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REGULAR ARTICLE

TECHNICAL EFFICIENCY OF PRODUCTION OF QUALITY PROTEIN MAIZE BETWEEN ADOPTERS AND NON-ADOPTERS, AND THE DETERMINANTS IN OYO STATE, NIGERIA

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ABSTRACT

This study determined the technical efficiency (TE) of production of Quality Protein Maize (QPM) and the effect on the adoption of QPM in Oyo State, Nigeria. QPM is an improved maize variety developed to reduce protein deficiency problems. A total of 100 maize farmers were sampled through a two-stage sampling procedure. Stochastic frontier approach using maximum likelihood estimation (MLE) was used to analyse the TE in the production of QPM, while probit regression was used to determine the effect of TE and other socioeconomic characteristics of the respondents on the adoption of QPM. The results revealed a mean TE of 0.89 and 0.78 for adopters and non-adopters of QPM respectively. This implied that adopters of QPM are more technically efficient than the non-adopters. Quantity of seed planted and fertilizer directly and significantly affected the TE of QPM while gross margin of maize farmers and income from other sources (at P<0.05), the level of education of farmers and QPM farm size (P<0.01) have significant and a negative effects on technical inefficiency from the results of the Tobit regression. The age (P<0.05) of the farmer has direct effect on technical inefficiency. In conclusion, TE, level of output, information availability on QPM and early maturity were significant determinants of QPM rather than the gross margin of production. Farmers decide to adopt QPM technology because of the high level of technical efficiency in the production of this variety. Their output from QPM can be increased by 11 percent, while the non-adopters can increase their maize output by 22 percent using the available technology.

Keywords: Resource-use efficiency, Stochastic Frontier Analysis, adoption, tobit regression, probit regression.
JEL: C12, C13, D24, D51, E23, H21, O31, O 33, P15, Q16, Q55

INTRODUCTION

Increasing agricultural productivity using the improved agricultural technologies is a precondition for achieving food security in a country deficient in food aids. Maize is the most important cereal in the world after wheat and rice with regard to cultivation areas and total production (**Moniruzzaman 2009; Onyibe *et al.*, 2006; Osagie and Eka, 1998**). The maize varieties referred to as conventional maize (CM) varieties are mostly grown by farmers and are deficient in two essential amino acids, lysine and tryptophan (**Teklewold *et al.*, 2015**). The average yield of maize in developed countries can reach up to 8.6 tonnes per hectare, production per hectare in many Sub-Sahara Africa (SSA) countries is still very low (1.3 tonnes per hectare) (**IIITA, 2007**). Adoption of new agricultural technology is an effective way to increase productivity and household welfare (**Afolami *et al.*, 2015; Mitten and Barret, 2008**). For instance, a study in Mexico showed that adoption of improved maize varieties improves household welfare (**Beceril and Abdullah, 2010**). Similar thing was also found in SSA where adoption of improved maize has positive outcomes on maize yield (**Alene *et al.*, 2009**).

QPM has superior nutritional and biological value and is essentially interchangeable with normal maize in cultivation and kernel phenotype (**Prasanna *et al.*, 2001**). This type of maize has twice the amounts of two essential amino acids namely Lysine and Tryptophan than normal maize (**Moro *et al.*, 1996; Teklewold, *et al.*, 2015**). QPM also make significant contributions to the food and livestock industries (**Dankyi *et al.*, 2005**). It can be easily adopted because of its high yield and nitrogen use efficiency. Farmers prefer the taste of QPM in the various recipes they prepared. The SG2000 effort in research and extension of QPM resulted in the registration and release of SAMMAZ-14 (**Ado *et al.*, 2005**).

However, very low adoption of productivity enhancing technologies has dwarfed efforts to reduce rural poverty (**World Bank, 2008**). The slow rate of adoption of improved agricultural technologies could be due to low expected benefits from the practice or could be due to other factors such as farmers' attitude or institutional factors which may not encourage the adoption of technologies by farmers (**Seyoum *et al.* 1998; Obwona 2000; Ajibefun 2006**).

Against this background, the main objective of this study is to determine the technical efficiency in production of QPM and its effect on the adoption in Oyo State, Nigeria. Specifically, the study describes the socioeconomic characteristics of maize farmers in the study area; estimates the technical efficiency in production of QPM and its determinants; and the effect of TE and other socioeconomic characteristics of the respondents influencing the adoption of QPM among the maize farmers.

The following hypotheses were tested in the study:

H_{01}: The adopters farmers are not significantly more technical efficient than non-adopters.

H_{02}: The gross margin of QPM does not affect its adoption by maize farmers.

H_{03}: the technical efficiency of maize farmers does not affect the adoption of QPM.

Theoretical underpinnings of technical efficiency

The theory underpinning this study on technical efficiency of QPM production by adopters and non-adopters is the theory of production. Given the input vector x for a producer i, the production function $m(x_i;\beta)$is defined by the maximum possible output that can be produced (**Parmeter and Kumbhakar, 2014**). Production efficiency is defined as the ability to produce a given level of output at lowest cost (**Ogundari and Ojo, 2007; Oladeebo and Oluwaranti, 2012**). Farrell's work had led to a better understanding of the concept of the efficiency. Farrell (1957) opined that production efficiency consist of three components: technical, allocative and economic efficiencies. In the output-oriented measure, technical efficiency(TE) is the degree to which a farmer produces the maximum feasible output from a given bundle of inputs (**Oladeebo and Oluwaranti, 2012**) and not every producer can reach the frontier production, even if they use the same level of input vector x (**Parmeter and Kumbhakar, 2014**). The percentage shortfall of output from its frontier given the inputs is called technical inefficiency (TI) (TI=1-TE) (**Parmeter and Kumbhakar, 2014**).Following the input-oriented measure, technical efficiency is the degree to which a farmer uses the minimum feasible inputs to produce a given level of output (**Oladeebo and Oluwaranti, 2012**).

Literature review on adoption, and factors affecting adoption of agricultural technologies

Adoption is a decision made by an individual or group to use an innovation in a continuous manner (**Akubuilo *et al.*, 2007; Olumba and Rahji 2014**). Technology is the systematic application of scientific or other organized body of knowledge to practical purposes. This includes new ideas, inventions, innovations, techniques, methods and materials (**Olumba and Rahji 2014**).

However, farmers' adoption of a new technology, such as improved maize seeds, is a choice between traditional and new technology (**Aloyce *et al.*, 2000**). An innovation is adopted when it is integrated by the user' (**INRAB, 1996; Adekambi 2005**). Therefore, adopters of improved variety of maize are maize-farmers who grow at least one improved variety of maize; while the non-adopters are not cultivating any improved variety of maize. Agricultural technology adoption study has many policy implications in agricultural development (**Fadare *et al.*, 2014**). It serves as a tool for evaluating the distributional impacts of new innovations, for documenting the impact of an innovation or extension effort, for identifying and reducing the constraints to adoption, and as a research guide to focussing innovation priority (**Feder and Slade, 1984; Adesina and Zinnah, 1993; Green and Ng'ong'ola, 1993; Doss, 2003; Langyintuo and Mungoma, 2008; Fadare et al. 2014**). Farmers' decision to adopt or not to adopt is usually based on the profitability and risk associated with the new technology (**Aloyce *et al.*, 2000**).

According to **INRAB (1996)**, four groups of factors have been identified to affect the adoption of agricultural technologies. These are: the complexity of the technology; the availability of initial fund; the expected gross margin and the possibilities of integration of the technology in the socio-cultural environment of the farmer.

Cymmit (1993); Houndekon and Gogan (1996) also identified other four groups of factors which are likely to influence the adoption of a technology as: personal characteristics of the farmer; factors related to the technology and institutional factors related to the production market and the information, and the farm characteristics.

The personal factors/characteristics of the farmer include the level of education of the farmer (**Alao 1971, Atala 1980, Cymmit 1993, Okwoche 1998, Kudi *et al.*, 2010, Ebojei *et al.*, 2012, Umar *et al.*, 2014**); the age, gender, years of farming experience, income level, farm size, labour, risk aversion (**Cymmit 1993, Aloyce et al., 2000**), the household size (**Amegbeto *et al.*, 2001, Umar *et al.*, 2014**). In addition to these factors, there is the rationality and efficiency of the farmer (**Dufuiet 1985, Cymmit 1993; Adekambi 2005**). Farmer decides to adopt a new method, selects an innovation depending on the technical characteristics, the environment and information they have about such technology (**Etoundi and Dia, 2008**).

The factors related to the technology include the economic and nutritional functions of the technology such as the output price of the product, the relative gross margin benefit of the technology, the efficiency of the technology, the cost and return of the investment, and the externalities (**Adekambi, 2005**).

The institutional factors include the access to credit (**Lawal *et al.*, 2004, Kudi *et al.*, 2011**), the land ownership of the farmer, the availability and accessibility to product and factors markets, the availability and the quality of the information about the technologies (**Ayinde *et al*., 2010; Idrisa *et al*., 2012, Fadare *et al.*, 2014**), the regular contact with extension agents (**Polson and Spencer 2004, Alene and Manyong 2007, Umar *et al.*, 2014**) and the development of non-farm activities (**Adekambi, 2005**).

Finally, the farm characteristics include the yield, (**Adesina and Seidi, 1995; Kudi *et al.*, 2011**), type of soil, its level of fertility before the adoption and the climate (**Cymmit 1993, Houndekon and Gogan 1996; Adekambi 2005**).

MATERIALS AND METHODS

The study area was Akinyele Local Government Area in Oyo State, Nigeria, with the headquarters in Moniya and shares boundary with Ibadan North Local Government area to the South; Afijio Local Government area to the North; Ido Local Government area to the West and Lagelu Local Government area to the East. Akinyele Local Government was carved out of the former Ibadan North District Council, comprising the present Akinyele and Ido Local Government. The final split of the Local Government came up in 1976 and 1989 respectively. The major occupations of the people residing in the area are farming, carpentry, trading, marketing, food processing as well as carving work. The crops grown in the area include: maize, cassava, banana, plantain, and cocoyam.

Sources of data

This study was mainly based on primary data, collected by administering a well-structured questionnaire among small scale maize-based farmers. The data collected includes the socio-economic factors like age, household size, maize farming experience, educational level, and farm size, adoption of improved seed, and usage of land management practices, input use and output.

Sampling procedure and sample size

A two-stage sampling procedure was used for this study. The first stage involved the purposive selection of ten villages (Ikereku, Oboda, Arulogun, Onidundu, Moniya, Akinyele, Talonta, Ojoo, Ijaye and Iroko) based on the intensity of maize production in the villages. The selection was done to reflect the most typical situation for maize-based farming systems. The second stage involved a simple random sampling 10 maize-based farmers in each of the 10 villages. Leading to a total of 100 respondents used for the study.

Analytical techniques

Descriptive statistics such as frequency tables, percentage, mean were used to analyse socio-economic characteristics and level of adoption of QPM variety. Gross margin analysis was used to estimate the cost and returns in production of the quality protein maize variety. The Average Gross margin is the difference between total revenue and the total variable cost incurred. This is expressed by Eq. 1.

$$GM = TR - TVC \qquad (1)$$

Where:
GM Gross Margin
TR Total Revenue (Quantity of output x Market price output)
TVC Total Variable Costs
Total Variable Cost includes the various cost of the quality protein maize. This varies with the level of the production like labour, seed and fertilizer.

Measuring Technical Efficiency (TE) is an important component of the stochastic frontier production function (**Abdus, 2013; Greene, 2008**). TE of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the farm (**Essilfie *et al.*, 2011**) while technical inefficiency is the amount by which the level of production for the farm is less than the frontier output (**Kibaara, 2005**). The stochastic production frontier (SFA) consists of a production function with a composite error term equal to the sum of two error components. The first error component, also called a statistical or white noise, accounts for random effects. The second component represents systematic effects that are not explained by the production function but attributed to technical inefficiency (**Hussain *et al.*, 2012; Ben-Belhassen 2000, Kumbhakar and Lovell, 2000**).

SFA has the advantage estimating the technical efficiency of production by farmers and the determinants. The maximum likelihood estimates of the parameters of the model (Eq. 2) are obtained by using the computer program developed by **Coelli (1996).**

$$LnY_i = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + V_i - U_i \qquad (2)$$

Where
Yi total farm output of maize (kg) in ith farm,
Ln the natural logarithm
$\beta_0,\ \beta_{1,}\ \beta_2, \beta_3$ are the parameters to be estimated.
$\beta_0,\ \beta_{1,}\ \beta_2, \beta_3$ are the parameters to be estimated
X_1 quantity of seed planted (kg),
X_2 sum of labour used (family and hired labour in man days),
X_3 quantity of fertilizer used (kg) in maize crop
$V_i - U_i$ Random error-term
U_i Inefficiency component of error term. Non-negative random variables called technical inefficiency (1- TE) effects of production of the farmers involved.

In this specification, we did not include area of land cultivated as a production factors because we found no significant difference among the various size of land cultivated for QPM. We assumed that the size of land cultivated is determined by capital and labour. Only quantity of fertilizer used, seed and labour used by the farmer were used.

It is assumed that the inefficiency effects are independently distributed as truncations of normal distributions with constant variance, but with means which are a linear function of observable variables (**Battese, and Coelli, 1995, Kumbhakar, *et al.*, 1991).** Tobit regression model was therefore used to determine the factors affecting the TE inefficiency.
The general form of the model is specified by Eq. 3

$$U_i = \delta_0 + \delta_1 Z_i + d_i \qquad (3)$$

Where the independent variables are as follows:
Z_1 Gross Margins (₦);
Z_2 Age (years);
Z_3 Household size (number);
Z_4 Marital status (1= married, 0=Divorced);
Z_5 Educational level (formal education =1, and 0 if otherwise);
Z_6 Years QPM farming experience (years);
Z_7 Total Farm size under cultivation of QPM (ha);
Z_8 Income from other occupation (₦);

d_i Random statistical noise introduced to capture events beyond the control of farmers
δ Parameters to be estimated.

Probit regression model was in addition used to determine the factors influencing adoption of quality protein maize seed and was estimated using some socioeconomic, demographic and farm level agronomic variables of the farmers. The probit regression method was used here, due to the binary nature of the dependent variable (1 if QPM is adopted and 0, otherwise). The model is stated as Eq. 4.

$$P_i = \beta_0 + \beta_i T_i + e_i \quad (4)$$

Where:
Pi is 0 for non-adopter and 1 for adopter for i[th] farmer. The independent variables are defined as follows:

T_1 Output (kg)
T_2 Quantity of seed (kg)
T_3 Total labour (number)
T_4 Quantity fertilizer (l)
T_5 Sex (1= male, 0= female)
T_6 Age (years)
T_7 Education Level (years)
T_8 Years farming (years)
T_9 Gross margin(₦)
T_{10} Total maize farm size (ha)
T_{11} Technical efficiency
T_{12} Household size (number)
T_{13} Information (1= is informed about the QPM, 0 = no information about QPM)
T_{14} Taste assessment (1=Excellent, otherwise 0)
T_{15} Grain quality assessment (1=Excellent, otherwise 0)
T_{16} Storability assessment (1=Excellent, otherwise 0)
T_{17} Early maturity assessment (1=Excellent, otherwise 0)
T_{18} Support variety (1= yes the farmer prefer QPM, 0= No)
T_{19} Storability rate (1=Excellent, otherwise 0)
T_{20} Grain rate (1=Excellent, otherwise 0)
T_{21} Early maturity rate (1=Excellent, otherwise 0)
T_{22} Total Farm Size (ha)
e Error term
$\beta_0 + \beta_1$ Parameters to be estimated

RESULTS AND DISCUSSION

Characteristic of adopters and non-adopters

The results in Table 1 showed that 59 maize farm households out of 100 randomly selected for the study were adopters of QPM technology while the remaining 41 were non-adopters. The table also presented the distribution of adopters and non-adopters by sex, age, marital status, educational level, maize farm size household size and years of farming experience. The results of the frequency analysis revealed that about 95% of the adopters were male and have an average maize farm of 2.0ha compared to 83% of non-adopters who cultivated an average of 1.9ha of maize. This result is an indication that men are more involved in QPM cultivation. The maize farmers in the study area also have an average of 16 years of farming experience. Only 61% of the adopters have a formal education against 78% of non-adopters. Adopters and non-adopters have respectively an average age of 54.33 and 54 years old and an average household of 5 members each. Most of the farmers were married.

Determinants of technical efficiency in the production of QPM

This study used the Maximum Likelihood Estimates (MLE) for efficiency estimation of the adopters and non-adopters of QPM in the study area and the results are in Tables 2 and 3.The estimated variance (σ^2) was statistically significant at 1% indicating goodness of fit and correctness of the specified distribution assumptions of the composite error term. The variance ratio parameter was also statistically significant at 1% level for both adopters and non-adopters which indicated that variation in the actual maize output from maximum QPM output in maize farms mainly arose from differences in farmer practices rather than random variability. Lambda (λ) (Tables 2 and 3) denotes the ratio of the variance of the farm-specific production behaviour (σu) to the variance of the statistical noise (σv) and its value 0.7 for adopters and 3.1 for non-adopters indicates that the one-sided error component dominated more than symmetric error component. Quantity of seeds and fertilizer application has positive and significant effect on TE of QPM adopters (Table 3) while quantity of seeds and labour influenced the TE of the non-adopters (Table 3). Table 4 further shows that farmers have not reached their highest production frontier. The results showed that the adopter have a higher technical efficiency than non-adopters. The mean technical efficiency for adopters is 0.8945, while the non-adopters have 0.7846. These results showed that both adopters and non-adopters of QPM can still improve the level of their TE by acquiring more technology package.

The test of hypothesis that adopters are not significantly more efficient than non-adopters is rejected. The results in Table 5 show that adopters are significantly more efficient than non-farmers at 5% of level of significance.

Determinants of Technical inefficiency in production of QPM

The results in Table 6 showed that the coefficients of age of the farmer, gross margin and income from other occupations were significant at 5% level of probability indicating that these variables have likelihood of influencing the technical inefficiency of production of QPM in a negative direction. The coefficients of educational level and total farm size were negative and significant at 10% level of probability indicating an inverse relationship with technical inefficiency of production QPM adopters. On the other hands, the results in Table 7 showed that gross margin, level of education, farm size and marital status of the respondents have the likelihood of influencing technical inefficiency of non-adopters of QPM in a negative direction.

Table 1: Socioeconomic characteristics of respondents (maize farmers)

		Adopters (n =59)		Non-adopters (n = 41)	
Variables	Distribution	Frequency	Percent	Frequency	Percent
Sex	Male	56	94.9	34	83
	Female	3	5.08	7	17
Age	< 50	11	19	6	24.4
	50 - 60	29	67	30	68.3
	> 60	9	14	5	7.3
	Min	38		38	
	Mean	54.3		54	
	Max	62		62	
	Std	5.8		5.6	
Marital Status	Married	58	98.30	41	100
	Divorced	1	1.70	0	0
Education Level	No formal	23	39	9	22
	Primary	23	39	11	26.8
	Secondary	13	22	21	51.2
Maize farm size	<2 ha	15	25.4	14	34.1
	≥2 ha	44	74.6	27	65.9
	Min	1.5		1.5	
	Mean	2.1		1.9	
	Max	3		3	
	Std	0.4		0.4	
Household size	3-5	22	37.3	14	34.1
	5-7	37	67.7	27	65.9
	Min	3		3	
	Mean	4.9		4.7	
	Max	8		7	
	Std	1.0		0.9	
Number of years of farming experience	< 7	2	3.4	0	0
	7-15	16	27.1	16	19.5
	15-30	41	72.9	25	80.5
	Min	2.5		7	
	Mean	16.0		15.5	
	Max	30		30	
	Std	4.3		3.5	

Source: Field survey 2014

Table 2: Maximum likelihood estimates of stochastic frontier for adopters of QPM

Variables	Coefficient	Standard-error	P>z
Ln seed used	0.1555**	0.0766	0.042
Ln fertilizer used	0.7596***	0.1536	0.000
Ln labour used	0.0541	0.0855	0.527
_constant	4.0809	0.3799	0.000
Sigma_(σv)	0.1953***	0.0385	
Sigma_(σu)	0.1447	0.1321	
Sigma_σ^2	0.0591**	0.0271	
Lambda (λ)	0.7412***	0.1654	
Gamma (γ)	0.3543		
Log likelihood function	48.8512		

Note: ** Significance at P< 0.05; *** Significance at P<0.01

The coefficients of gross margin, education level and farm size were negative and significant indicating that an increase in any of these factors reduces the inefficiency of the adopters of QPM. Farmers with higher education level or greater gross margin are less inefficient than farmers with low education or less gross margin. The coefficient of marital status was also found to be negative and significant at 1% level of probability, implying that married farmers have lower technical inefficiency than their unmarried counterparts. The coefficient of years of farming experience was positive and significant at 1% level of probability meaning that the more the years of experience in farming, the more technically inefficient the farmers were contrary to a priori expectation. A notable result in both cases (adopter and non-adopters) was the coefficient of age of the farmers found to be positive and significant implying that the older the farmer whether adopter or non-adopter of QPM becomes, the more his/her is technically inefficient in QPM production in the study area.

Table 3: Maximum likelihood estimates of stochastic frontier for non-adopters of QPM

Variables	Coefficient	Standard-error	P>z
Ln seed used	0.6319***	0.1330	0.000
Ln labour used	0.2490**	0.1073	0.02
Ln fertilizer used	0.3117	0.2119	0.141
Constant	2.2387	0.4911	0
Sigma_(σv)	0.1048*	0.0581	
Sigma_(σu)	0.3208***	0.0836	
Sigma_σ^2	0.1139***	0.0447	
Lambda (λ)	3.0597***	0.1343	
Gamma (γ)	0.9035		
Log likelihood function	29.2614		

Note: ** Significant at P< 0.05; *** Significant at P<0.01, * Significant at P<0.1

Table 4: Frequencies distribution of TE among adopters and non-adopters

Level of Efficiency	Frequencies (%)	
	Non-Adopters	Adopters
< 0.50	2.4	0
0.51- 0.55	2.4	0
0.56 - 0.60	0	0
0.61- 0.65	14.4	0
0.66 - 0.70	4.8	0
0.71- 0.75	14.4	1.7
0.76 - 0.80	14.4	0
0.81- 0.85	9.6	1.7
0.86 - 0.90	16.8	54.2
0.91- 0.95	19.2	42.4
0.96 -1.00	2.4	0
Total number of farmers	41	59
Mean TE	0.7846	0.8945
Std. Deviation	0.1219	0.03164
Minimum TE	0.4923	0.7342
Maximum TE	0.9548	0.9462

Source: Computed from MLE Results

Table 5: Test of Hypothesis

Variable	Obs	Mean TE	Difference TE	Std. Dev.	Z value
Non adopters	41	0.7846	0.1099	0.1234	5.5718
Adopters	58	0.8945		0.0319	

Table 6: Determinants of technical inefficiency of adopters in the production of QPM

Variables	Coefficient	Standard Error	P>t
Gross Margin Adopters (Z_1)	-2.17E-06**	9.52E-07	0.037
Age (Z_2)	0.0053666**	0.0020881	0.021
Household size (Z_3)	0.0044558	0.008528	0.608
Marital status (Z_4)	-0.0156691	0.0322683	0.634
Educational Level (Z_5)	-0.0196132*	0.0111324	0.097
Years of QPM farming experience (Z_6)	0.0004007	0.0024672	0.873
Total farm size(Z_7)	-0.0271504*	0.014181	0.074
Income from other occupation (Z_8)	-3.36E-06**	1.24E-06	0.015
Constant	-0.0161838	0.0872543	0.855

** Significant at P< 0.05; *Significant at P<0.1

Effect of TE and other socioeconomic factors influencing the adoption of QPM

The results of the probit regression in Table 8 revealed that educational level has the likelihood of influencing farmers adoption at P<0.01. The level of output, sex, technical efficiency of the farmer, level of information about QPM, early maturity assessment by farmers and the early maturity rate were significant factors found to influence the adoption QPM by farmers in the study area. The gross margin of the QPM technology was however not significant determinants of adoption of QPM.

The negative sign of the coefficients means that an increase in the quantity of the factor is likely going to reduce adoption of QPM. For instance, coefficient of sex was found to be negative indicating that male farmers adopted the QPM more than female. The farmers were found also to be sensitive to both time and rate of maturity of QPM. The positive sign on early maturity showed that farmer adopt a variety of maize (such as the QPM) that has a short maturity. This could be explained by the fact that agriculture is subject to several random effects, in this case, 'the earlier the better'. However education level has a negative influence on the adoption.

Most of the adopters have basic education which might probably be responsible for the negative coefficient of educational level which indicate contrary to the a priori expectation that the more the level of education of the adopters the lesser the adoption of QPM. This results might be as a result of the fact that all the educated farmers need to know have been acquired, so more education have therefore no longer have any positive effect on adoption of QPM. The positive coefficient of information on QPM showed that information has a direct influence on adoption QPM. This was in agreement with **Etoundi, and Dia** (2008) who stated that an innovation will only be adopted when the people concerned are convinced, depending on the information they have.

The coefficient of the gross margin though positive was not statistically significant meaning an acceptance of the second hypothesis (gross margin of QPM does not affect its adoption by maize farmers). The implication of this finding was that gross margin was not the first priority of the farmer. Maize farmers first consider the quantity of input that the new technology will require from them or whether they will technically be efficient before taking decision on adopting QPM. The technical efficiency was significant and it has a positive influence on the adoption. That means that the decision to adopt a QPM technology depends on technical efficiency. The third hypothesis which states that technical efficiency of maize farmers does not affect the adoption of QPM was rejected. This means that we accept the alternative hypothesis that states that technical efficiency of the farmer affects adoption of QPM.

Table 7: Determinants of technical inefficiency of non-adopters in the production of QPM

Variables	Coefficient	Standard Error	P>t
Gross Margin of Maize farmers(Z_1)	-0.0000288***	1.87E-06	0.000
Age (Z_2)	0.009767***	0.0014948	0.001
Household size(Z_3)	0.0059477	0.0155003	0.717
Marital Status (Z_4)	-0.0622679***	0.0098172	0.001
Educational level (Z_5)	-0.1253167***	0.0261214	0.005
Years of QPM farming experience (Z_6)	0.0165907***	0.0040377	0.009
Total farm size (Z_7)	-0.0641954***	0.0155171	0.009
Income from other occupation (Z_1)	2.20E-06	2.11E-06	0.346
Constant	0.1033699	0.0910789	0.308

*** Significant at P<0.01

Table 8: Determinants of adoption of QPM

Adopters	Coefficient	Std. Err.	z	P>z
Output	0.0402199*	0.0228002	1.76	0.078
Quantity of seed	0.0083794	0.0263017	0.32	0.75
Total labour	-0.0674162	0.0557777	-1.21	0.227
Quantity fertilizer	6.142973	14.20955	0.43	0.666
Sex	-2.76933**	1.238683	-2.24	0.025
Age	0.1808657**	0.0923677	1.96	0.05
Educational level	-3.94358***	1.464793	-2.69	0.007
Years farming	0.1560298	0.1316964	1.18	0.236
Gross margin	0.0001338	0.0001021	1.31	0.19
Total Maize Farm Size	0.1538765	0.923489	0.17	0.868
Technical efficiency	28.45941*	15.84958	1.8	0.073
Household size	0.7897135	0.5036214	1.57	0.117
Information	3.705962*	1.956624	1.89	0.058
Taste assessment	-0.8189139	0.8924002	-0.92	0.359
Grain quality assessment	0.3190167	0.9730986	0.33	0.743
Storability assessment	2.294649	2.099249	1.09	0.274
Early Maturity assessment	1.454987*	0.814393	1.79	0.074
Support variety	-0.7527491	0.8774568	-0.86	0.391
Storability rate	-1.931774	2.273421	-0.85	0.395
Grain rate	-2.223016	1.874022	-1.19	0.236
Early maturity rate	6.342952*	3.538526	1.79	0.073
Total Farm Size	-0.1609631	0.8686031	-0.19	0.853
_constant	-57.70713	42.35485	-1.36	0.173

Log likelihood = -16.876294, Pseudo R^2 = 0.7402

Note: ** Significance at P< 0.05; *** Significance at P<0.01; *Significance at P<0.1

DISCUSSIONS

The results of the socioeconomic characteristics of maize farm households in Table 1 showed that the majority of maize farmers in the study area were male. The sex of the respondents become critically important because the farming communities in the study area allocate responsibilities based on sex differences. The average year of farming experience of 16 years indicates that most of the respondents have been practicing farming for long. Accumulated years of farming experience help farmers in crop selection and enable them to evolve the farming practices that are most suitable to their fragile environment. The average household size of 5person in the study area appears not too large but can serves as a proxy for labour as individual in the household is seen as a potential source of labour in the study area. Availability of family labour reduces labour constraints faced during the peak of the farming season.

The value of gamma which is the ratio of the variance of the farm-specific performance of technical efficiency (σ_u^2) to the total variance of output (σ^2) was 0.35 for adopters and 0.90 (Table 2 and Table 3). This means that 35 and 90 percent of the variation in output among the adopters and non-adopters farms respectively was due to the difference in efficiencies. The positive coefficients of the variable inputs such as quantity of seeds and fertilizer on the TE of adopters of QPM imply that increase in quantities of these inputs ceteris paribus, would result in increased QPM output. Similarly, the positive coefficients of seeds and labour on the TE of non-adopters of QPM implied that increase in quantities of these inputs would result in increased conventional maize output. The indices in Table 4 showed that the technical efficiency of the sampled maize farm households (adopters and non-adopters of QPM) was less than one (less than 100%), implying that all the maize-based farming households in the study area were producing below the maximum efficiency frontier. Some QPM farming households demonstrated a range of technical efficiency of 0.9462 (94.6%), while the non-adopters were 0.9548 (95.5%). The mean technical efficiency of 0.8945(89.5%) for adopters and 0.7846 (78.5) for non-adopters implied that on the average the QPM adopters and non-adopters were respectively able to obtain a little over 89 and 78percent of potential maize output from a given mix of production inputs. About 10.5 and 22.5 percent efficiency gap from the optimum (100%) was therefore yet to be attained by QPM adopter and non-adopters.

CONCLUSION AND RECOMMENDATIONS

The main objective of this study was to estimate the Technical Efficiency (TE) of production of QPM by the adopters and compared the results with those of the non-adopters of the technology. It further established whether TE drives the adoption of QPM in the study area or not. The results showed the mean TE of adopters of QPM and non-adopters as 89% and 78% respectively indicating that there is considerable room for improvement in the utilization of inputs used in the production of this variety. While the adopters of QPM can increase their maize output performance by almost 11%, the non-adopters can improve their production of maize by 22% given the present state of technology.

Maize farmers adopt QPM because it is more technically efficient to produce; due to information received on QPM and their assessment of period of maturity. More farmers can be encouraged to adopt QPM variety through more sensitization using extension services. There is need for government policy that subsidizes hybrid maize seeds such as the QPM and fertilizers so that farmers can use more of these to enhance maize output.

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