Determinants of efficiency differentials in lowland rice production systems in Niger State, Nigeria

M.A.Y. Rahji
Department of Agricultural Economics
University of Ibadan, Nigeria.

Abstract

The study investigated production efficiency differentials between groups of farmers in lowland rice production systems in Niger state, Nigeria. The data for the study came from a sample survey of the study area. The sampled farmers were classified into adopters and non-adopters of the recommended improved management practices based on an adoption score of 40%.Multiple regression analysis, involving the estimation of stochastic frontier production functions, was used in analyzing the data set for the groups. For the adopters,. three factors land, labour seed are significant at 1% while two, intermediate inputs and miscellaneous costs are significant at 5%. Out of these only labour has a negative sign all others have positive signs .As regards non -adopters, only three factors are significant. Land and seeds are positive and significant at the 5% level. Labour is negative and significant at the 1% level. These results tend to indicate over utilization of labour in rice production systems in the area of study. The gamma values of 0.7864 for adopters and 0.6532 for non-adopters mean that the groups attained about 79 and 65 percent technical efficiency levels respectively. There is thus scope to decrease the input use level with out the output being affected. Farm size, education, household size and distance to input source were found to affect the technical efficiency of the farmers the same way but at different levels of significance. However, while extension service is highly significant for adopters it is not for non-adopters. Farm expansion policy was recommended so as to absorb the excess labour in the systems. Critical inputs should be made available at lower prices to the rice farmers as incentives to stimulate increased production of rice in the area of study

Keywords: Efficiency differentials, lowland rice production systems, improved management practices, Stochastic frontier production function, Niger state, Nigeria.

Introduction

Rice is one of the major cereals widely grown for food in Nigeria. It is cultivated under diverse ecological and production systems. Five major systems have been identified. These are: the upland rain-fed, inland shallow swamp (fadama), mangrove / tidal swamp, deep water/ floating and lowland irrigated rice production systems (Olayemi, 1997).

The total land area under rice cultivation in Nigeria is about 1.642 million hectares (FAO, 1994). This yields about 3.185 million tons of paddy annually. Despite this, a lot of foreign exchange is spent on rice importation in Nigeria. It was estimated that 60.337 billion US dollars were spent on rice importation between 1988 and 1990 (WARDA, 1993).

In view of this fact and the high demand for the commodity, the Federal government declared a policy of self-sufficiency in rice production. The policy of self-sufficiency in rice production in Nigeria indicates the desire by the country to supply the gross domestic demand for rice However, the cropping systems, are known to be beset with problems associated with low yield (Adeniyi, 1988). This according to Olayemi (1997) has led to low returns and decline in local production of rice.

The two species of rice in West Africa are *Oryza sativa* and *Oryza glaberima*. These are, the red rice, which is native to Africa and white rice which originated from South-East Asia. In Nigeria, Ofada rice was the common traditional seed variety planted. In more recent years, improved seeds of Federal Agricultural Research *Oryza* (FARO) such as FARO 11 (OS6) and FARO 3 (Agbede) and others have come into prominence (Olayemi, 1997). In addition to this, improved management practices have been developed (NCRI, 1984). These practices have been disseminated to farmers in Nigeria for adoption. Some studies have been carried out to investigate factors related to adoption of improved technologies in Nigeria (Iwueke, 1991; Njoku, 1991; Onyenwaku, 1991 and Chikwendu *et al*; 1996). How these factors affect the adoption of recommended management practices for low land rice and their impact on productivity and efficiency has not been sufficiently investigated. There is thus a research gap in the literature on rice production in Nigeria.

Problem statement

Recent rice importation figures attest to the fact that rice is in high demand in Nigeria (NCRI, 1997; FOS, 1997). UNCTAD (1995) reported that import into the country, rose from about 200,000 tonnes in 1988 to over 300,000 tonnes in 1995. FOS (1999) put Nigeria's rice importation in 1998 at 465,000 tonnes. Total domestic production and imports added up to 24,955.9 ('000MT). Out of this, domestic production stood at 1,714 ('000 MT) while imports reached 23,242 ('000 MT). This estimate does not consider unrecorded trade (smuggling). There is thus a wide demand-supply gap for rice in Nigeria. It is believed by the policy makers that this gap can be closed locally. According to Nasko (1989), given the land and human resources in Nigeria, and the available and known technologies for food production, there is no justification what so ever for Nigeria to import any of her staple food. This assertion could have been contributory factor to the decision of the government in adopting the self-sufficiency strategy for rice production in Nigeria.

The problem identified therefore centres on understanding the adoption behaviour of rice farmers and the improved production technology (biological, mechanical and chemical) available and attainable. It also borders on examining how the improved practices will lead to a structural shift in the production parameters and efficiency of the farmers. The problem is: the rate of diffusion of these technologies is still low. This raises the research question as to whether or not the forces driving improved management practices adoption are fully understood. What factors significantly influence this adoption? What is the nature of resource shifts or production parameter shifts that is associated with the practices? Will they lead to significant improvement in rice production efficiency? These are some of the pertinent questions to be addressed in this study. There is a dearth of such studies in the case of Nigeria. This study intends to bridge this apparent information gap in the literature.

The efficiency with which farmers use available resources and improved technologies is important in agricultural production. The demand for food crops is increasing due to population increases. The possibility of expanding production by bringing more resources, especially land, into use is becoming more and more limited. It is thus of policy relevance to seek ways of improving the production efficiency of farmers. Factors, which result into efficiency differentials among farmers, need to be examined in terms of farm specific characteristics. According to Kalirajan and Shand (1989) and Parikh and Shah (1994), the level of technical efficiency of farmers could be determined by a host of socio-economic and demographic factors

The main issue in the Nigerian agriculture is that of low productivity. In recent years, despite all the human and material resources put into the sector, the rate of its productivity increase is said to be declining (Falusi,1995). According to FACU (1992) and FDA (1993,1995), the productive efficiency for most crops still fall under 60 percent. There is thus scope for increases in output from existing hectarages. This study is designed to examine the technical efficiency and efficiency differentials based on improved management practices available to the farmers.

Objectives of the study

The main objective of this study is to examine production efficiency and efficiency differences between adopters and non- adopters of improved management practices in rice production in the area of study. The specific objectives include; to

1. estimate technical efficiency in rice production based on the adoption or non-adoption of improved rice management practices by the farmers
2. assess the production efficiency differentials between the adopters and non-adopters of the recommended management practices.

3. examine the sources of efficiency differentials between the groups of rice producers
4. identify farm characteristics that influence efficiency in rice production in the area of study
5. make policy recommendations based on the findings of this study.

Methodology

(i) Area of study

Niger state, Nigeria is located between 8^0 11^1 to 11^0 20^1 N of the equator and between 4^0 30^1 and 7^0 15^1 E of the equator. It covers an estimated area of 4,240 km^2. The mean annual rainfall ranges between 800 to 1000mm. The average annual number of rainy days ranges between 187 to 220 days. The rains start in late April and end in October with the peak being in July. The dry season lasts for about six months of the year from November to April. The average minimum temperature is about 26^0C while the average maximum temperature is about 36^0C. The mean relative humidity ranges between 60 percent (January to February) and 80 percent (June to September). The state falls within the guinea savannah vegetational belt. This vegetation supports the cultivation of root crops and grains. The predominant crops are rice, sorghum, millet, yam, groundnut and cotton.(NCRI,1984;1997).

(ii) Method of data collection

Niger state is divided into three agricultural zones. These are Bida, Kuta and Kontagora zones. Bida zone is purposively selected for this study. This selection is based on; one, its long history of lowland rice production; two, its proximity to the National Cereals Research Institute (NCRI) at Baddeggi where low land rice technologies emanate and are disseminated.

Bida zone is made up of seven Local Government Areas. Three of these, Lavun, Bida, and Gbako LGAs were randomly selected. In each LGA, 4 villages were randomly selected for a total of 12 villages. These are Labozhi, Batabi, Egbeko and Kitche in Lavun LG and Ebonka, Ebba, Baddeggi and Egbati in Bida LGA. In Gbako LGA, Ndabe, Lemu, Gbemgba and Kataeregi were selected. In each village, 35 farmers were randomly selected from the list of farmers in the areas. This gave a sample size of 420 farmers.

(iii) Methods of data analysis

A two-step procedure is adopted for this analysis. In the first step, a stochastic frontier Cobb-Douglas production function is specified and estimated to measure the farm level efficiency of the rice farmers categorized as adopters and non adopters of improved management production practices. The model is specified

$$LnY_i = a_o + \sum_{i=1}^{m} a_i \ln X_{ij} + V_i - U_i \qquad (1)$$

where: Y_i= Monetary value of rice per farm, a_o, $a_{i's}$ are parameters to be estimated, $X_{i'}$, the factors of production in use, V_i and U_i are assumed to be independent of each other. V_i is the two-sided normally distributed random error (V ~N(0, δ^2). U_i is the one-sided efficiency component with a half-normal distribution [U~ [N(0, δ^2)]. This is a non-negative random variable that is assumed to account for the existence of technical inefficiency, and $e_i = V_i - U_i$, the deterministic error term of the ordinary production function.

The maximum likelihood estimation of (1) provides estimators for a's, the variance parameters; sigma – squared (σ^2), gamma (γ) and lambda (λ). The following relationships are worth noting.

$$\sigma^2 = \sigma u^2 + \sigma v^2 \qquad 2(i)$$

$$\gamma = \sigma u^2 / \sigma^2 \qquad 2(ii)$$

$$\lambda = \sigma u / \sigma v \qquad 2(iii)$$

The parameter gamma (γ) has a value between zero and one (Battese and Tessama, 1993). According to Battese and Corra (1977), gamma (γ) is the total output made on the frontier function, which is attributed to technical efficiency. Similarly, (1 - γ) measures the technical inefficiency of the farms. The parameter lambda (λ) is expected to be greater than one. Such a result according to Tadesse and Krishnamoorthy (1997), indicates a good fit for the model and the correctness of the specified distribution assumptions for V_i and U_i.

In agricultural production, land labour and seeds are generally regarded as inputs. However, in rice production, agricultural chemicals such as pesticides, herbicides and insecticides may be necessary. In fact, the latter set of inputs is a component of the improved rice management practices disseminated to farmers in the study area.

On the basis of the foregoing, land (X_1) in hectare, labour (X_2) in hours, intermediate inputs (X_3) in Kg, seeds (X_4) in kg, miscellaneous cost (X_5) and capital /credit (X_6) (N) are included in the stochastic production function.

In the second stage, the level of technical efficiency of the farms was determined for the two groups separately. The sources of technical inefficiency were then empirically identified and examined. According to Bravo – Ureta and Pinheiro (1993) this is done by investigating the relationship between farm/farmer characteristics and the computed efficiency indices.

Issues in the estimation techniques

There is controversy on this approach in the literature. Bravo-Ureta and Pinheiro (1993) criticized it while Kalirajan (1991) and Ray (1998) especially argued its reasonableness and appropriateness if it is assumed that the production function is multiplicatively separable in terms of discretionary and non-discretionary inputs.

The range of values for the technical efficiency index is another issue of controversy in this methodology. The range is bounded between zero and one. These values can, therefore not be assumed to be normally distributed (Ekanayake, 1987; Squires and Tabor, 1991). Yet empirical applications of this approach, ignoring these observations, abound in the literature (see Amaza and Olayemi, 2002; Ajibefun and Daramola, 2000). These studies used an estimating equation of the form

$$TE = b_o + \Sigma b_i Z_i + e_i \qquad (3)$$

But, as suggested by Ekanayake (1987), the technical efficiency index must be transformed into the natural logarithm of the ratio of the technical efficiency to technical inefficiency as transformed technical efficiency (TET). This transformation makes it possible for the ratio to assume any value (Admassie, 1999). The dependent variable of the estimating equation thus becomes

$$TET = \ln\left(\frac{TE}{1-TE}\right) \qquad (4)$$

This adaptation uses all available information on both technical efficiency and inefficiency so is deemed to be an improvement over using only one of them as is commonly done.

It is thus hypothesized that the following socio-economic/ demographic factors: farm size in hectare (Z_1), education of head in years (Z_2), farming experience of head in years (Z_3) are significant factors affecting the production of rice in the area of study. According to Rougoor et al; (1998),older household heads tend to be more experienced. Hence, farming experience and age are likely to move in the same direction. A strong positive correlation is therefore expected between them. To prevent the problem of multi-collinearity, age is dropped in favour of farming experience. Olomola (1998), found farming experience to be positive and significantly correlated with animal traction adoption. This finding is consistent with the notion that as far as adoption and adaptation to new technology are concerned, experience not age is the best teacher (Shultz,1975). More so, farming experience has been shown to enhance efficiency due to prudent resource allocations while age can hinder adoption of new technologies due to higher risk aversion associated with older farmers (Rougoor et al;1998). Polson and Spencer(1991), and Olomola (1998) found age to be negatively and significantly related to adoption. In Nigeria albeit Africa, the farming population is already assumed to be aged at 51 years (WHO,1991). Age, although may be an important variable in explaining the variation in technical efficiency and often included in such studies as the current one is dropped. This is because; one, it was found to be highly correlated with farming experience of the farmers in our data set(r=0.8912). Two, this is supported by Admassie (1998) who dropped age in a similar study and for the same reason. Three, this research has a policy-oriented focus. Based on empirical evidence in the literature, age hinders adoption hence it cannot be used as a reasonable and meaningful policy variable. Experience which can be acquired in terms of training, interaction with extension agents exposure to media and research institutes is more amenable to policy formulation and manipulation than age. Credit use/access is a dummy variable: if yes=1, otherwise=0 (Z_4), household size (Z_5) is the number of members, distance to source of input in Km (Z_6) and extension contact measured as number of visits (Z_7) are determinants that explain efficiency differential in the production of rice in the study area. The factors are fitted into a regression equation represented by

$$TET = b_o + \sum_{i=1}^{n} b_i Z_i + \varepsilon_i \qquad (5)$$

where, TET is the transformed value of technical efficiency index.

Adoption index used in categorizing the farmers

In this study, the package approach to technology adoption is used. (Byerlee and Polanco, 1986; Daramola, 1987). As a result, an index that quantifies the adoption level of the recommended practices or components of the innovation is required. This is used to measure the relative contribution of each component to output. The components are ranked and the rankings are used to develop the adoption index of the farmers (Balcet and Candler, 1982 and Daramola, 1987).

The average weights/ranks assi-gned to the various components/ practices are adapted from Daramola (1987). The farmers have adoption index ranging from zero to one hundred. These are calculated from: improved seeds; 35% since this is the main component in rice production, fertilizer; 30%, agronomic practices; 25% (seed pruning 5%, planting-date 5%, seed rate 5%, nursery dressing 5%, spacing 5%), agrochemical; 10% (herbicides 5% and pesticides 5%) and green manure; 0% as no farmers adopted this. The adoption index is equal to 1 if the farmer scores 40% and above hence an adopter otherwise it is 0, implying non-adopter. The 40% lower limit for adoption thus denotes the threshold concept implicit in qualitative response models such as probit / logit or Tobit. But, it is used here in categorizing the rice farmers as adopters and non- adopters of the recommended improved management practices These groups are classified as different production systems in this study.

Results and discussions

The results of the analysis revealed that the following management practices were recommended for lowland rice producers in the area of study: (i) the improved seeds varieties recommended include FARO 27, FARO 29, FARO 30, FARO 32, FARO 33, FARO 34, FARO 35, FARO 36, FARO 37, FARO 44 and FARO 50. These have maturity period of between 115 and 135 days with a yield potential of 3 – 5 tons per ha, (2) the seeds are to be soaked in 12% salt solution for two minutes, separated, washed thoroughly and dried before sowing in the nursery, (3) the seeds are to be sown in the nursery in June, and transplanting is done in July/August or when the rain is fully established, (4) the seed rate for direct seeding is 3 – 5 seeds per stand. For transplanting, this is 45 – 50 kg of seeds per ha and (5) the nursery should be sprayed with fungicide such as Dithene (wp) at 20g in 10 litres of water to be applied at 10 – 14 days after sowing and fortnightly when necessary in the field to control blast infection. Other practices include, (6) a 20 X 20 cm for the non-lodging varieties and 25 X 25 cm for varieties that lodge at 3 – 5 plants per stand; (7) inorganic fertilizer application rates are 60kg N/ha, 30kg P_2O_5/ha, and 30kg K_2O/ha, (8) as green manure, Sesbania rostrata, Azolla, Aeschemenes spp are recommended as a substitute or supplement to inorganic fertilizer, (9) for effective control of weeds, any of Stan F-34, Risane, Tamanice, Basagram PL, should be applied at the rate of 8 – 10 litres/ha or Ronstar PL at the rate of 5 – 6 litres/ha, 14 – 21 days after transplanting; and (10) pesticides recommended include; granu-lar Carbofura at the rate of 1.0kg ai/ha or Isazofos at 0.75kg ai/ha for the control of African rice gall, midge and stem borers others are Dithene M-45 at fortnightly intervals at 2kg/1000c/ha or Benlate at monthly intervals for the control of rice blast or brown – spot disease

The data indicated 150 adopters and 270 non-adopters. Table 1 indicates that all the adopters used improved seeds, 96% plant at the recommended time, 78% applied inorganic fertilizer, while 65% spaced as recommended. In addition to this, 45% of the adopters used the recommended seed rate, 40% applied herbicides while 10% and 5% of the adopters nursery-dressed and used pesticides respectively. None of the adopters used the green manure.

Table 1: Distribution of respondents by status of adoption and percentage of adoption

Practices	No. of Adopters	% of Adopters
Improved seeds	150	100
Planting data	144	96
Inorganic fertilizer	117	78
Spacing	98	65
Seed rate	68	45
Herbicides	60	40
Seed priming	18	12
Nursery dressing	15	10
Pesticides	8	5
Green manure	0	0

Source: Field Survey, 2003.

The results of the Cobb-Douglas based stochastic frontier production function estimated for the two groups are presented in Table 2. For the adopters, seeds (X_4), Inter inputs (X_3), land (X_1) and Miscellaneous cost (X_5) have positive significant influence on the value of the output(revenue). The first factor (seeds) is significant at the 1% level while the others are significant at the 5% level. Labour (X_2) though significant at the 1% level has a negative impact on the dependent variable. In order of significance and /or magnitude of the parameters, the most important factors in the production of rice by this group are seeds, labour (absolute value and 1% level, Inter inputs, land and miscellaneous cost.

Table 2: Stochastic frontier production function results for rice farmers in Nigeria

Variables	Adopters Parameters	t-values	Non-Adopters Parameters	t-values
Land X_1)	0.3276***	2.8099	0.2415**	2.0075
	(0.0810)		(0.1203)	
Labour (X_2)	-0.3541***	3.2074	-0.3012***	2.9558
	(0.1104)		(0.1019)	
Inter Inputs (X_3)	0.4182**	2.3574	0.0936	1.1250
	(0.1774)		(0.0832)	
Seeds (X_4)	0.5467***	3.4233	0.3271**	2.4502
	(0.1597)		(0.1335)	
Misc. costs (X_5)	0.2113**	1.9859	0.1450	1.0233
	(0.1064)		(0.1417)	
Capital input (X_6)	0.1835	1.2412	0.0823	1.1152
	(0.1478)		(0.0738)	
Constant (K)	3.9621		3.7834	
λ	1.9188		1.3724	
γ	0.7864		0.6532	
Log likelihood	121.5687		163.4319	
N	150		270	
δu^2	0.1388		0.1237	
δ^2	0.1765		0.1884	
δv^2	0.0377		0.0657	

Source: Field Survey, 2003.

*** significant at 1% ** significant at 5%

As regards the non-adopters of the improved management practices only three out of the six factors are significant. These are labour, which is negative and significant at the 1% level. Seeds and land are significant at the 5% level. These factors are important in that order in terms of their significance.

With regard to the measures, of goodness of fit of the model, the lambda (λ) values of 1.9188 for adopters and 1.3724 for non-adopters which are greater than one signify a good fit for the estimated model and the appropriateness of the theoretically required distributional assumptions for the decomposed error terms (Tradesse and Krishnamoorthy, 1997).

Technical efficiency and inefficiency

By way of meeting the first objective of this study, the statistics gamma((γ) obtained from the estimated model are used. The gamma (γ) values of 0.7864 for adopters and 0.6532 for non-adopters imply that the groups attained about 79 percent and 65 percent technical efficiency respectively. These values are between zero and one as required (Battese and Tessama, 1993). They represent the total output made on the frontier production function attributed to technical efficiency

The estimates of technical inefficiency are thus 21 percent, and 35 percent for the groups. These estimates represent the largest proportional reduction in inputs that can be achieved in the production of rice without the output being affected or reduced

Technical efficiency and inefficiency differentials

An assessment of the technical efficiency shows that a differential of 14 percent (79-65) exits between the groups This means that the adopters are 14 percent more technically efficient than the non-adopters. Similarly, the non-adopters are 14 percent (35-21) more technically inefficient than the adopters. The implication of these findings is that adopters of improved management practices are more technically efficient and less technically inefficient than the non adopters. The better performance of the adopters in terms of these production efficiency differentials is adduced to the adoption of improved management practices by the adopters.

Table 3 presents the results for the effect of hypothesized socio-economic factors on technical efficiency of the groups. The R^2 values of 0.7582 and 0.7134 are high. These indicate that the factors explain about 76 percent and 71 percent of the variations in technical efficiency of rice farmers. The models are thus acceptable on statistical grounds. The calculated F-values 65.8786 and 93.1666 test the overall significance of the models in terms of whether or not the explanatory variables, taken together have significant influence on the dependent variable (TET). These values are greater than the tabulated values of 2.00 and highly significant.

On the basis of these facts, the alternative hypothesis was accepted in each case at the 5% level of significance. As regards the individual variables, for adopters, farm size (Z_1), education (Z_2), and extension visits (Z_7) have positive significant influence on technical efficiency. The first is significant at the 5% level while the remaining two are significant at 10% level. Both Households size (Z_5) and distance to source of improved inputs (Z_8) are negative but significant at the 5% level. For the non-adopters farm size (Z_1) and education (Z_2) are positive and significant at the 5% and 10% level respectively. The household members working on the farm (Z_5) and distance to source of improved inputs (Z_6) are negative. The former is significant at the 5% level while the latter is significant at the 10% level.

The results tend to suggest that increasing the farm size, since most of the farmers are small- scale producers will improve their technical efficiency. This could be in terms of economies of scale or the benefit of attaining the optimum farm size, in production The education variable is also positive and significant. However, these farmers cannot be sent to school rather aggressive awareness campaigns and mass-mobilization through agricultural information programmes are needed. Agricultural shows, and competition could be organized to sensitize the farmers on improving their technical efficiency.

Table 3: Factors affecting technical efficiency of rice farmers in Niger State

Variables	Adopters	t-values	Non-Adopters	t-values
Farm Size (Z_1)	0.2543**	2.3076	0.2168**	2.2749
	(0.1102)		(0.0953)	
Education (Z_2)	0.1037*	1.6807	0.0946*	1.6597
	(0.0617)		(0.0570)	
Experience (Z_3)	0.1642	0.9574	0.1584	1.2260
	(0.1715)		(0.1292)	
Credit access (Z_4)	0.1380	1.2455	0.1295	1.1360
	(0.1108)		(0.1140)	
HH Size (Z_5)	-0.2117**	2.3444	-0.2236**	2.5124
	(0.0903)		(0.0890)	
Dis. to Inputs (Z_6)	-0.1816**	2.0359	-0.2681*	1.7353
	(0.0892)		(0.1545)	
Extension (Z_7)	0.306**	2.1272	0.0743	1.1207
	(0.1439)		(0.0663)	
Constant (K)	1.8457		1.6793	
R^2	0.7582		0.7134	
$\overline{R}^2$	0.7463		0.7057	
F	65.8486		93.1666	
N	150		270	

Source: Field Survey, 2003.
** significant at 5% * significant at 10%.

Out-migration of some farm household members into rural non-farm enterprises, trade or vocation will reduce the labour available for agricultural production from the household labour pool. However, the farmers are not aware of this and hired labour is expensive. They should therefore be enlightened / educated on the need for reduction in their labour input. They should be encouraged to send their children to school. This will drastically cut the use of child-labour for farm activities.

The results tend to indicate that reducing the distance to the source of improved inputs or making them available within reach of the farmers will increase their technical efficiency. For these resource – poor farmers, it is recommended that such inputs be channeled through farm input delivery on credit to be paid for at harvest. This will preclude the problem of credit or liquidity constraint among the farmers. Those without cash will come into the input markets to increase aggregate demand for them and by extension increase aggregate output of the crop.

Policy implications

There is the need for a more widespread adoption of the recommended practices as adopters are more technically efficient and less technically inefficient in rice production. If it is assumed that a 50% and above adoption rate is equivalent to full adoption, then only improved seeds (100%), planting date (96%), inorganic fertilizer (78%) and spacing (98%) can be said to have been fully adopted. The other practices have scores ranging between 0% (Green manure) and 45% (seed rate).In terms of the number of practices that, are assumed to be fully adopted with 50% score (4 out of 10), the performance rate becomes about 40%. This is considered to be sub-optimal. It tends to support the fact that both the rate of adoption and the rate of use of the adopted technologies are generally low in Nigeria (Ayoola, 1990; Uwatt, 1997). There is the policy need to provide incentives to the farmers so as to change their adoption behaviour. An aggressive and effective extension-service delivery system is needed

The results tend to suggest over-utilization of labour in rice production in the area. A policy to reduce this input may be difficult to implement. However, the rice farmers could be advised to expand their scale of operation. They are as of now small-scale producers. Increases in farm sizes may help spread the excess labour in production. Farm size expansion policy is supported by the positive significance of land in the estimated frontier model,

Intermediate inputs, seeds and items under miscellaneous costs should be made available at lower prices. By so doing, more of these inputs will be used and ceteris paribus output is expected to increase. This could lead to the achievement of the much desired rice self-sufficiency goal of the government.

For both adopters and non-adopters, farm size and education have significant impact on technical efficiency levels. Extension is significant at the 10% level for adopters but is insignificant for non-adopters. Both have positive signs. Increases in these variables will increase the technical efficiency of the farmers. Farm expansion measures in terms of cooperative farming arran-gements, aggressive adult education programme and improved extension services delivery system are recommended.

Household size (which can be a proxy for labour supply) and distance to source of inputs are both negative and significant at different levels. The implication is that increases in these factors will reduce technical efficiency. To mitigate this, the focus should be on the improvement of labour capa-city. The key inputs should also be made available or within reach of farmers by establishing input centres in the area. Again farm expansion in terms of cooperative organization is recommended mop-up the excess labour that may be available within the household so as to improve the technical efficiency

Reference

Adamassie, A. 1999. Sources of efficiency differentials in small holder agriculture. Quarterly Journal of International Agriculture, 38 1999) No. 3; 203-220.

Adeniyi J.P. 1998. On–farm research results in Nigeria rice cropping systems: A review of Nigeria farming systems research network workshop; Jos, Nigeria (eds) Abalu, G.O. and Kalu, B.A pp 129-134.

ADP 1975. Agricultural development projects (ADP) Report, Nigeria.

Ajibefun, I.A. and Daramola, A.G. 2000. Measurement and sources of technical inefficiency in poultry egg production in Ondo State, Nigeria. Journal of Rural Economics and Development, Vol. 13(2): 85-94.

Amaza, P.S. And Olayemi, J.K. 2000. Analysis of technical inefficiency in food crop production in Gombe State, Nigeria. Applied Economics Letters, 2002, 9; 51-54.

Balcet, J. and Candler, M. 1982. Farm technology adoption in northern Nigeria: Volume 1. Main Report. World Bank Research Project RPO, 1982 pp 671 – 88.

Battese, G.E. and Coelli, T.J. 1992. Frontier production functions, technical efficiency and panel data with application to paddy farmers in India. Journal of Productivity Analysis, 3: 153-169.

Battese, G.E. and Corra, G.S. 1977. Estimation of a production frontier model with application to the pastoral zone of eastern Australia. Australian Journal of Agricultural Economics, 21 : 169-179.

Battese, G.E. and Tessenia, G.A. 1993. Estimation of stochastic frontier production functions with time-varying parameters and technical efficiency using panel data from Indian villages. Agricultural Economics 9: 313-333.

Bravo-Ureta, B.E. and Pinheiro, A.E. 1993. Efficiency Analysis of developing country agriculture: A review of the frontier function literature. Agricultural and Resources Economics Review 22(1): 88 – 101.

Byerlee, D. and Polanco, E. 1986. Farmers' stepwise adoption of technological packages: Evidence from the Mexican Altiplans American Journal of Agricultural Economics, Vol. 68, No. 3: 521-527.

Chikwendu, D.O.; Ubi, E.O. and Onyibe, J.E. 1996. Adoption of improved technologies for millet production by farmers in Borno State of Nigeria. Samaru Journal of Agricultural Research; 13: 73-81.

Daramola, A.G. 1987. Quantitative Analysis of the adoption of improved food production. Technology in Oyo State, Nigeria. Unpublished PhD Thesis Department of Agricultural Economics, University of Ibadan, Nigeria.

Ekanayake, S.A.B. 1987. Location specificity, settle: type and productive efficiency : A study of the Mahawel, project in Sri Lanka" in the Journal of Development Studies, 23 (1987).

FACU 1992. Proceedings on the 4th Annual National Farming Systems Research and Extension Workshop Federal Agricultural Coordinating Unit (FACU) Reports, Ibadan.

Falusi, A.O. (1995. An overview of Nigeria's rural economy : problems, prospects and potential. Paper presented at NCEMA, August, 20-25, 1995, Ibadan.

FAO 1999. Improved Upland Rice Farming Systems (Ed) H.K. Parden, Rome.

FDA 1993. Federal Department of Agriculture: Food security and Nigeria agriculture: a national agenda. Federal Ministry of Agriculture, Water Resources and Rural Development, Abuja Nigeria.

FDA 1995. Federal Department of Agriculture; Federal Ministry of Agriculture Reports, Abuja, Nigeria.

FOS 1997. Federal Office of Statistics (FOS): Annual abstracts of statistics Abuja, Nigeria.

FOS 1999. Federal Office of Statistics: Annual Abstracts of Statistics (FOS) Abuja, Nigeria.

Iwueke, C.C. 1991. Appraisal of yam mini-set technique by farmers in south-eastern state agricultural technologies for resource-poor farmers. (Eds) Olukosi, J.O. Ogundipe, A.O. and Kalu, B.A. Nigerian National Farming Systems Research Network. SamOla Commercial press, Zaria, Nigeria. Pp 247-253.

Kalirajan, K.P. and Shand, R.T. 1989. A generalized measure of technical efficiency. Applied Economics, 21: 25-34.

Kalivrajan, K. 1991. "The importance of efficient use in the adoption of technology: A panel data analysis. Journal of Productivity Analysis 2(2): 113-126.

Nasko, G. 1989 Food self-sufficiency in Nigeria: A review of Federal Government Programme: Federal Civil Service forum, N.I.I. Victoria Island, Lagos.

NCRI 1984. Steps to grow lowland rice. Agricultural Extension and Research Liaisons Services', National Cereal Research Institute (NCRI), Badeggi, Nigeria.

NCRI 1997. Rice production in Nigeria: Problems and prospects. National Cereals Research Institute (NCRI) Report, 1997, Badeggi, Nigeria.

Njoku, J.F. 1991. Determinants of adoption of improved oil palm production technologies in Imo State Nigeria: Research report No. 10, African Rural Social Scientist Network, Winrock International, U.S.A.

Olayemi, J.K. 1997. The Nigerian rice industry; performance, problems and prospects. A Research Report Food and Agriculture Organization F.A.O. December, 1997.

Olomola, A.S. 1998. Choice and productivity effects of animal traction technology in the semi-arid zone of Northern Nigeria. Research

Monograph No 12. Winrock International. October, 1998.

Onyenwaku, O.E. and Mbuba, A.C. 1991. The adoption of seed yam mini-set multiplication technologies by farmers in Anambra State, Nigeria. Nigerian Journal of Agricultural Extension, 61:26-33.

Parikha, A and Shah, K. 1994. Measurement of technology efficiency in the north- western frontier province of Pakistan. Journal of Agricultural Economics, 45(1): 132 – 138.

Polson, R.A. and Spencer, D.S.C 1991. Technology adoption process in subsistence agriculture: The case of cassava in south-western Nigeria. Agricultural Systems, 36 :65-78.

Ray, S.C. 1988 Measu.ement and test of efficiency of farms in linear programming models: a study of west Bengal farms. Oxford Bulletin of Economics and Statistics, 47(4): 371-386.

Rougoor C.W.; Trip, G; Huirne. R.B.M. and Renkema, J.A. 1998. How to define and study farmers management capacity: Theory and use in Agricultural Economics. Agricultural Economics, 18:261-272.

Shultz, T.W 1975. The value of the ability to deal with disequilibria. Journal of Economic Literature, 13 :827-846.

Squires, D. and Tabor, S. 1991. Technical efficiency and future production gains in Indonesian agriculture in Developing Economics, 24(3): 258 – 270.

Tadesse, B. and Krishnamoorthy S. 1997. Technical efficiency in paddy farms of Tamil Nadu An analysis based on farm size and ecological zone. Agricultural Economics, 16: 185-192.

UNCTAD 1995. Agricultural and Trade Commodity Year Book.

WARDA 1993. Rice Trends of sub-saharan Africa: A synthesis of statistics on rice production, trade and consumption. West African Rice Development Association Abidjan, Cote D'Ivoire.