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Determinants of adoption and productivity of improved rice varieties in southwestern Nigeria

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The study examines the status of adoption of improved rice varieties and its impact on rice production among smallholder farmers in southwestern Nigeria. Data for this study were generated from a farm survey of rice farmers selected by multi-stage sampling technique in two of the rice producing states of the region. The study employed adoption index, logit model and stochastic frontier model to assess the adoption status, its determinants and impact on farmers' productivity respectively. The results show that farmers have responded appreciably to intervention programme that promote the use of improved rice varieties with an adoption rate of 68.7% which has resulted in an estimated proportional production increase of 19.4%. The mean yield of improved rice varieties (1.601 tons/ha) was significantly higher than the yield of the local varieties (1.154 tons/ha) with a yield advantage of 38.7%. In addition, rice yield for adopters of improved rice varieties (1.90 tons/ha) was significantly higher than that of non adopters (1.07 tons/ha). However, land area cultivated to rice, frequency of extension contact and the yield rating of the improved rice varieties were significant determinants of farmers' decision to adopt improved rice varieties while with an average technical efficiency score of 78.4%, rice farmers have room to increase their productivity by increasing their farm size, quantity of improved seed and fertilizer.

Key words: Improved rice variety, farm productivity. Southwestern Nigeria.

INTRODUCTION

Over decades, rice has occupied a prominent position as a strategic crop for food security and economic development of nations of the world. FAO (2000) classified the crop as the most important food depended upon by over 50 percent of the world population for about 80% of their food need. Due to the growing importance of the crop and the increasing challenges of attainment of food security, it has been estimated that annual rice production needs to increase from 586 million metric tonnes in 2001 to meet the projected global demand of about 756 million metric tonnes by 2030 (FAO 2002 quoted in Kueneman 2006). Recent global trend in the rice industry however shows that there is a growing import demand for the commodity in Africa, as evidenced from pressure on world supply and the steady increase in the world price of the commodity in the last five years (FAO, 2006).

In the West Africa sub region, Nigeria has witnessed a well established growing demand for rice as propelled by rising per caput consumption and consequently the insufficient domestic production had to be complemented with enormous import both in quantity and value at various times (Erenstein et al., 2004; Daramola, 2005). The enormous importation has however been considered by various regimes as an avoidable drain on the country's foreign exchange earnings in view of the abundant natural endowments for expanded production in Nigeria. In the past, the main impetus to the growth recorded in domestic rice production was due to area expansion. However, recent strategies through research system sought to increase production through increased productivity. This is pivoted on intensification, involving the development and dissemination of improved rice varieties and other modern inputs as a composite package to rice farmers.

Reports (Oyekanmi et al., 2008; Nwite et al., 2008) from research stations (based on their on-station and on-farm trials) showed that the adoption of the technologies and improved management practices should lead to substantial yield increases in rice production. This invariably underscores the significant role that technology stands to play in attaining the much needed growth in the rice sub sector. Kebede (2001) however predicated such growth

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Table 1. Distribution of respondents by States and ADP Zones.

State	ADP zone	Number of respondents
Ogun State	Abeokuta Zone	39
	Ikenne Zone	42
Osun State	Ife/Ijesa	41
	Iwo	35
Total	**4**	**157**

on productivity gained through greater technical and allocative efficiencies of the farmers in response to the changing technological and production environment. This nonetheless depends on appreciable adoption of the technologies at the farm level.

However, rural social scientists have long maintained that adoption of improved technology and market integration are predicated on the differential possession of economic resources like land, labour, and capital (Erbaugh 1999). This is in addition to socioeconomic and institutional factors as well as the physical attribute of the technology itself.

The Nigerian agricultural sector is however dominated by smallholder farmers who by virtue of their low income have dwindling capacity to access and procure capital, labour and modern inputs. Against the market environments that do not guarantee a fair price for a commensurate returns to investment on modern inputs, the farmers are indeed faced with a production environment that is capable of limiting their enthusiasm to adoption of improve production technologies in rice production. Consequently, this limits the benefits of increased productivity and efficiency derivable from the use of these technologies. This study therefore seeks to determine the level of adoption of improved rice varieties and, its contribution to increased productivity and technical efficiency of smallholder rice farmers in Southwestern Nigeria.

Conceptual framework

Issue of technology adoption among agricultural producers has received tremendous attention of agricultural development planners over decades. These studies according to D'souza et al. (1993) have generally focused either on technology adoption process at the farm level or on identifying the significant characteristics associated with adopters of individual technology. Regardless of whichever is the focus, adoption is generally a decision at the individual farmer's level, subject to various constraints bothering on resource (human and material) endowment and time variation which makes adoption a dynamic process.

In some cases, however, it is considered to be more beneficial to focus on the latter with the principal aim of targeting specific variables for policy formulation or specific group of farmers to promote the adoption of an innovation. Technology adoption literatures have however grouped factors affecting technology adoption under human capital, structural, institutional, and environmental categories (Feder and Slade, 1984; D'souza et al., 1993; Isham, 2002).

Human capital factors include educational background of the farmer, age or experience in farming. While education is expected to have positive association with adoption decision, a priori expectation on the influence of age is negative as younger farmers are expected to be more receptive to new innovations. Institutional factors include processes that facilitate build up of social capital, contact with extension information, group participation, credit and alternative sources of income which are all expected to have positive influence on adoption decision. In addition to these are the specific attributes of the technology under focus.

The work of Isham 2002 showcase the positive impact of social capital by predicting that farmers that have neighbours that adopt technology or those with higher level of social capital accumulates more information and thus adopt technology more rapidly. Similarly, Negatu and Parikh (1999) dwelt on the significant impact of technology transfer from the source to the farmer through a link like extension agents and the central role played by the attributes of the technology and institutional circumstances play in technology adoption.

MATERIALS AND METHODS

The sampling frame for this study consists of farmers growing rice under various cropping systems in the region and rice farmers were selected by multistage-sampling technique. Southwestern Nigeria comprises of six (6) States out of which two (Ogun and Osun) representing one-third of the total number of States in the region were randomly selected for the study since rice is grown across the six States. Two prominent rice producing zones and villages were then identified with the support of Agricultural Development Project (ADP) staff in each of the States followed by random selection of 10 villages per zone and finally 5 rice farmers per village from the list of rice farmers obtained from the village head or another person designated by the village head. The study eventually interviewed a total of 200 farmers out of which 157 questionnaires with distribution as shown below; were certified as containing enough information for analysis (Table 1).

Analytical tools employed included descriptive statistics such as frequency distribution, means and percentages while adoption index was estimated for each of the prominent rice varieties grown in the area and consequently for local and improved rice varieties in the region. Over the years, two methods of determining adoption rate have been established in literature; the first is based on expressing the number of farmers adopting a particular technology as a percentage of the total number of farmers under study (Floyd et al., 1999) and the second, expressing the land area put under a particular technology as a percentage of the total land area grown to the crop (Akino and Hayami 1975, Ahmed and Sanders 1991, Philips et al., 2000). While the former is said to be subjective in the sense that adequate consideration is not given to variation in size of holdings between adopters and non adopters (Philip et al., 2000), the latter is more applicable to crop production with an additional advantage of providing for easy determination of the contribution of the technology to the production of the particular crop within the area of study. Hence for this study, the latter method is adopted and the adoption index is given by:

$$\beta_v = \frac{\sum_{i=1}^{n} R_{vi}}{\sum_{i=1}^{n} R_T} \quad (1)$$

Where β_v = the adoption rate for rice variety v, R_{vi} = land area grown to rice variety v by farmer i (i=1, 2, ………..n), and R_T = total land area grown to rice by farmer i

It is a fundamental belief that technological changes in production systems can increase productivity in agriculture as well as production and employment in other sectors (Afolami and Falusi, 1999; Dayanatha et al., 1991). It is therefore important to investigate whether a particular technology had actually brought any change in production. In this regard, the proportional production increase (PPI) that could be attributed to improved rice varieties among the rice farmers was estimated by:

$$PPI = \frac{\Delta Y}{\bar{Y}} . R_{vm} \quad (2)$$

Where PPI = Proportional production increase, ΔY = change in yield (i.e. mean yield for improve varieties – mean yield for local varieties), $\bar{Y}$ = mean yield for rice in the area regardless of variety, and R_{vm} = adoption index for improved varieties.

A model was also specified to identify the farmer, farm and variety specific variables that influence the probability of adoption and intensity of use of improved rice varieties by rice farmers in the zone. Also included are institutional variables such as frequency of contact with extension agent, membership of farmers association and access to credit.

In most cases, analytical models used to assess adoption of conservation technologies have been based on the dichotomous approach of describing whether or not a farmer adopts a complete or few components as against the continuous model which supports the measurement of intensity of use (Mbaga-Semgalewe and Folmer, 2000). The dichotomous (yes and no) approach have been found to be more appropriately measured by discrete choice (binary) framework otherwise known as "Qualitative, Quantal or Categorical models prominent among which are the Probit, and Logit models with principal features of having an endogenous random variables assuming values of 1 (Yes) and 0 (No) (Adesina and Zinnah, 1993; Jabar et al., 1998; Baidu-Forson, 1999).

The binary models are designed with both deterministic and random utility components in order to accommodate unknown and unobserved attribute of an alternative in the individual utility function. Usually, the probability of selecting an alternative by an individual consumer (in this wise farmer) is based on the premise that the utility derivable from such choice would exceed that from any other alternative in the pool.

The functional form of the Logit model is given by Friendly (1995) as:

$$\pi(X_{ii}) = \frac{e^{(\alpha + \beta X_{ij})}}{1 + e^{(\alpha + \beta X_{ij})}} \quad (3)$$

This is transformed into the logistic regression model by a linear function of explanatory variables:

$$Logit\ (\pi_{ij}) = \alpha + \beta X_{ij} \quad (4)$$

Where π_i = adoption decision of farmer i assuming binary form of (1) for adoption and (0) for non adoption, X_{ij} = $_{jth}$ predetermined (covariates) household or technology attributes, α = constant term of the regression equation to be estimated, and β = parameters to be estimated.

Hence, the logit model was applied to all the farmers (both adopters and non adopters) to identify factors influencing the farmers' decision to adopt or not to adopt the improved rice.

In assessing the potential of the level of technology use to bring about the desired growth in the sub sector, a stochastic frontier model was also specified to determine the technical efficiency of the farmers in rice production. Following Zaibet and Dharmapala (1999), the multiplicative stochastic production function is of the form:

$$Q_i = f(X_{ki}\ \beta)\varepsilon_i \quad \text{(i = 1, 2, …, n), (k=1, 2, …, k)} \quad (5)$$

Where Q_i is the rice output of the i^{th} farm, X_{ki}, is a vector of k inputs used by the ith farm, β is a vector of parameter to be estimated and ε_i is the farm specific composite residual term comprising a random error term v_i and an inefficiency component u_i.

$$\varepsilon_i = v_i + u_i \qquad (i = 1, 2, ..., n) \quad (6)$$

The two components v and u are assumed to be independent of each other, where v is the two-sided, normally distributed random error $v_i \approx N(0, \sigma_v^2)$ and u is one-sided efficiency component with a half-normal distribution $(u_i \approx N(0, \sigma_v^2|)$ (Sharma et al., 1999). It follows that the maximum likelihood estimation of Equation (5) yields estimates for β and λ, where β was as defined earlier, $\lambda = \sigma_u / \sigma_v$, and $\sigma^2 = \sigma_v^2 + \sigma_u^2$. Gamma function is defined as $\gamma = \sigma_u^2 / \sigma^2$, so that $0 \leq \gamma \leq 1$ and represents the total variation in output from the frontier attributable to technical efficiency.

However, the farm specific measure of technical inefficiency can be determined (Bravo-Ureta and Rieger, 1991; Zaibet and Dharmapala, 1999) from the conditional expectation of ui given ε_i as:

$$E[u_i|\varepsilon_i] = \frac{\sigma_u \sigma_v}{\sigma}\left(\frac{f*(\lambda\varepsilon_i / \sigma}{1 - F*(\lambda\varepsilon_i / \sigma}\right) \quad \text{I = 1, 2, ……., n} \quad (7)$$

where f* and F* are the values of the standard normal density and distribution functions respectively, evaluated at $\varepsilon_{i\lambda/}\ \sigma$. The individual farmer's level of technical efficiency (TE_i) is then calculated as:

$$TE_i = \exp(-E[u_i|\varepsilon_i]) \quad \text{i = 1, 2, …….n} \quad (8)$$

Such that $0 \leq TE_i \leq 1$

The empirical stochastic production frontier model of the rice farmers is specified as the Cobb Douglas function given by:

$$LnQ_j = \beta_o + \beta_1 \ln FZ + \beta_2 LnLB + \beta_3 LnLcSd + \beta_4 Ln\mathrm{Im}Sd + \beta_5 LnFert + v_i - u_i \quad (9)$$

Where Ln = Natural logarithm that is, (logarithm to base e), Q_j = total output of rice produced in (kg) for j= 1, 2. (1= upland and 2 lowland), FZ = size of rice farm (ha), Lb = total input of labour (both hired and family in Mandays), LcSd = quantity of local seed planted (kg), ImpSd = quantity of improved seed planted (kg), and Fert. = quantity of fertilizer used (kg).

Literatures (Helfand and Levine, 2004; Rios and Shively, 2005)

Table 2. Socio-economic characteristics of rice farmers.

Characteristics	Adopters	Non-adopters	Total	Test statistic
Sex:				
Male	118(89.40%)	20(80.00%)	138(87.90%)	1.74[a]
Female	14(10.60%)	05 (20.00%)	19 (12.10)	
Education:				
Illiterate	45 (34.10%)	20 (80.00%)	65 (41.40%)	18.26 [a]*
Educated	87(65.90%)	05(20.00%	92 (58.60)	
Membership of Association:				
Member	100(75.80%)	14 (56.00%)	114 (72.60)	4.13 [a]*
Non Member	32 (24.20%)	11(44.00%)	43 (27.40)	
Access to Alternative Income:				
Have alternative income	78 (59.50%)	01 (3.80%)	79 (50.30)	26.92 [a]*
None	53 (40.50%)	25 (96.20)	78 (49.70)	
Age	53.82(13.25)	49.88(10.49)	53.17(12.86)	1.40 [b]
Years in Rice Production	26.87(6.80)	24.64 (5.00)	26.55 (6.58)	1.63[b]
Size of Rice Farm	3.52 (1.58)	1.71(1.02)	2.62 (1.52)	7.36[b]*
Frequency of Extension	3.50 (1.50)	1.60 (1.29)	3.20 (1.62)	5.94 [b]*

*Significant at P ≤0.05.
[a] Chi-Square Statistics.
[b] T-Statistics.

have dwelt extensively on the direct relationship between increases in output as of consequence of increase in farm size and invariably labour (under low level of mechanization). However, evidences abound that when land becomes limiting, seeking increased growth in food production through productivity increase becomes an option with greater potential. Productivity at this instance is then sought through intensification (Sivanappan, 1995; Jabar et al., 1998; Upton, 1996 and Cassman 1999) that encompasses increased use of modern inputs (example, improved seed and fertilizer). The *a priori* expectation is thus for the variables included in the frontier function to have direct relationship and consequently impact positively on the efficiency of the farmers.

As a means of further precipitating the impact of the improved seed technology on rice production, the study also compares the efficiency of adopter and non-adopters of improved rice varieties among the farmers.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

The distribution of the socio-economic characteristics of the respondents by their adoption status is shown on Table 2. Generally, rice production in the study area was male dominated (89.20%) while majority of the farmers (58.6%) had formal education. Also, about 73% of the farmers belonged to farmers' associations or cooperative societies while about 50% had non-farm sources of income. Average age of the farmers was 53 years with experience in rice production spanning over 26.6 years while average size of rice farm was 2.60 hectares.

The distribution of the socio-economic characteristics of the farmers by their adoption status showed that majority of the adopters (65.90%) are educated, belong to farmers association (75.8%) and had access to non-farm income (59.50%) while majority of the non-adopters (80.0%) had no formal education, depend solely on farming (96.20) but also belongs to farmers associations (56.0%). In addition, rice farmers who adopt improved rice varieties cultivated larger farms (3.52 ha) and had more contact with extension agents (3.5) than non-adopters with farm size and extension contact score of 1.71 ha and 1.60 respectively. However, there was no significant difference in the age and years of experience in rice production for the two categories of farmers (p ≤ 0.05).

Production systems

Table 3 shows the production systems adopted by the farmers. Majority (75.1%) of the farmers engaged in rain fed upland rice production followed by rain fed lowland (14.7%). Irrigated rice farming was not popular among the small holder farmers as just 5.7% engaged in either irrigated upland and/ or lowland rice production. Rice was commonly grown as a sole crop (75.8%). This include those who practiced both sole and mixed cropping, while relay cropping (4.4%) was relatively unpopular in rice production among the farmers. About 92% of the farmers' cultivated improved varieties (including those who cultivated both improved and local varieties) while just 8.3% cultivated local varieties only.

Adoption of improved rice varieties and sources of seed

The estimated adoption level of the different rice varieties

Table 3. Production systems adopted by farmers.

Production systems	Osun		Ogun		Total	
	F	%	F	%	F	%
Type of rice grown						
Upland	55	73.7	62	76.5	117	75.1
Lowland	15	19.7	08	9.9	23	14.7
Upland and Lowland	02	2.6	05	6.2	07	4.5
Irrigated Lowland	02	2.6	03	3.7	05	3.2
Irrigated Upland and Lowland	01	1.3	03	3.7	04	2.5
Cropping systems						
Sole	36	47.4	51	63.0	87	55.4
Mixed	25	32.9	06	7.4	31	19.8
Relay	02	2.6	05	6.2	07	4.4
Sole and Mixed	13	17.1	19	23.4	32	20.4
Rice variety grown						
Local	05	6.6	08	9.9	13	8.3
Improved	52	68.4	55	67.9	107	68.2
Both	19	25.0	18	22.2	37	23.5

F = Number of respondents.

Table 4. Adoption index for local rice varieties cultivated by farmers.

Variety	Osun		Ogun		Total	
	Land Area	Adoption Coefficient	Land Area	Adoption Coefficient	Land Area	Adoption Coefficient
Local						
Ofada	34.2	0180	62.8	0.302	97.0	0.244
Ilesa	12.0	0.063	-	-	12.0	0.030
Mokwa	-	-	1.0	0.005	1.0	0.003
Akure	-	-	0.7	0.004	0.7	0.002
Benue	-	-	0.4	0.002	0.4	0.001
Ode-Omi	-	-	6.2	0.003	6.2	0.012
Eleefa (OS6)	-	-	8.7	0.042	8.7	0.022
Total	**46.2**	**0.237**	**79.9**	**0.385**	**126.1**	**0.313**
Improved						
FARO 44	6.3	0.033	1.9	0.009	8.2	0.021
FARO 45	3.8	0.020	-	-	3.8	0.010
FARO 50	6.3	0.033	2.7	0.013	9.0	0.023
ITA 150	95.9	0.505	100.9	0.485	196.8	0.495
ITA 235	16.7	0.088	-	-	16.7	0.042
ITA 257	1.3	0.007	-	-	1.3	0.003
ITA 321	-	--	5.0	0.02	5.0	0.013
ITA 360	-	-	3.3	0.02	3.3	0.008
WAB 189	-	-	16.6	0.08	16.6	0.042
WITA 1	-	-	3.3	0.02	3.3	0.008
WITA 4	-	-	4.6	0.02	4.6	0.011
WITA 12	17.6	0.040	-	-	7.6	0.019
Total	**137.9**	**0.708**	**138.3**	**0.666**	**276.3**	**0.687**

Table 5. Sources of local and improved varieties grown by farmers.

Sources	Local Varieties						Improved					
	Osun		Ogun		Total		Osun		Ogun		Total	
	F	%	F	%	F	%	F	%	F	%	F	%
MANR[a]	02	2.6	03	3.7	05	1.9	11	14.5	28	34.6	39	24.8
ADP[b]	00	0.0	00	0.0	00	0.0	31	40.8	11	13.6	42	26.8
Local Market	18	23.7	35	43.2	53	33.8	02	2.6	05	6.2	07	4.5
Fellow farmer	10	13.2	19	23.5	29	18.5	02	2.6	05	6.2	07	4.5
WARDA	00	0.0	0	0.0	00	0.0	05	6.5	03	3.7	08	5.1
Research Inst.	00	0.0	0	0.0	00	0.0	01	1.3	04	4.9	05	3.1
Farmers' Assoc.	01	1.3	05	6.2	06	3.8	05	6.6	06	7.4	11	7.0
Special Prog.	00	0.0	05	6.2	05	3.4	03	3.9	10	12.3	13	8.3
Input Store	08	10.5	04	4.9	12	7.6	06	7.9	07	8.6	13	8.3
Buying Agent	37	48.7	10	12.3	47	30.0	10	13.3	02	2.5	12	7.6
Total	**76**	**100**	**81**	**100.**	**157**	**100**	**76**	**100**	**81**	**100.0**	**157**	**100**

F = Number of respondents.

identified by the farmers is shown in Table 4. The result shows that a substantial proportion of land area grown to rice was cultivated to improved rice varieties with an adoption rate of 68.7% while the adoption rate for local varieties was estimated as 31.3%. Explicitly, the improved rice varieties grown by the farmers included ITA 150, WAB 189, ITA 235, WITA 4, ITA 315, ITA 321, ITA 128, ITA 360, WAB 450.P31, WAB 450-131 and WITA 1 while the local varieties included *Ofada*, *Eleefa*, *Ilesa*, *Ode-omi*, *Benue local*, *Akure local*, and *Mokwa*. However, while ITA 150, WAB 189, ITA 235, and WITA4 are the prominent improved rice varieties, *Ofada, Eleefa, Ilesa* and *Odeomi* are the local varieties commonly grown by the farmers in order of importance.

Among the improved varieties, ITA 150 was the most prominent with estimated adoption rate of 49.5% followed distantly by ITA 235 and WAB 189, each with adoption rate of 4.2%. Similarly, *Ofada* rice was the most prominent local rice variety with an adoption rate of 24.4% followed by *Ilesa* and *Mokwa*. However, there was a marked variation in the spread of the local and improved varieties of rice grown in the states as more rice varieties (both local and improved) were grown in Ogun State than in Osun State. Table 6 shows that the ADPs (26.8%) and Ministry of Agriculture (24.8%) of the respective states were the most important sources of improved rice seeds, while farmers obtained the seed of the local varieties mainly from the local markets (33.8%), and from input store (30.0%).

Factors determining adoption of improved rice varieties

The description of the socio-economic variables considered in the estimation of the logit adoption model is shown in Table 5. The results of the Logit likelihood regression model (Table 7) showed that the overall predictive power of the model (92.2%) and explanatory power (75.9%) are quite high while the significant χ^2 (for $\beta = 0$) is indicative of the strength of the joint effect of the covariates on the probability of adoption among smallholder rice farmers in the study area. The results also showed that the decision on whether or not to cultivate improved rice varieties was significantly influenced by the size of rice farm (RICECULT), yield rating of improved rice varieties (YLDRATIN) and frequency of extension contact (EXTFREQ). Also, the Wald χ^2 indicating the individual effect of the covariates shows that the most important factors influencing the probability of adoption of improved rice varieties in southwestern Nigeria are the respective yield performance of the varieties (20.714) and the frequency of extension contact (7.093).

Studies in adoption of agricultural innovations among Nigerian farmers have confirmed the influence of socio economic characteristics on adoption decision of farmers. In a study on adoption of sawah rice production technology, Fashola et al. (2007) found that membership of association, level of education, were important contributor to adoption decision of farmers, however, this study shows that rather than these variables, frequency of extension contact and the attribute of the technology in terms of productivity were significant contributors to adoption of improved varieties among farmers. However, similar study by Omonona et al. (2005) on adoption of improved cassava varieties in Edo State, Nigeria showed that sex, age, access to extension agent, access to inputs and crop yield were significant variables positively influencing adoption of improved cassava varieties. It is then suffice to say that extension contact and basic attribute of improved varieties are significant motivating factors for adoption of improved varieties among crop farmers.

Table 6. Description of variables included in the regression model.

Explanatory Variable (X_j)	Description of variables/covariates
Sex	Male =1 Female = 0
Education	Educated = 1 None = 0
Membership of Association	Member = 1, Non-member = 0
Alternative Income source	Availability of non-farm sources of income: Yes = 1 No = 0
Age	Age in years
Experience in Rice Cultivation	Years in rice cultivation
Total size of land holding	Land holding in hectares
Size of rice farm	Size in hectares
Frequency of Extension Contact	Frequency Score: Not at all = 0, occasionally = 1, Quarterly = 2, fortnightly = 3 monthly = 4, weekly = 5.
Fertuse	Use of fertilizer (Used = 1, Not used = 0)
PIIP	Participation in intervention programme: Participation = 1 Non participation = 0
Drougtole	Tolerance rating relative to local variety(Higher = 3, Similar = 2 Lower = 1)
Procesin	Processing quality relative to local variety (Higher = 3, Similar =2 Lower = 1)
Dseratin	Disease resistance rating relative to local variety (Higher = 3, Similar =2, Lower = 1)
Yldratin	Yield rating relative to local variety (Higher = 3, Similar = 2 Low er = 1)
	Level of education Illiterate = 0, Adult education =1, primary school = 2, Secondary = 3, Post secondary = 4
Educlevel	Level of education Illiterate = 0, Adult education =1, primary school = 2, Secondary = 3, Post secondary = 4
Credit	Access to credit facilities: Yes =1, No = 0
Infosos	Number of sources of information on rice production identified by farmer
Farmers output of rice (Q)	Farmer's total output of rice (kg)
Labour	Man-day of labour used in rice production
Quantity of local seed planted	Quantity of seed in kg
Quantity of improved seed planted	Quantity of seed in kg

Table 7. Log likelihood estimate of adoption decision model.

Covariates	B	Std. error	Sig. t	Wald
(Constant)	-7.187*	4.245	0.090	2.866
FERTUSE	0.063	1.144	0.956	0.003
PIIP	1.659	1.553	0.285	1.142
RICECULT	3.157*	1.912	0.099	2.726
DROUTOLE	1.104	0.752	0.142	2.151
PROCESIN	0.171	0.712	0.810	0.058
DSERATIN	0.680	0.960	0.479	0.501
YLDRATIN	1.489**	0.098	0.001	20.714
EDUCATIO	0.409	0.455	0.452	0.564
EXTFREQ	0.996**	0.374	0.008	7.093
ALTINCOM	-0.61	1.947	0.975	0.001
ASOSMEM	2.160	1.441	0.134	2.246
CREDIT	-1.242	1.559	0.426	0.635
INFOSOS	-0.659	0.565	0.244	1.359
AGE	-0.025	0.058	0.665	0.188

**Significant at: P≤0.05 *Significant at P≤ 0.10.
-2 Log of likelihood function = 44.096 χ^2 = 88.840*
Adjusted R^2 = 0.759. Overall Correct predictions = 92.2%.
Adopters (n = 130) = 95.3%. Non Adopters (n = 27) = 75.0%.

Table 8. Rice productivity differential by variety and adoption status of farmers.

Category	Rice yield	Standard Dev	T-Value
Improved Varieties	1.60	0.54	7.32*
Local Varieties	1.15	0.35	
Adopters	1.90	0.15	2.29*
Non Adopters	1.07	0.17	

Significant at P ≤ 0.05.

Yield and technical efficiency differential among rice varieties

Pair-wise comparison of the yield (paddy) of the prominent rice varieties indicated that the mean yield of improved rice varieties (1.601 tons/ha) was significantly higher than the mean yield of the local varieties (1.154 tons/ha) amounting to a 38.7% yield advantage (Table 8). Given a yield differential of 0.447 ton/ha between improved and local rice varieties and with an adoption coefficient of 0.687, the improved rice variety technology

Table 9. Summary of variables in the stochastic frontier model.

Variable	Mean	Standard deviation
Rice Output (kg)	1694.60	1495.81
Farm Size (ha)	1.72	1.86
Labour (mandays)	29.00	19.06
Quantity of local variety planted (kg)	28.30	22.88
Quantity of Improved Variety Planted (kg)	24.92	19.41
Quantity of Fertilizer (kg)	19.60	28.50

Table 10. Maximum likelihood estimate of the frontier production model.

Variables	Coefficients	Standard Error	T-Statistics
Constant	3.46	0.334	10.35928
Farm size (ha)	0.344	0.147	2.340136
Labour (man-day)	-0.567	0.117	4.846154*
Local Seed (kg)	0.115	0.138	0.833333
Improved Seed (kg)	0.504	0.081	6.222222*
Fertilizer (kg)	0.266	0.029	9.172414*
σ^2	0.202	0.067	3.014925*
Γ	0.533	0.207	2.574879*
Log Likelihood Function	-40.975		

*Significant at ($P \leq 0.05$).

could be said to have contributed an estimated proportional production increase (PPI) of 19.4% based on the ground that the average yield for rice among the farmers regardless of variety planted was estimated as 1.586 tons/ha. In addition, the study also revealed that rice yield for adopters of improved rice varieties (1.90 tons/ha) was significantly higher than that of non adopters (1.07 tons/ha).

Table 9 show the summary statistics of the variables include in the frontier model. The results of the stochastic frontier analysis indicated that farm size, labour, quantity of improved seed and fertilizer are significant contributors to farmers output of rice (Table 10). The results show that farmers can increase their rice output by increasing the quantity of improved seed and fertilizer used while making use of additional labour is capable of decreasing farmers output of rice. The Gamma function (0.533) is significantly different from zero thereby implying that inefficiency exists among rice farmers in the study area. The estimate also implies that 53.3 percent of the variation in farmers output is attributable to variation in the individual farmer's technical efficiency. Average efficiency score of the rice farmers was 78.4% indicates that rice farmers in the study area stand the chance of improving their efficiency by about 22%. Similar studies by Okoruwa et al. (2006) and Idiong (2007) estimated technical efficiency among rice farmers to be between 76 and 82% thereby implying that considerable room exist for improvement in the productivity of rice farms.

However, adopters of improved rice varieties were significantly higher in efficiency (0.78) than non adopters (0.71) thereby underscoring the importance of improved seed on farmers productivity and thereby justifying investment on rice varietal development which has been associated by Dalton and Guei (2003) to the enormous producer surplus recorded in seven most important producer of rice (Nigeria inclusive) in West Africa.

In addition, the mean efficiency of the top 10% efficient farms was 0.889 and that of the bottom 10% of the non efficient farms was 0.625. Based on these categorization, the distribution of the socio economic characteristics of the two categories of rice farmers show that 90% of the efficient farmers (top 10%) have contact with extension agents during the last two years, 80% belong to Farmers association, average farm size of 0.96 ha, mean age of 44.4 years and 9.2 years of formal education in contrast to 50% of the non efficient farmers (bottom 10%) having contact with extension agent, 20% belonging to farmers association, average farm size of 0.49 ha and a mean age of 54.4 years and 3.9 years of formal education (Table 11).

Conclusion and policy implication

The main aim of this study is to analyze the use of improved rice varieties and its contribution to smallholder rice production in Southwestern Nigeria. The study has shown that farmers are responding appreciably to

Table 11. Socio-economic characteristics of the most efficient and least efficient group of rice farmers.

Socio-economic characteristics	Top (10%) Efficient Farms	Bottom (10%) of Non Efficient Farms	Test Statistic	
			Value	Sig. P
Contact with Extension Agent	09 (90.0)	05 (50.0)	3.810[c]	0.051
Membership of Farmers Associations	08 (80.0)	02 (20.0)	7.200[c]	0.007
Average Farm Size	0.96 (0.047)[a]	0.49 (0.041)[b]	7.51[t]	0.00
Average age	44.40 (1.536)[a]	54.40 (1.301)[b]	4.97[t]	0.00
Years of Education	9.20 (0.388)[a]	3.90 (0.504)[b]	8.322[t]	0.00
Average Efficiency Score	0.889	0.625		
	Adopters	**Non Adopters**		
Average efficiency score	0.783 (0.084)	0.625 (0.074)	4.341	0.00

*Figure carrying the different superscripts across a row a significantly different.
C = Chi Square Statistics; t = t-statistics.

intervention programmes that promote the cultivation of improved rice varieties in the region with an adoption rate of 67%. However, the average yield for the study area (1.601 tons/ha) has indicated that the improved rice technology is yet to have an appreciable impact on productivity. The production frontier model however showed that farmers in the study area can increase their productivity through increased land area, quantity of improved seed and fertilizer thereby confirming the notion that increased use of modern inputs could lead to higher productivity resulting from positive interaction among inputs especially when they are of improved quality (Okike et al., 2001).

Bearing the problem in distribution system for these modern inputs (improved seed and fertilizer) in mind, it becomes necessary to increase effort at ensuring an efficient extension delivery system that would provide for accelerated distribution and consequently adoption of the high potential improved varieties. Such effort should give adequate consideration to capacity building among the farmers for expansion of holdings while research and extension system effort should sustain effort at further increasing yield potential of the crop and frequency of contact with farmers respectively as these have been empirically shown to be among the motivating factors for increased adoption of improved rice varieties by farmers. Increasing frequency of extension contact might entail recruitment of more extension staff complemented with regular routine training to update their technical skill.

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