

Full Length Research Paper

Economics of wetland rice production technology in the Guinea Savannah of Nigeria

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This study examined the costs and returns and the technical efficiency of wetland rice production technology in Niger State of Nigeria. The study measured the rate of compliance with the recommended package and the technical efficiency of the production technology. Primary data were collected from 50 sampled farming households in Niger State using structured interview schedules. Descriptive and inferential statistics was used to analyze the data. A double log production function was also employed to analyze the data using the maximum likelihood estimation (MLE) procedure to derive the stochastic frontier production function. A typical farming household using the production technology had an average farm size of 1.35 ha. Rice was grown sole. The farming households complied with the technology at 47% level with a yield gap of 69% and a positive gross margin. The study revealed the presence of increasing returns to scale for the production technology. The estimated parameters of labour, fertilizer, farm size and level of compliance had the expected positive signs. The coefficients of labour and fertilizer were significant ($p < 0.05$). The study further revealed a mean output-oriented technical efficiency of 0.75. The optimal usage of the technology is however not yet attained. While the present level of compliance with recommended production package afford the farming households positive gross margin, they are yet to attain their potential yields. To move closer to this potential, the present production technology needs to be reevaluated for improvement and better efficiency. There is also dire need for modifications that fulfill the low-cost input desires of the small scale farming households.

Key words: Wetland, production technology, technology compliance, yield gap.

INTRODUCTION

World rice production in 2004 was less than 610 million tones. Asian farmers produced about 90% of the total rice, with two countries, China and India, growing more than half the total crop (Rice around the World, 2008). Rice Scientists divide rice into two main groups, tropical indica and temperate japonica. Within each type are varieties that are grown under different environmental conditions. Scientists divide rice into two main groups, tropical indica and temperate japonica. Within each group are varieties that are grown under different environmental conditions. The most basic distinction with respect to rice cultivation is between wet- and dry-rice varieties. Wet-rice is most commonly grown in Nigeria, frequently in paddy

fields where rice is cultivated on irrigated or flooded land. Dry varieties are typically grown on uplands.

The demand for rice in Nigeria is growing faster than for any other major staple food with consumption broadening across all socio-economic classes including the poor. Rice is one of the most widely and commonly consumed staples. On the average, Nigerian consumes 24.8 kg of rice per year, representing 9% of total caloric intake (Wudiri and Fatoba, 1991). Substitution of rice for coarse grains and traditional roots and tubers has fuelled growth in demand at an annual rate of 5% between 1961 and 1992 (Osiname, 2001).

Estimates indicate that Nigeria rice imports represent more than 25% of agricultural imports and over 40% of domestic consumption (Federal Office of Statistics 1998). Nigeria has thus become a major rice importer in the world market and second only to Indonesia between 2000 and 2005.

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To solve some of the problems facing the 70% of Nigerians involved in the agricultural sector that are mostly crop producers, Research Institutes in Nigeria are mandated to generate and disseminate high-productivity technologies that are consistent with sustainable natural resource management (Idachaba, 1998). While some progress could be said to have been made by Agricultural Research Institutes, their overall impact on production has been limited due to many factors (Okali et al., 1994; Hildebrand and Russell, 1998; Zeller, 1998). Dalton (1996) submits that the income level of the farmer plays a major role in their choice and number of technology components complied with. Compliance by users of technologies presupposes that such technologies are not only adaptable but affordable. The salient questions to which answers were sought in this study are: how far are the farming households complying with the recommendations of wetland rice production technology, what is the level of the farmers' efficiency in rice production?

This study specifically measured the level of compliance of farming households with wetland rice production technology; determined the costs and returns, measured the technical efficiency of wetland rice production technology and offered useful suggestions based on the findings of the study.

MATERIALS AND METHODS

This study was conducted in the Zone 1 of Niger State Agricultural Development Project (ADP) which is located between 8°11' and 11°20'N of the equator and between 4°30' and 7°11' E of the equator. The mean annual rainfall ranges between 800 - 1000 mm with average rainy days of about 6 months. The rains start in late April and ends in July. The dry season lasts for about six months of the year from November to April. The average minimum temperature is about 26°C while the average maximum temperature is about 36°C. The zone is in the Guinea savannah vegetation belt and is traversed by the Niger and Wuya Rivers (Federal Ministry of Agriculture and Rural Development FMARD, 2004). This ecology supports the cultivation of root crops and grains amongst which rice is predominant (NCRI, 1998, 2002). The zone accounts for 69% of rice produced in the state, 72% of which is produced in the wetland ecology.

The study used both primary and secondary data. Cross-sectional data from 50 farming household heads were collected with the aid of interview schedules administered by trained enumerators. The target population for the study is the small scale farming households. A three stage sampling technique was used to select the sample for the study. Stage one involved the selection of ADP zone 1 which is the largest producer of rice in the state. Ten villages were thereafter selected from the existing village listings of the ADP and 50 farming households were randomly selected from the villages.

A combination of analytical tools was utilized to achieve the stated objectives. The farm budget analysis was employed to determine the costs and returns to the technology. The procedures followed were:

$$TR - TVC = GM. \dots\dots\dots (1)$$

Where TR = Total Revenue, TVC = Total Variable Cost and GM = Gross Margin.

The total value of output for the technology was compared with the expected standards as stipulated by National Cereals Research Institute.

The Stochastic production frontier model was used to measure technical efficiency, and inefficiency of resources. The production frontier model derived from the composed error model of Aigner, Lovell and Schmidt (1977), and used by Rahji, 2005 was adopted for this study. The frontier production model with a multiplicative disturbance term was used in this study.

$$Y = F (X_{ai} \beta) eE. \dots\dots\dots(2)$$

Where, Y = output of potatoes in kilogram
 X_a = is a vector of input quantities; B = is a vector of parameter and E = is a stochastic disturbance term consisting of two independent element u and v where

$$E = U + V$$

The symmetric component, V, accounts for random variation in output due to factors outside the farmer's control such as weather and diseases. It is assumed to be normally, independently and identically distributed as $N \sim (0, \sigma^2_v)$. A one-sided component ≤ 0 reflect technical inefficiency relative to the stochastic frontier. Thus, $U = 0$ for a farm output which lies on the frontier and $U < 0$ for output which is below the frontier hence, the distribution of U is half normal. Rice production in the study area is assumed to be specified by Cobb Douglass frontier production function defined as

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + V_i - U_i \dots\dots\dots (3)$$

Where, Q = Quantity of wetland rice output in (kg), X_1 = fertilizer in (kg), X_2 = farm size in (ha), X_3 = labour in (man-day), X_4 = use of improved seed which is a dummy variable: adopted = 1; 0 otherwise). $\beta_1, \beta_2, \beta_3, \beta_4$ = are coefficients of the various inputs with respect to output level. V_i = random error due to mis-specification of the model and variation in output due to exogenous factors outside the farmers control.

U_i = inefficiency component of the error term.

The inefficiency model is represented by U and is defined by

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 \dots\dots\dots (4)$$

Z_1 = Age of farmers (years)
 Z_2 = Education (a dummy: up to 6 years of formal education = 1, otherwise = 0)
 Z_3 = Compliance with technology recommendation. The level of compliance by the user of a technology is the degree at which the user is correctly using all the recommendations included in the technology package. Wetland production technology is made up of nine components. If a component is used always a weight of three is allocated to the user, if used sometimes a weight of two is allocated if not used at all, the farmer has zero allocation. These allocated scores are then summed up for each of the respondents and is divided by the weighted score of what it should be if all the components are used always. This is measured in percentage.

RESULTS AND DISCUSSION

The mean age of the household head in the study area is 49.9 years with an average of 18 years of farming experience. The average household size is 20 members per household. Only 8% of the farming households using wetland rice technology borrowed or leased their farm land. The study revealed that 84% of the farming households inherited their farm land. This pattern

Table 1. Analysis of component specific compliance.

Technology components	Compliance index
Use of High yielding varieties (HYV)	80.7
Spacing (inter-intra row)	43.3
Seed rate	52.7
Land preparation	43.3
Fertilizer rate	40.0
Fertilizer application method	44.0
Number of times of Fertilizer application	40.7
Manual weed control	50.0
Bird scaring	16.0
Goat scaring	0
Manual threshing /winnowing	80.0
Mechanical threshing/winnowing	0
Time of harvest	72.74
Mean compliance index	47.20
Yield Gap	69.0%

Source: Field Survey.

Table 2. Farm Budget Analysis.

Mean Value of output(Naira)	152,576
Mean farm size (ha)	1.35
Means Variable costs(Naira)	98,537
Output/input value	1.6
Gross margin(Naira)	54,039.4
Gross margin/ha(Naira)	40,029.2
Expected gross margin/ha*	300,000
Return to capital	1.98

Source: Field Survey * Expected gross margin is derived from the NCRI on station trial.

indicates that farming household heads have property rights over their land and may therefore not be reluctant to accept new technologies. The ownership of wetland is of importance in the study area since wetland is scarcer than other ecologies. The average farm size is 1.35 ha with over 72% of the respondents having their farm sizes below 2 ha, indicating the small nature of farming activities in wetland ecology (Olayide and Heady, 1982; Sanginga et al., 2002).

The study revealed that about 47.0% of farm operations were carried out by family labour while the rest (53.0%) were carried out using hired labour. This suggests a relatively high demand for labour using hoe-cutlass technology.

Using a compliance index on a scale of 100, the level of compliance with the nine components of wetland rice technology is summarized in Table 1.

The study revealed that the compliance scores are high for high yielding varieties used by the farmers (80.7), Bird scaring (69.0), manual threshing (80.0) time of harvest

(72.0), seed rate (52.7) and weed control (50.0) The low scores recorded for fertilizer rate (40%), land preparation (43) and spacing may account for the high yield gap (69%) recorded for wetland rice production in the area. Fertilizer has been known to account for more than 50.5% reduction in yield when not applied (Fagade, 1976). The zero score for mechanical threshing indicates the non availability of mechanical threshers to the farming households. Since farmers are located far from the villages or towns where goats are reared, there may be no need for goats scaring as observed in the study area. Almost all the farming household planted rice as sole crop in the study area and this is one of the recommendations required for the realization of the full potential of wetland rice production technology. The study further reveals that on the average, labour cost alone constitutes about 56.0%, capital costs constitute about 20% while other operating costs is 24% of the total cost of using this technology. This scenario clearly indicates that wetland rice production technology is labour intensive.

Table 3. Estimates of the Stochastic and Efficiency / Inefficiency.

Variables	Parameter	Standard error
Fertilizer (X_1)	0.1998** (4.9630)	0.0402
Farm Size (X_2)	0.3681 (0.8560)	0.3681
Labour (X_3)	-0.5380 (1.0452)	0.5147
Seed (X_4)	0.5006** (4.7030)	0.1064
Constant (K)	6.2026** (16.5776)	0.3472
Inefficiency model		
Age (d_1)	0.2503 (0.0242)	10.3430
Education (d_2)	-0.1875 (1.1809)	0.1576
Compliance (d_3)	0.3400** (4.3207)	0.0787
Constant (d_0)	-27.2721** (3.7995)	7.1778

Table 4. Estimates of the Stochastic and Efficiency/Inefficiency.

Variables	Statistics
σ^2	5.7755** (3.4174)
Loglikelihood (H_1)	-40.2941
Loglikelihood (H_0)	-166.1652
Mean Efficiency	0.7542

Figures in parenthesis are t-values
**significant ($p < 0.05$).

1 USD is equivalent to N120

These findings agree with those of Falusi (1995) and Idachaba (1995) that labour is the most important factor in Nigerian agriculture. The gross margin analysis shows that the use of the technology resulted in a gross margin of N40 029.20 ha⁻¹ with output/input value of 1.6. This is an indication of positive return on unit of capital employed (Table 2).

Table 3 is a summary of the likelihood parameters of the stochastic production frontier for the production technology in the study area. The variance parameter represented by sigma-squared (σ^2) is significant ($p < 0.05$) and positive. This indicates the goodness of fit and correctness of the specified distributional assumptions of the composite error term. The magnitude of the variance ratio is also estimated to be high at 0.99 suggesting that the systematic influences that are unexplained by the production function are the dominant sources of errors.

The estimated equation is:

$$\ln Q = 6.20 + 0.1998 \ln X_1 + 0.3151 \ln X_2 - 0.5380 \ln X_3 + 0.5006 \ln X_4$$

Diagnostic statistics

This means that about 99% of the variation in output may be explained by differences in technical efficiency (Table 4). In addition, the parameter coefficients of fertilizer (X_1) and improved seed (X_4) are significant at $p < 0.05$ level, confirming the influence of these inputs on farm output variation (Fagade and Nguyen, 2001; NCRI 2002). This tends to suggest that improved seeds and fertilizer usage are significant in explaining rice output variability when wetland production technology is adopted. The stochastic frontier indicates that output elasticity of fertilizer and improved seed are 0.1998 and 0.5006 respectively. The scale elasticity of 0.4675 however indicates a decreasing return to scale and indicates that the farmers using this technology are operating in the stage two of production space.

The coefficients of age and compliance have positive signs in the inefficiency model. While only that of compliance is significant at 5% level. By implication increasing the level of compliance have the tendency to reduce inefficiency. The insignificant coefficients in the model are however retained. The parameter (gamma) is estimated to be 0.998. This confirms that the technical inefficiency effects are significant in the estimated model. It also implies that the traditional production function with no technical inefficiency effects is not an adequate representation of the data.

The mean technical efficiency for the sample of rice farming households using wetland production technology is 0.7542. The mean technical inefficiency is thus 0.2458, (about 25%). The average technical inefficiency index of about 0.25 implies that rice production is at 75% of its potential. This suggests a potential to increase production by 25% given the available wetland production technology.

The intensive use of labour by the farming households implies a conflict in the demand for labour for farming and other activities in the area. Under sole cropping which is prevalent in the study area, the conditions for the use of? The technology is favorable. There is likelihood that farmers will continue to use the technology. The farming households' positive gross margins suggest that the use of technology meets the farming households' objective of increased income. There is however the need to re-evaluate and modify the wetland rice production technology as presently constituted for better efficiency. There is a dire need for modifications that fulfill the low - labour and cost input desires for the Nigerian farming systems and other developing countries experiencing similar situation. There is also a need for policy to address the

issue of non-availability of fertilizer at the right time and at affordable prices to local farmers. This has been a major problem confronting the rural farmers in the country. Addressing this issue has the tendency of increasing the level of compliance of rice farmers to NERICA recommended technology which has the probability of reducing the NERICA yield gap in the country. Programmes that will educate the farmers on the need to comply with the components of NERICA technology such as seed rate, spacing, mechanical threshing/winnowing and empowering such farmers may also be of policy relevance.

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