World Journal of Agricultural Sciences 8 (6): 624-631, 2012
ISSN 1817-3047

DOI: 10.5829/idosi.wjas.2012.8.6.1638

Adoption of 'Ofada' Rice Variety and Technical Efficiency of Rice-Based Production Systems in Ogun State, Nigeria

[1]O.A.C. Ologbon, [2]E.E. Ikheloa and [1]E.O. Akerele

[1]Department of Agricultural Economics and Farm Management,
Olabisi Onabanjo University, Yewa Campus, Ayetoro, Ogun State, Nigeria
[2]Department of Agricultural Economics and Extension,
Ambrose Alli University, Ekpoma, Edo State, Nigeria

Abstract: Since the mid-1970s, rice consumption in Nigeria has risen tremendously at about 10% per annum due to changes in consumer preference. Most public and private sector interventions programmes at increasing the productive capacities of various factors within the system notwithstanding, domestic production has not been able to meet the local demand leading to considerable import, which today stood at about 1,000,000 metric tones yearly. Milled rice is procured from neighbouring West African communities with Nigeria spending annually over U.S. $300 million on its imports alone. Inadequate use of yield improving technologies has been identified as major setback in rice-based production systems in most developing economies especially in Africa. This study had examined the factors influencing adoption of the improved Ofada rice variety as well as measured the technical efficiency of rice farmers in the rice-growing Obafemi-Owode Local Government Area of Ogun State, Nigeria. Primary data were collected in a two-stage sampling procedure and analysed for 105 rice farmers selected from ten (10) prominent rice-producing communities in the study area. Probit and Gross margin models were used to estimate the determinants of adopting the improved Ofada rice variety and the profitability of the rice enterprise, respectively, while farmers' production efficiency was measured using the stochastic frontier model. Profitability index was 0.32 indicating that every Naira expended on Ofada rice production will return about 32kobo to the rice farmer as net income. Years of farmer's education, number of contacts with extension workers and cost of cultivars were the variables that jointly influenced adoption of the improved Ofada rice variety being statistically significant at 5%, 10% and 5%, respectively. The maximum likelihood estimate showed that quantity of planted cultivars and size of farmland are positively significant at 1% depicting an increase in rice output as farmland and seeds are increase. It was recommended that policy that will further enhance adoption of the improved Ofada rice variety be put in place as well as effective extension programmes to sufficiently service the farmers.

Key words: Technical efficiency · Technology · Adoption · Ofada · Variety · Gross margin

INTRODUCTION

Rice is a common staple food in Africa; a rich and cheap source of carbohydrate to both man and animals. Going by the National Population Commission NPC (2006) figure, the Nigerian population figure is over 140 million with a domestic economy predominantly dominated by agriculture, which accounts for about 40% of the Gross Domestic Product (GDP) and two third of the labour force. Rice has served as a major staple cushioning the effect of under-nutrition and severe hunger among many Nigerian households as it is commonly eaten in many localities, processed into different forms. The preferred forms among the Yorubas include jollof, fried rice and white rice. It is milled into flour and then cooked in boiling water and turned into a thick paste called Tuwo in Northern part of Nigeria.

Correspondence Author: O.A.C Ologbon, Department of Agricultural Economics and Farm Management, Olabisi Onabanjo University, Yewa Campus, Ayetoro, Ogun State, Nigeria. Tel: +243-805-2100-305.

Rice cultivation is most suitable to regions with high rainfall as it requires much moisture for best performances under labour-intensive cultural practices [1]. It was on record with the Federal Ministry of Agriculture and Rural Development (FAMARD) that as at year 2001, Kaduna State was the largest producer of rice in Nigeria, accounting for about 22% of the country's rice output, followed by Niger (16%), Benue (10%) and Taraba (7%) State. The National and International Research Institute (NIRI) in Nigeria have developed over 52 varieties of rice with potential yield of 2-8 tonnes paddy per hectare and maturity period ranging from 95-140 days [2]. However, in spite of the suitable weather and enormous manpower and available facilities for its cultivation, Nigeria is not yet among the world leading rice producers [3]. Several measures have been taken by successive government to ensure rice self-sufficiency and policy change in Nigeria including banning and de-banning of rice importation, Structural Adjustment Programmes (SAP) as well as subsidy/concessional duties on importation of farm inputs and machinery. Unfortunately however, inconsistence of this various policies and programmes and the implementation have made the rice self-sufficiency realization a mirage in Nigeria.

Rice Production Trends in Nigeria: Rice production started in Nigeria in 1500 BC when the low yielding indigenous red grain species *Oryza glaberrima* L. was widely grown in the Niger Delta belt of the country. The high yielding white grains specie *Oryza sativa L* was introduced about the 1890s and by 1960 had already accounted for more than 60% of the rice species grown in the country. Today, rice is cultivated in virtually all agro-ecological zones in Nigeria, but on a relatively small-scale. In 2000, out of 25 million hectare of land cultivated to various foods crop, only about 6.7% was cultivated to rice [4].

The trend in rice production shows that paddy rice first experienced a boom in the period 1965-1970, when average output stood at 321,000tons. During this period, average area cultivated to rice was 234,000 hectares while average national yield was 1.36 tonne per hectare. Another significant improvement in rice production in Nigeria was recorded in 1986-1990, when rice output increased to over 2 million ton while average area cultivated and yield rose to 1,069,200 hectares and 2,096 tonne per hectare, respectively. However, the West Africa Rice Development Authority (WARDA) reported a decline in the Nigerian rice self-sufficiency ratio from 99.4% in 1965 to 36.7% in 1991. Small-holder farmers dominated rice production in Nigeria with 0.5-1.5 hectares per farmer using manual labour for virtually all it operations. The land put under rice cultivation in 2003 was about 2.10 million hectares, which was expected to increase to 3.0 million hectare in 2007 [4]. The estimate of land devoted to rice production in Nigeria between 2003 and 2007 and rice production trends in Nigeria between 1980 and 2005 are presented in Tables 1 and 2, respectively.

Table 1: Estimated land devoted to rice production in Nigeria (2003-2007)

Zone	2003	2004	2005	2006	2007
North West	493.674	53.121	569.08	616.40	663.72
North East	538.92	571.25	603.81	644.37	684.93
North Central	727.25	765.09	802.96	850.28	897.60
South South	68.56	110.07	142.47	195.81	228.39
South East	121.53	149.16	176.21	210.01	243.81
South West	139.62	172.07	204.53	245.09	285.65
Total	2089.554	2298.85	2499.06	2761.96	2999.3

Source: Presidential Committee Report on increased rice production and export, 2007.

Table 2: Rice Production Trends in Nigeria (1980-2005)

Period	Average area Cultivated Land (hectare)	Average Output (tone)	Average Yield (ton/ha)
1980	550,000	1,090,000	1.982
1981	660,000	1,241,000	2.068
1982	600,000	1,250,000	2.083
1983	630,000	1,280,000	2.032
1984	650,000	1,300,000	2.000
1985	670,000	1,430,000	2.134
1986	700,000	1,416,522	2.023
1987	745,000	1,780,000	2.023
1988	1,041,000	2,081,000	1.999
1989	1,652,000	3,303,000	1.999
1990	1,208,000	2,500,000	2.070
1991	1,652,000	3,226,000	1.953
1992	1,664,000	3,260,000	1.959
1993	1,652,000	3,226,000	1.960
1994	1,714,000	2,427,000	1.416
1995	1,796,000	2,920,000	1.626
1996	1,815,770	2,909,230	1.002
1997	1,742,800	2,960,280	1.669
1998	1,840,630	2,999,570	1.630
1999	1,718,870	3,225,780	1.977
2000	1,594,840	2,960,280	1.856
2001	1,770,000	2,752,000	1.355
2002	1,699,000	3,1192,000	1.818
2003	NA	3,520,000	-
2004	2,228,100	3,713,900	1.623
2005	2,707,900	3,929,400	1.451

Source: PCU, FMARD (2001); FAO (2003); CBN (2005)

Olorunfemi [5] observed that increase in rice production is expected when Nigerian farmers in all ecological zones cultivate improved varieties with appropriate cultural and management practice. A remarkable effort to develop suitable rice varieties for Nigerian farmers was made in 1997, with the release of FARO 51, a variety that is resistant to the Africa Rice Gall Midge (ARGM) Orseolia oryzivora [6]. Recently, WARDA has developed an improved variety for upland rice farmer known as NERICA (New rice for African countries) with a potential yield of over 3.0 ton per hectare under strict compliance with recommendation [5]. The NERICA variety has been reported to posses properties that satisfy different consumer preference in term of grain type, swelling capacity; lose content, higher protein content and less cooking time.

Problem Statement: Rice has a great economic importance as it serve as a source of income and a major staple food in most Nigerian homes. However, it has been reported that demand for rice has always been far above the level of domestic production. This is partly because of the stress farmers face in the local production which is attributed to poor technology, high poverty and illiteracy level, as well as the undignified societal status of the average Nigeria farmer thereby causing a gradual reduction in farmers involvement in rice production. So many other factors have been blamed for the low level of rice production, which include problem of fertilizer shortage, weed and pest infestation, birds, problems of input procurement and high cost of inputs, lack of credit facilities, among others. These factors have jointly led to the large gap observed in rice demand and domestic production over the years. For instance, Kazeem [7] observed that demand for rice had risen steadily while domestic production increased at a much lower rate and it is a little wonder that the demand will still increase due to the expected increase in population by over 50 percent between the years 2000 and 2020 [8].

Since the mid-1970s, rice consumption in Nigeria has risen tremendously, at about 10% per annum due to constantly changing consumer preference, with per capita consumption of about 3.0 kilograms in the 1970s rising to 22.0kg at 3.0 million metric tonne as deficit in the 1999. This notwithstanding, Ogundari [2] noted that domestic production of rice has never been able to meet up with its local demand leading to considerable imports. According to a CBN report, the rice import bill in 1999 was US $259 million which almost tripled to US $655 million and later US $756 million in 2001 and 2002, respectively, standing at about 1,000,000 metric tonnes yearly [9]. This study was carried out to determine technology (Ofada rice variety) adoption decisions and technical efficiency of rice-based production systems among a sample of rice farmers in Owode Local Government Area of Ogun State, Nigeria.

Conceptual Framework

Concept of Technology Adoption: Rogers and Shoemaker (1971) defined adoption as a decision to make full use or new idea. Also adoption as a mental decision making steps, which an individual goes through from hearing about an idea to the point where he adopts and continues to it. The perceived newness of an idea for individual determine his or her reaction if this ideas new to the individual it is an innovation. Rogers (1995) emphasizes that exchange of information and its diffusion take place within a social system. Processed information becomes knowledge when an individual understands and evaluates it thus a knowledge system is more individualized and premised around personal recognition (Demiryurek, 2000). Five stages are recognized in the adoption process, namely:

- Awareness individual is exposed to improved practices but lack complete information about it. The farmer, know little or nothing about its special qualities its potential usefulness and how it would work.
- Interest stage: The individual develops interest in the improved practices and seek additional information about it.
- Evaluation stage: The individual applies the new to his present and anticipated future situation and decide whether or not to try it.
- Trial stage: The individual applies the new ideas (on a small-scale in order to assess it suitability in practice). Here he put the changes in practice i.e. he must learn how, when, where, how much etc. also personal assistance may be require at this stage to put the improved information into use. Usually is to try little at first and then make large-scale use of it; if the small-scale experience proves successful.
- Adoption stage, at this stage, full use is made of one innovation. A person at this stage decide that new ideas is good enough for full scales use.

All factors that influence decision to adopt or reject an innovation can be broadly classified into personal, economic and social factors, some of which include age of the farmer, level of education, farm size, farm income or farmer's status, farming experience, source of credit and information [10], contact with extension agent and social participation. This has therefore been observed to lead to the recent ineffectiveness generally observed in the adoption of technologies in rice production across the nation [11].

Technology Adoption and Measurement of Technical Efficiency: The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers. This is particularly so in developing economies where resources are meager and opportunity for developing and adapting better technology are dwindling [12]. Okoruwa and Ogundale [13] reported that the level of technical efficiency of a farmer is characterized by the relationship between observed production and some ideal or potential production and thus argued that if farmers are not making efficient use of existing technologies, then efforts designed to improve efficiency would be more cost effective than introducing new technology as a means of increasing output. Ewuola [14] attributed the low productivity in the agricultural sector to the subsistence nature of agriculture and non-adoption of appropriate technology varieties. According to Okoruwa and Ogundale [13], efficiency measurement is imperative as success indicator and performance measure by which production units are evaluated, as well as an avenue to identify sources of production inefficiency.

Since the early eighties, much of government's efforts on the development of agriculture in Nigeria have been emphasizing the need for adoption of improved technology. For instance, Shampine [15] canvassed for the need for adoption of technologies by small-scale farmers to improve production capacities through the instrumentality of improved technology given the population growth rate of 3.5% per annum against food production increase of 2.5%. In their own study, Ewuola [14] observed that adoption of improved varieties can lead to the desired result in agricultural productions only if farmers comply with the recommendations and requirements of the technologies, in terms of input use and timing of operation. Alternatively, partial adoption can be explained as a constraint to the technical efficiency to produce varieties (or resource management practices) adapted to heterogenous production conditions or with traits valued by producers and consumers [16].

Efficiency Measurement Using the Stochastic Frontier: Efficiency is the maximization of output input ratio. There are three components of efficiency namely; technical, allocative and economic efficiencies. Technical efficiency is a measure of effectiveness in which maximum output is obtained from a given combination of inputs i.e. the ability to operate on the production frontier. According to Balogun [17], technical efficiency can be defined as the ability to successfully produce maximum amount of output from a given set of inputs. Technical Efficiency assumes the essential nature of output of goods and services to remain unchanged and focus on reducing the cost of input for production. Efficiency is maximum when it is impossible to recombine a given set of resource to obtain a larger quality or output, technical efficiency relates to the degree to which a farmer produces the maximum feasible output from a given bundle of input (an output oriented measure). Allocative efficiency on the other hand, relate to the degree to which farmer utilizes input optimal proportion, given the observed input price [18]. It refers to the situation where resources are given in profit maximizing sense so that the marginal value products of resources are equal to their unit prices. Economic efficiency combines Technical and Allocative Efficiencies. Perfect technical and allocative efficiencies imply that the firm is maximizing profit and minimizing cost for a given level of output; in other words, the firm is operating on the expansion path. The popular approach to measure efficiency, the technical efficiency component, is the use of Frontier production function [19-23].

Methodology

Study Area: The area of the study is Obafemi Owode Local Government Area (LGA) of Ogun State. It is located on Latitude 6°N and 8°N and Longitude 21/21°E and 5°E. The local government occupies an area of 204,187 hectares representing 6.3% of the land extent of Ogun State. It is bounded in the North by both Odeda and Abeokuta Local Government Areas, in the South by both Remo and Ifo Local Government Areas and in the West by Ifo Local Government. The local government area has a tropical climate with a rainy season from March to November and dry season from December to February. The average temperature is about 31°C, humidity about 95% and an average annual rainfall of 192mm. Owode known as Owode-Egba is the headquarters of the local government and it has been most populated settlement in the local government area since 1963. Other important settlements are Obafemi, Ogunmakin, Oba, Mokoloki, Ofada, Ajebo, Siun, Kobape and Fidiwo. The people are predominantly farmers who engage in various agricultural activities. The farmers produce large quantities of crops like rice, cassava, maize, among others. Obafemi Owode LGA is the largest producer of a rice variety popularly known as Ofada rice among several households. The popularity of this rice variety has put the name of the local government on the African map of rice producers.

Data and Sampling Techniques: Both primary and secondary data were used for this study. Primary data was collected from the field with the use of structured questionnaires and focused interviewed on targeted rice farmers. Secondary data was collected from the scholar work, journals and data from local government and research institute. A two-stage sampling technique was employed involving purposive cluster selection of ten predominant rice growing communities from the local government, namely Omu, Abule Ojo, Lagila, Ajorinye, Lisogbe, Someke, Ikogi, Siun, Adesanmi, Asaya. Twelve farmers who grow the improved Ofada rice variety were randomly selected from each of the twelve communities in the second stage. However, due to non-response and/or incomplete data, information from only 105 farmers was found useful for the study.

Methods of Data Analysis: The gross margin budgetary analysis and profitability index was used to determined the profitability of rice farming while probit model was used to capture the adoption decision of farmers on the improved Ofada rice varieties. The Stochastic frontier model was used to estimate the technical efficiency of rice production by the farmers. The mathematical notations for the analytical tools are given below:

Gross Margin $(G.M) = TR - TVC$

$$\text{Profitability Index } (P.I) = \frac{FNI}{TR}$$

where

GM = Gross Margin (•);
TR = Total Revenue (•);
TVC = Total Variable Cost (•)
FNI = GM – TFC (•)
TR = Total Return (•);
TFC = Total Fixed Cost (•) and TR = P*Q
TNI = Total Net Income (•);
GR = Gross Revenue (•)
P = Price of rice/Tonne (•) and Q = Output of rice (Tones).

The Probit Model: The probit model was used to capture the determinants of adoption of Ofada improved variety by rice farmers in the study area. The model is specified as:

$$Y^* = \bullet' X_i + U_i$$

Y^* is observable but Y is observed as a dummy variable (i.e. Y takes value of 0 or 1).

Y = 1 if $Y^* > 0$ (farmer adopting the Ofada improved variety)
Y = 0 if otherwise (farmer not adopting the Ofada improved variety)

$$\text{Pr}ob(Y_i = prob(U_i > \bullet' X_i)$$

$$= 1 - f(-\bullet' X_i)$$

where f = cumulative distribution function of U_i and

$$\text{Pr}ob(Yi = 0) = 1 - (prob(Y = 1)$$

$$= 1 - (\text{Pr}ob U_i - \bullet' X_i)$$

$$= 1 - (1 - f(-f \bullet' X_i))$$

Y is a dichotomous variable depicting the probability of adoption of the improved Ofada rice variety, taking up value 1 if a farmer allocated over 50% of rice acreage to the improved variety and 0 otherwise. The socio-economic and farm related explanatory variables included in the model are sex of the farmer (1 = male, 0 = female); Age of farmer (yrs); Level of education (yrs); Area of farm land (ha); Cost of improved seeds (•); No of visit of extension agent/year; Amount of loan obtained obtained (•); quantity of household labour and hired labour used in a rice production cycle (manday).

The Stochastic Frontier Model: The model specified to estimate the technical efficiency of rice production is given as:

$\ln Y = f(\bullet' X_i) + V_i - U_i$

where

Y = Rice output (kg);
X_1 = Quantity of seed (kg);
X_2 = Hired labour (Mandays)
X_3 = Family labour (Manday) and
X_4 = Size of farmland (Ha);
• = Vectors of unknown parameter;
U_i = Technical inefficiency, a non-negative random error variables defined as:

$$U_i = b_0 + b_1 Z_1 + b_2 Z_2 + b_3 Z_3 + b_4 Z_4 + e_i$$

where

Z_1 = Farmer age (yrs);
Z_2 = Years of experience (yrs);
Z_3 = Years of formal education.
Z_4 = Amount of loan obtained (•);
$\bullet_I$ = Stochastic error term; b_i s are the estimated parameters.

RESULTS AND DISCUSSION

Budgetary Analysis for Rice Farmers Planting the Improved Ofada Rice Variety: Table 3 showed the mean total variable cost as • 123,295.14 while mean total fixed cost was • 56,288.92 giving a total cost of • 179,583.86. The mean total revenue was • 262,789.16 giving an estimated gross margin value of • 139,494.02. The profitability index of 0.32 indicated that every Naira expended on Ofada rice production will return about 32 kobo to the rice farmer as net income, with the implication that planting the improved Ofada rice variety is profitable in the study area.

Determinants of Ofada Rice Variety Adoption: The result of the Probit estimate is presented in Table 4. Level of education, number of extension visits and cost of improved cultivars are statistically significant at 5%, 10% and 5%, respectively. The positive coefficients for level of education and number of extension visit imply that the probability of adoption increases for every additional year of education and numbers of visit per cropping season by 0.1% and 0.72%. For cost of improved seed, the negative sign indicated a decrease in adoption of the improved variety by 0.13% with every one unit increase in the cost of improved seed.

Table 3: Budgetary analysis for sampled farmers that planted the improved Ofada rice variety

Items	Mean Value •/Ha	% of Total Cost
Total Revenue	262,789.16	
Variable Production Costs		
Cost of seed (kg)	1,528.14	1.23
Cost of Herbicides (litres)	2,897.24	2.35
Cost of fertilizer (kg)	10,743.21	8.71
Cost of labour (Manday)	107,264.31	86.0
Other associated costs	862.18	0.69
Total Variable Cost (TVC)	123,295.14	
Fixed Production Cost		
Land Cost (Ha)	56,288.72	1.02
Total Fixed Cost (TFC)	56,288.72	100.0
Total Cost (TVC + TFC)	179,583.86	
Gross Margin (TR – TC)	139,494.02	
F. Net Income (GM – TFC)	83,205.30	
Profitability Index	0.32	

Source: Field Survey, 2009

Table 4: Probit Results of the determinants of adoption of improved rice varieties

Variables	•Coefficient	t-value
Sex	0.1431	0.990
Age	0.2263	0.503
Level of education	0.1008**	1.763
Farm size	0.2187	0.210
Number of Ext. Visit	0.1798*	2.353
Loan obtained	-0.7148	0.404
Hired labour	-0.6458	0.896
Household labour	-0.5912	0.601
Cost of Seed	-0.1306**	-1.671
Constant	0.5228	1.362

Source: Data Analysis, 2009.

*** Significant at 1%; ** Significant at 5%; * Significant at 10%

Table 5: Stochastic production frontier for Ofada rice farmers

Variables	Ordinary least Square	Maximum likelihood estimates
Constant	1.303 *(13.62)**	0.3317**(14.39)*
Seed quantity (kg)	0.6266 *(13.08)**	0.607**(13.7)*
Hired labour (mandays)	-0.257 *(-1.47)*	-0.214 *(-1.27)*
Family labour (mandays)	0.985 *(0.56)*	-0.581 *(-0.35)*
Size of farmland (Ha)	0.1525**(2.90)*	0.152**(2.85)*

Source: Data Analysis, 2009.

***,** and* depict significance at 1%, 5% and 10%. (*Standard errors are in parenthesis).*

Technical Efficiency of Ofada Rice Production: The maximum likelihood estimate for Ofada rice production is presented on table 5. Quantity of planted seeds and size of farmland are positively significant at 1% depicting an increase in rice output as farmland and seeds are increase. The coefficient of seed and farm land of 0.63 and 0.15 signifies about 63 and 15% increase in rice output for every 1% increase in the quantity of seed and farmland, respectively.

Table 6: Factors influencing inefficiency in Ofada rice variety production

Variable	Coefficient	t-value
Farmers age	0.818	0.66
Years of experience	-0.66	-1.85**
Educational level	-0.142	-1.56
Loan obtained	0.128	0.45
Sigma squared	0.195	3.14
Gamma	0.501	2.52**
Log likelihood function		0.375
L. R. Test		0.873

Source: Data Analysis, 2009

*** Significant at 1%; ** Significant at 5%; * Significant at 10%

Table 7: Deciles distribution of technical efficiency

Deciles Range of technical efficiency	Frequency	% Frequency
0.40 – 0.60	2	1.9
0.61 – 0.80	22	20.9
0.81 – 1.00	81	77.2
Total	105	100
Min. = 40%;	Max. = 100%;	Ave. 84.3%

Source: Field Survey, 2009

Determinants of Technical Inefficiency in Ofada Rice Production: The results of the inefficiency model shows that only years of experience have significant effect on the technical efficiency of the Ofada rice production, with a negative sign indicative of an increase in technical efficiency in rice production as year of rice cultivation experience increases. The variance ratio denoted as gamma is estimated at 25.2 percent suggesting that influences that are unexplained by the production function are the dominant sources of inefficiency in rice production systems in the study area.

The frequency distribution of technical efficiency is presented in table 7. The table shows that 77.2 percent of sampled farmers have technical efficiencies of above 81 percent operating close to the frontier with a mean of 84.3 percent. This signifies that there exist a 15.7 percent potential for farmers to increase their production and hence, their income at the existing level of resources and technology.

CONCLUSION

Two important factors affecting farmer’s adoption behaviour in the study area are the number of extension visit and farmer’s level of education. High cost of the input will reduce effort on rice expansion programme. This suggests the needs to subside the procurement and distribution of fertilizer. Based on the empirical results, it was recommended that adequate provision of efficient and effective extension programmes which will serve as an information link between farmers and research organizations and also assist farmers in establishing agro-allied service center in the study area was imperative. Policy attention should be directed toward providing improved rice varieties available at affordable price and accessible to farmers in the study area.

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