makes two decisions with regard to his willingness to grow improved maize. The first decision is whether to allocate a positive amount of land to improved maize variety at all while the second decision is about the share of land to allocate, conditional on the first decision.

Originally proposed by Cragg (1971), the double- hurdle model is a parametric generalization of the Tobit model, in which two

Table 1. Awareness and adoption of improved maize varieties.

Variable	Frequency	Percentage
Level of awareness		
Households with awareness	352	97.8
Households without awareness	8	2.2
Total (sample size)	360	100.0
Level of adoption based on awareness		
Adopters	321	91.2
Non adopter	31	8.8
Total (level of awareness)	352	100.0

Source: Field Survey, 2011.

separate stochastic processes determine the decision to adopt and the intensity of adoption of the technology (Greene, 2000). The double-hurdle model has an adoption (D) equation:

$D_i = 1$ *if* $D^*_i > 0$
$D_i = 0$ *Otherwise*

$$D^*_i = \alpha Z'_i + \mu_i \quad (1)$$

Where D* is a latent variable that takes the value 1 if the farmer adopts improved maize varieties and zero otherwise, D_i is the observed variable which represent farmers adoption decision, Z is a vector of explanatory variables hypothesized to influence adoption, α is a vector of parameters and μ is the error term. The level of adoption (Y) has an equation of the following:

$$Y^*_i = \begin{cases} Y_i = \beta X'_i + v_i & \text{if } Y^*_i > 0 \text{ and } D^*_i > 0 \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

Where Y_i is the proportion of land area planted with improved maize varieties (signifying the extent or intensity of adoption), $\hat{Y}_i$ is the unobserved or latent variable for the intensity of adoption, X is a vector of explanatory variables hypothesized to influence intensity of use of improved maize varieties, β is a vector of parameters to be estimated and v_i is the error term.
The error terms, μ_i and v_i are distributed as follows:

$$\left.\begin{matrix} \mu_i \sim N(0, 1) \\ v_i \sim N(0, \sigma^2) \end{matrix}\right\}$$

The error terms, μ_i and v_i are assumed to be independent of each other and normally distributed with zero mean and constant variance. The log-likelihood function for the double-hurdle model following Greene (2000) is:

$$LogL = \sum_0 ln\left[1 - \Phi(\alpha_i Z'_i)\left(\frac{\beta X'_i}{\sigma}\right)\right] + \sum ln\left[\Phi(\alpha Z'_i)\frac{1}{\sigma}\phi\left(\frac{Y_i - \beta X'_i}{\sigma}\right)\right] \quad (3)$$

In this case, the model relating to adoption was specified as:

$$Y_1 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots + \beta_{12} X_{12} \quad (4)$$

Where the explanatory variables are defined as: X_1 = Education of the household head (years), X_2 = Age of household head (years), X_3 = Farming experience (years), X_4 = Household size (number), X_5= Farm size (ha), X_6 = Off-farm income (₦), X_7 = Access to credit (1 if yes, 0 otherwise), X_8 = Frequency of extension service contacts (frequency), X_9 = Distance to market (km), X_{10} = Membership in association (1 if yes, 0 otherwise), X_{11} = Seed availability (1 if adequate, 0 otherwise), X_{12} = Land security (1 if secured, 0 otherwise) while the dependent variable, Y_1 = adoption of improved maize varieties (1 if adopted, 0 otherwise) and βs are coefficients of parameters to be estimated.

RESULTS AND DISCUSSION

Level of awareness and adoption of IMVs

Descriptive statistics results showed that majority (97.8%) of sampled households were aware of improved maize varieties. Of the aware households, majority (91.2%) were adopters while 8.8% were non adopters (Table 1).

Improved maize varieties cultivated in Osun state

Five improved maize varieties were commonly cultivated in the study area. DMR-ESR-Y was most widely adopted (61.9%) while 3.1% TZMSR-W was least adopted (3.1%) as shown in Table 2.

Socioeconomic characteristics of respondents

The mean age of the total respondents was 58.6±13.3 years which was an indication that the respondents were fairly in their active years. The mean age of the adopters and non adopters were 52.1±9.4 years and 54.2±10.8 years respectively. The mean age difference between adopters and non adopters was observed to be significant at 5% level. This indicated that age influences adoption of improved maize varieties.

Respondents composed of both male and female household heads. Majority (83.6%) were male while 16.4% were female headed. The male headed households' proportion for adopters and non adopters

Table 2. Improved maize varieties cultivated.

Variety	Frequency	Percentage
DMR-ESR-W	47	14.6
DMR-ESR-Y	199	61.9
DMR-LSR-W	29	9.0
DMR-LSR-Y	36	11.2
TZMSR-W	10	3.1
Total	321	100

Source: Field survey (2011).

Table 3. Socioeconomic characteristics of respondents.

Variable	Pooled (n=360)	Adopter (n=321)	Non-adopters (n=39)	t-value
Mean age (year)	58.6(13.3)	52.1(9.4)	54.2(10.8)	2.8824**
Sex (%)				
Male	83.6	84.7	74.4	
Female	16.4	15.3	25.6	
Education (%)				
No education	36.7	35.2	48.7	
Primary	21.9	23.7	7.7	
Secondary	28.6	26.8	43.6	
Tertiary	12.8	14.3	0.0	
Mean year of education (year)	7.1(6.3)	6.3(2.1)	5.6(2.2)	4.5768**
Mean farmsize (ha)	3.2(2.1)	2.8(2.0)	2.6(2.0)	3.5540**
Mean farming experience (year)	31.9(13.8)	30.5(13.4)	26.9(12.3)	2.6911**
Income sources (%)				
Farming only	54.7	57.1	35.9	
Farming/petty trading	19.4	16.5	43.6	
Farming/artisan	14.7	14.6	15.4	
Farming/civil service	11.2	11.8	5.1	
Membership in Association (%)				
Yes	52.8	54.2	35.9	
No	47.2	45.8	64.1	

ha = hectare, % = percentage, **=5% level of significance, standard deviation in parenthesis.
Source: Field survey (2011).

were 84.7 and 74.4% respectively. This shows that male headed were higher than female headed households for each category of respondents. This could be attributed to various reasons such as economic and social position of female headed households, including labour shortages and limited access to required information and inputs.

Education is an important determinant of adoption decisions. It helps to understand and interpret the information coming from any direction to farmers (Bekele and Mekonnen, 2010). To a greater degree, education determines the ability to read and/or write by farmers. As shown in Table 3, 36.7% of the total respondents had no formal education while 21.9, 28.6 and 12.8% completed primary, secondary and tertiary education respectively. If completion of primary school is taken to measure ability to read and/or write, the finding revealed that 63.3% of the total respondents could read and/or write, while 36.7% of them could not. This indicated that the level of literacy is high; this may be the reason for high rate of adoption as shown in Table 1. The mean year spent in acquiring formal education for the total respondents was 7.1±6.3 years while it was about 6.3±2.5 years and 5.6±2.2 years for adopters and non adopters respectively. The mean difference of the year spent in

Table 4. Probit estimates of socioeconomic factors determining adoption.

Variable	Coefficient	Standard error	P-value	Marginal effect	t-value
Age	-0.0702***	0.0156	0.000	-0.0099	4.50
Education level	0.0789***	0.0237	0.001	0.0113	3.33
Farming experience	0.0705***	0.0163	0.000	0.0101	4.33
Household size	0.1241**	0.0569	0.029	0.0167	2.18
Farm size	0.0949**	0.0236	0.000	0.0128	4.02
Access to credit	0.3327	0.0234	0.155	-0.0467	2.26
Seed availability	0.8346	0.5609	0.137	0.1518	
Distance to market	-0.0782**	0.0346	0.024	-0.0978	
Extension contact	-0.1483	0.2393	0.536	0.0012	
Land security	0.0797	0.2629	0.762	0.0061	
Off farm Income	0.0001	0.0015	0.967	0.0000	
Membership	0.2946	0.2273	0.195	0.0456	
Constant	0.2887	0.9300	0.756		
LR chi2(13)	112.06				
Prob > chi2	0.0000				
Log likelihood	-104.5536				

*** = 1% significance, ** = 5% significance. Source: Field survey (2011).

school between adopters and non adopters was significant at 5% level. This indicated that there is a relationship between education and adoption of improved maize varieties in the study area.

Membership of respondents in different farmers' association is assumed to have influence on adoption decision of farm households. It makes farmers to have more access to input, information and better interpretation of available information related to new technology. More than half of the respondents (52.8%) were members in one farmers association or the other while, 47.2% were not. Further, within each category, greater percentages of adopters (54.2%) were members in farmers' association while greater percentages of non adopters (64.1%) were not.

The mean farm size of the total respondents was 3.2±2.2 ha. The mean farm size for adopters category was the highest (2.8±2.1 ha) whereas it was 2.6±2.0 ha for non adopters. The mean difference of the total farm size between the adopter and non adopters' categories was found to be significant at 5% level.

This shows that farm size has a relationship with adoption of improved maize varieties in the study area. Farming experience is likely to have a range of influences on adoption. A more experienced farmer appears to be more knowledgeable and may have a lower level of uncertainty about new technologies. Table 3 shows that the mean years of farming experience was 31.9±13.8 years for the total respondents. The adopters and non adopters category of the respondent had mean years of 30.5±13.4 and 26.9±12.3 respectively. The mean difference of farming experience between adopters and non adopters was found to be significant at 5% level. This indicates that farming experience influences adoption of improved maize varieties in the study area. Some respondents had other sources of income besides farming which implied that they engaged in off farm activities. Of the total respondents, 54.7% got their income solely from farming. Others combined petty trading (19.4%), artisans (14.7%) and civil service (11.2%) with farming. Further, within each category; majority of adopters (57.1%) got their income solely from farming. For the non adopters, majority (43.6%) earned their income from farming and petty trading.

Determinants of adoption of improved maize varieties

The double hurdle model shows the result of probit model for adoption and the truncated regression model for use intensity of improved maize varieties in the study area. The estimated coefficients of probit model and truncated regression model are presented in Tables 3 and 4 respectively.

Factors determining adoption of improved maize varieties

Age of the household's head was found to be a statistically significant variable at 1% level with negative relationship. The negative relationship implies that age reduces adoption probability. A unit increase in the age of the respondent reduces probability of adoption by 0.9%. This implies that the older the respondent, the lower the probability of adoption. This finding agrees with previous studies on technology adoption such as Bamire et al. (2002) and Akinola et al. (2008).

The coefficient of level of formal education of the household head was positive and statistically significant at 1% level. Education which is the ability of respondents to read and/or write increased adoption probability in the study area. Educated farmers are more analytical and observe easily the obvious advantages of new technologies. The positively significant influence implies that the higher the level of formal education, the higher the probability of adoption of improved maize varieties. This agreed with previous studies on technology adoption such as Lemchi et al. (2005) and Nnadi and Akwiwu (2008).

The coefficient of farming experience was positive and statistically significant at 1%. This implies that the more the years of experience in farming, the higher the likelihood of adopting improved maize varieties. Increased years of farming experience furnished farmers with more knowledge that increased their rationality in the use of innovations. This is in consonance with Nnadi and Amaechi (2007) that explained increased years of farming experience as a valuable asset in adoption decision making. However, this contradicted Bamire et al. (2002) that indicated that the older the farmer, the less likely he is to adopt new ideas as he gains more confidence in his accustomed ways and method because experience affects individual mental attitude to new ideas differently and influences adoption in several ways.

Household size was statistically significant and positively related to the probability of adoption at 5%. The direct relationship implies that large household size predisposes adoption of improved maize varieties. This may be due to the fact that large household size is assumed to be an indicator of labour availability and that such a household would like to improve its food security. This is in agreement with the study conducted by Nnadi and Akwiwu (2006).

Total farm size of the respondent was positive and had statistically significant influence at 1% level on the adoption of improved maize varieties. Nowak (1987) argues that larger farm owners have more flexibility in their decision making, greater access to discretionary resources, and more opportunities to use new practices on a trial basis with more ability to deal with risk. This could be explained by the fact that large farm size presupposes large farm asset. Thus, farmers who had more assets had more dispositions to adopt new technologies than those who had less. A similar result was reported by Nkonya et al. (1997) and Aklilu and De Graaf (2007).

Distance of the farmers' village to market center was found to be statistically significant with negative relationship at 5% level. The negative relationship implies that the farther the distance between farmers' village and the market center, the lower the probability of adopting improved maize varieties. This may be due to the fact that relative proximity to market reduces marketing cost. Therefore, longer distance to market, better yield associated with improved maize and huge associated marketing costs might be responsible for the lower probability of adoption decision. This result is consistent with other studies such as Tesfaye and Alemu. (2001) and Kebede (2006).

With respect to other variables, none was statistically significant. Off farm income, membership in association, land security and improved seed availability were positive as expected. However, access to credit and frequency of extension services paradoxically had negative influence on adoption of improved maize varieties in the study area.

Factors determining use intensity of improved maize varieties

The result of the truncated regression model for the use intensity of improved maize varieties upon adoption showed that age of the household head was statistically significant at 5% level but had a negative influence on the hectares of land cultivated (Table 5). This implies that the older the respondents, the smaller the land area planted with improved maize varieties. An increase in the age of the respondent reduced the use intensity of improved maize varieties. This agreed with previous studies on technology adoption, such as Bamire et al. (2002) and Akinola et al. (2007).

The level of formal education was positive and statistically significant at 5% level. This outcome was expected and conforms to the study conducted by Bekele and Mekonnen (2010). An increase in the level of education of the respondents increased the intensity of use of improved maize varieties. The more educated a farmer, the more he is to diagnose and observe the benefits of new technologies, hence, more hectares of land was put into cultivation of improved maize varieties.

Household size which is an indication of labour availability had a positive influence on the intensity of use of improved maize varieties and was significant at 1% level. As the household size increased, the size of land in hectares planted with improved maize varieties increased. An increase in household size of the respondents increased the use intensity of improved maize varieties. This outcome was in line with the expectation as the sign could be either positive or negative (Zeller et al., 1998). The larger the household, the more the pressure to ensure food security, hence, the cultivation of more hectares of land with improved maize varieties.

The coefficient of farm size of the respondent was positive and statistically significant at 5%. As expected, the larger the farm size, the more the areas planted with improved maize varieties. An increase in the farm size of the respondent increased the areas planted with

Table 5. Truncated regression estimates for use intensity of improved maize varieties.

Variable	Coefficient	Standard error	p-value	t-value
Age	-0.0615**	0.0266	0.021	2.31
Level of education	0.0833**	0.0367	0.024	2.27
Farming experience	0.0223	0.2625	0.395	
Household size	0.2446***	0.0877	0.000	2.79
Farm size	0.0675**	0.0269	0.013	2.51
Access to credit	0.0675	0.3336	0.013	
Seed availability	-1.1708	1.0051	0.245	
Distance to market	-0.0610	0.0542	0.262	
Extension contact	3.9693***	0.3793	0.000	10.46
Land security	0.2037	0.3837	0.0596	
Off farm income	0.0046**	0.0021	0.030	2.19
Membership in association	0.4849**	0.1969	0.014	2.46
Constant	-2.0506	1.6209	0.207	
Sigma	2.3317	0.1433		
LR chi2 (1)	238.82			
Prob > chi2	0.0000			
Log likelihood	-418.4937			

*** = 1% significance, ** = significance at 5%. Source: Data Analysis, 2011.

improved maize varieties. This agreed with Gebremedhin and Swinton (2003) and Kabubo-Mariaura et al. (2010).

Frequency of extension service contact was a positive and statistically significant variable in determining intensity of use at 1% level. Households that had regular contacts with extension agents are more enlightened through advisory services and therefore appreciate the more, benefits of a new technology. An increase in frequency of contact with extension agent increased the intensity of use of improved varieties. This finding agrees with Knowler and Bradshaw (2007).

Coefficient of off farm income was statistically significant positively in determining the use intensity of improved maize varieties at 1% level. This implies that the more the income realized from off farm engagements, the more the hectares of land cultivated with improved maize varieties. Increase in the income from off farm engagements increased the intensity of use of improved maize. This may be due to the fact that more money is available to acquire more hectares of land, more seeds and associated inputs. The positive sign was in line with “a priori” expectation and agreed with Lapar and Pandey (1999).

Membership in association was statistically significant and had a positive relationship at 5% level. The more the respondents join farmer’s association, the more the hectares of land cultivated with improved maize varieties. This implies that information related to procurement and benefits of improved maize varieties were discussed and disseminated at farmers’ meetings. An increase in the number of respondents in farmers’ association increased the use intensity of improved maize varieties. This finding is consistent with the expectation and agrees with Akinola et al. (2008).

However, farming experience, access to credit and land security variables had positive influence on intensity of use of improved maize varieties as anticipated but statistically insignificant. On the other hand, improved seeds availability and distance of farmers’ village to market were also statistically insignificant with negative relationship.

Conclusion

The study revealed that the level of awareness and adoption of improved maize varieties were high in the study area and that IMV adoption was profitable. The study concluded that the adoption decision of improved maize varieties was driven by a host of socioeconomic factors such as age, level of education, farm size, farming experience, household size and distance to the nearest market center while insight into key socioeconomic factors influencing use intensity was provided which included age, level of education, farm size, household size, frequency of contact with extension agent, off farm income and membership in associations. Policies should target strengthening maize farmers to have access to improved education and frequent extension service contact for aiding acceptance and dissemination of agricultural technology information which has the potential to increase the rate of adoption and intensity of use of improved maize varieties.

Conflict of Interest

The authors have not declared any conflict of interest.

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