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Productivity Differentials in Rice Production Systems: Evidence from Rice Farmers in Five Agroecological Zones in Nigeria

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Abstract

Rice has increasingly become a major staple food for generality of Nigerians-urban and rural alike. Arising from the supply-demand gap in the Nigeria rice food subsector, local rice production is increasingly being promoted in the country to reduce the dependence on imports, ensure stable and sustainable low-prices, improve rice self-sufficiency and create employment. This paper therefore examines the different rice production systems across five different agroecological zones in Nigeria with a view to evolving most economical strategies to improving rice productivity in Nigeria. Data were collected from a representative sample of 149 rice farmers across five different agroecological zones in Nigeria. Representative farms operating within five production systems (upland; lowland; irrigated; upland and lowland; upland, lowland and irrigated) were employed for the analysis. Data were analysed using crop budget analysis (cost structures, net returns) and a double log production function model. The results of the analysis revealed that irrigation system and a combination of rainfed upland, lowland and irrigated system offered the best net returns in rice production. Rice yield in Nigeria was positively influenced by the quantities of fertilizer (β=0.329), agrochemical (β=0.416) and being a female rice farmer (β=0.532) but negatively influenced by the years of education (β=0.388), the quantities of seed (β=1.49) and labour use (β=0.918). It was recommended that policy efforts to boost rice yield must aim at reducing associated cost of fertilizer procurement and reducing cost of labour by encouraging mechanization of rice production in Nigeria.

Keywords: Rice; Production systems; Agroecological zones; Net returns; Nigeria

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Introduction

Rice has increasingly become a major staple food for generality of Nigerians-urban and rural households alike. With this high consumption has come an increasing need for importation resulting largely from the disequilibrium between local rice production and local demand. Arising from this, local rice production is gradually more being promoted in the country to reduce the dependence on imports, ensure stable and sustainable low-prices, improve rice self- sufficiency and create employment. This paper therefore examines the different rice production systems across five different agroecological zones in Nigeria with a view to evolving most economical strategies to improving rice productivity in Nigeria.

Rice was ranked 7th in Nigeria in 2013 in terms of volume of production compared to some other food commodities **(Figure 1)**. It is however, ranked highest in Nigeria in terms of value of importation compared to other major food commodities as shown in **Figure 2** [1]. This unhealthy situation has increased government's resolve to create the necessary enabling structures to improve rice production, reduce importation and ensure rice self-sufficiency. This was particularly highlighted in the current agricultural promotion policy (APP) dubbed "Green Alternative" of the current administration in Nigeria. While previous policies have failed to yield the needed results due largely to several inherent factors such as poor policy implementation strategies, corruption and a host of other issues which are beyond the purview of this paper, the current agricultural policy is intended to learn from past mistakes while leveraging on the renewed commitment to diversify the economy of Nigeria from largely oil dependent to agriculture and other related sectors.

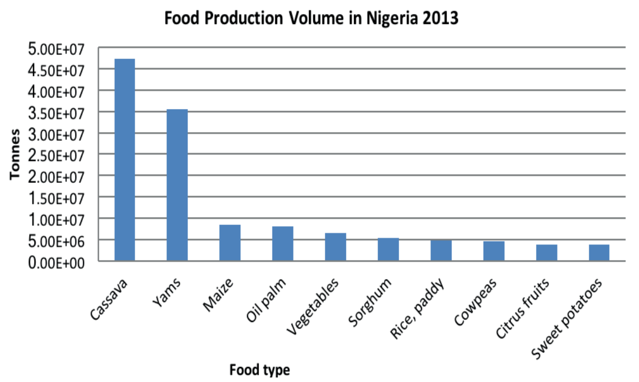

Figure 1 Food production volume in Nigeria, 2013. *Source: FAOSTAT (2017).*

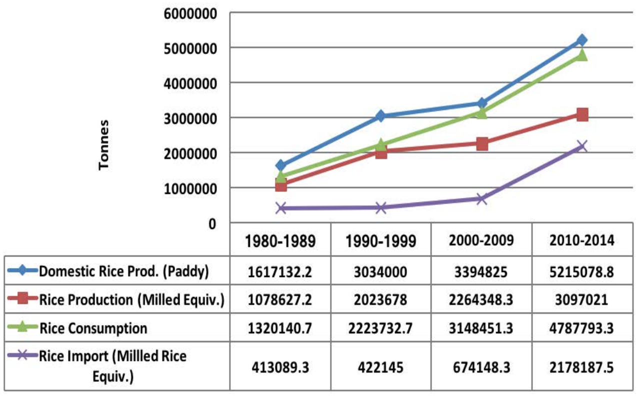

Figure 2 Nigeria rice productions, consumption and import trend, 1980-2014. *Source: FAOSTAT (2016).*

The gap created by the disequilibrium between domestic rice production and consumption in Nigeria has been met by importation. For example, rice importation surged by over 79% between 1980 and 2013 from a quantity of 450000 MT to about 2.2 million MT [1]. The result of this was the enormous increase in foreign exchange expended on rice importation in Nigeria. **Figure 2** shows Nigeria rice importation expenditure in US$. The amount expended on rice importation averaged US$ 300 million between the year 2000 and 2006. Between 2006 and 2008, rice importation expenditure increased from US$ 300 million to US$ 800 million, an increase of about 37.5% [2]. This trend has continued over the years. In order to stem this ugly tide in the face of dwindling foreign reserve in the country, government has been putting together plans to ensure that there is increased productivity in rice through improving yield and increasing land acreage put into rice production. One of such plans has been the increase in the number of improve rice varieties available to farmers. Others include subsidizing inputs to farmers particularly fertilizer and improving postharvest processing facilities for rice paddy in the country.

Comparison of Nigeria's rice production and import to other West African Countries

Whilst there has been improvement in rice production in Nigeria compared to other West African countries, rice importation nonetheless, has also been skyrocketing **(Table 1)**. The reasons for this are not far-fetched. Population has grown steadily and with increasing urbanization, demand has also been very high with no commensurate increase in local production. This has made Nigeria an attractive market compared to the other countries within the West African sub-region. Apart from the official reported figures of rice importation into Nigeria, there have also been reported cases of cross-border smuggling of rice into the country [3,4]. These have all combined to render the rice industry in Nigeria uncompetitive with local rice farmers facing stiff challenges with little or no incentive to upgrade and improve competitiveness of their rice farming enterprise.

One of the major strategies currently advocated at improving the rice industry in Nigeria has been on improving average rice yield per hectare. In order to achieve this goal however, there is need to understand the economies of the different rice production systems currently being put into practice by rice farmers in Nigeria including the current adaptive strategies within the rice production systems (for example, combination of different rice production systems among rice farming households).

Rice production systems in Nigeria

The quality and quantity of locally produced rice in Nigeria varies according to the system within which it is grown. Although, it is widely understood that in Nigeria, average paddy quantities produced are generally low and with the quality of processed rice being very poor. Five rice growing systems are identifiable in Nigeria [5]. These include Rainfed upland, Rainfed lowland, Irrigated lowland, Deepwater and Mangrove swamp production systems **(Table 2)**. These production systems can be found in all identified agroecological zones in Nigeria. Field evidence has revealed that farmers may also combine one or more of the production systems within their rice production enterprise. For example, due to land fragmentation and the quest to improve available acreage put into rice cultivation, farmers may be able to annex a combination of rainfed upland and lowland collectively or a combination of rainfed upland, lowland and irrigated systems for their rice production in different farmlands. For our study, some farmers had farmlands of different sizes put into two or more of the production systems (rainfed upland and lowland or rainfed upland, lowland and irrigated). This may result in increasing paddy yield per hectare depending on some other underlying farm management attributes such as optimal use of fertilizer, type of seeds used on the production system, seed planting technology employed (direct seeding or transplanting) amongst others. We have therefore sought to understand the economics of these rice production strategies in this study in order to fill the inherent knowledge gap.

Materials and Methods

Data used for this study were basically cross-sectional. Data were collected using pretested survey questionnaire administered to representative rice farmers in five states (Kebbi, Kaduna, Niger, Nasarawa and Ebonyi) representing five agroecological zones in Nigeria during the 2016 postharvest season. Selection of representative rice farmers was done by random sampling from lowland, upland, irrigated and a

Table 1 Comparison between Nigeria and Some West African Countries' rice production and imports (mean values, 1980-2014).

Country	Indicators	Mean (1980 – 1989) tonnes	Mean (1990 – 1999) tonnes	Mean (2000 – 2009) tonnes	Mean (2009 – 2014) Tonnes
Nigeria	Production	16,17,132.20	30,34,000	33,94,825	52,15,078.80
	Import Quantity	4,13,089.30	4,22,145	6,74,148.30	21,78,187.50
Benin	Production	8,241.90	19,122.40	73,165.20	2,00,466.60
	Import Quantity	38,096	1,71,406.10	3,81,729	8,78,707
The Gambia	Production	28,791	19,433.20	31,790.20	64,324.60
	Import Quantity	42,930.10	63,364.20	89,296.60	93,631
Ghana	Production	71,500	1,70,089	2,69,961.30	5,22,047.20
	Import Quantity	53,351.70	1,23,380.30	4,49,272	4,77,058.30
Guinea	Production	5,87,792	9,06,117.50	12,62,205.60	18,22,392.40
	Import Quantity	1,03,806.80	2,17,252.70	2,48,294.60	2,79,739.80
Côte d'Ivoire	Production	5,09,100	6,54,767.80	6,63,810.60	15,25,749.60
	Import Quantity	3,42,019.30	3,79,268.80	7,64,906.30	11,66,490.30
Source: Computed from FAOSTAT (2016)					

Table 2 Rice production systems in Nigeria and their locations.

Production System	Major States Covered	Estimated Share of National Rice- Farmed Area	Share of Total Domestic Production	Average Yield/Ha	Potential Yield/Ha
Rainfed (Upland)	Ogun, Ondo, Abuja, Osun, Ekiti, Oyo, Edo, Delta, Niger, Kogi, Sokoto, Kebbi, Kaduna, FCT and Benue	30%	17%	1.7MT	3.5MT
Rainfed (Lowland- “Fadama”)	Adamawa, Ebonyi, Kwara, Ondo, Ekiti, Edo, Delta, Rivers, Bayelsa, Cross River, Akwa Ibom, Lagos and all major river valleys	47%	53%	2.2MT	5MT
Irrigated	Adamawa, Niger, Sokoto, Kebbi, Borno, Benue, Kogi, Anambra, Enugu, Ebonyi, Cross River, Kano, Lagos, Kwara, Akwa Ibom, Ogun	17%	27%	3.5MT	6-7MT
Deep Water	Flooded areas: Rima Valley in Kebbi State and deep flooded areas of Delta State	5%	3%	1.3MT	2.5MT
Mangrove Swamp	Ondo, Delta, Edo, Rivers, Bayelsa, Cross River, Akwa Ibom	1%	1%	2.0MT	4MT
Source: Ezedinma (2005) and Potential Yield from Grant et al. (2009)					

combination of one or more of the other rice farmers employing the other systems within the study areas. Data for the study were collected on socio-economic characteristics such as age, marital status, gender, household size and composition, farming experience, level of education, access to credit and so on. The input-output data such as the quantity and cost of rice production across the production systems were collected from farmers employing five rice production systems – rainfed upland, rainfed lowland, irrigated, rainfed upland and lowland, rainfed upland, lowland and irrigated. In all, a total of 150 rice farmers were administered the questionnaire and 149 respondents were valid for data analysis. The valuation of the inputs used for the analysis is described subsequently.

The use of tractor during land preparation was contracted. And, for this study, the variable input costs for traction service therefore reflects the service charge paid by the rice farmers. Seed prices were the average farmer reported seed cost including transportation cost. The study therefore used this as a representation of the actual cash outlay in terms of purchase or an opportunity cost in case own seeds used by the farmer which were saved from last year's harvest. Fertilizers (NPK and Urea) were valued at their actual market prices plus transportation cost incurred. For the non-paid labour (mainly family labour), we assumed an opportunity cost equal to the average wage rate prevalent in the study area, while for financial outlay, we compiled the reported interest rates paid as reported by the farmers following the research data [6]. This, we believe, also provides a realistic approximation of opportunity cost in case of farmers who used own funds. The other fixed costs include regular tax payment (to officials of local government or State government) and depreciation of the implement or machinery used. Contracted implements or machineries were included in service charges.

We employed the following template for our budget analysis:

Paddy revenue=Paddy quantity × Paddy price

Variable input cost=Fertilizer + Agrochemical + Seed + Fuel + Traction service

Total operating cost=Variable input cost + Paid labour cost

Total production cost=Total operating cost + Non-paid labour cost (imputed) + Fixed cost

Operating ratio=Total operating cost/Gross paddy revenue

Average Production costs=Total production cost/paddy yield

Gross margin=(Paddy revenue – Average production cost)/ processing cost

Percentage gross margin=Gross margin/Total production cost

Average costs were used for our analysis and all calculations were done on a per hectare basis. Net returns were calculated for each production systems by deducting the total costs of production from the total revenue for paddy rice. Crop budgets were prepared to establish the different cost structures for each system. Total revenue was estimated by multiplying the weighted average price of a kg of rice paddy by the quantity harvested per hectare. Total costs of production included the costs of inputs and transportation (variable costs) and imputed cost of labour and imputed fixed costs.

For our analysis, it is worthy of note to state that, we worked on the assumption that paddy is arguably primarily produced for the market. All paddy produced by the farmers were therefore valued at their sale value (market value). This presupposes that the market value is believed to adequately reflect the opportunity cost of paddy produced but not marketed (that is, paddy used for either home consumption or other purposes such as gifts or seed for the next planting season). More so, the data used are average values and may therefore masked significant variations that seem to be evidenced in the different rice production systems employed by farmers in all the agroecological zones. Nonetheless, the results provide useful information to guide policy towards improving rice productivity and achieving the goal of rice self-sufficiency.

The ordinary least square (OLS) regression technique was employed to estimate the factors influencing rice yields in various rice production systems. The general form of the OLS production function fitted for the analysis was of the type following some research which were already conducted [7,8]:

$$Q=A\, x_1^{\alpha}\, x_2^{\beta} \text{--------} X_m^{\eta}$$

Where:

Q=Output measured in kg of paddy

A=Constant parameter of production efficiency

X=Explanatory variables

α, β, ..., η are parameters that represent the output elasticity and $\alpha + \beta + \ldots\ldots+n=1$ and

$0< \alpha, \beta, \ldots\ldots\eta<1$

The exponential functional form was transformed into linear equation by taking the natural logarithm of the equation. The following factors were included in the regression: quantity of seed, fertilizer, agrochemicals and hired labour, age of rice farmer, gender of rice farmer, years of rice farming experience etc.

The empirical model employed is specified thus:

$$LnY=\beta_0 + \beta_1 Ln_{AGE} + \beta_2 Ln_{SEX} + \beta_3 Ln_{EDUYRS} + \beta_4 Ln_{SEED} + \beta_5 Ln_{FERT} + \beta_6 Ln_{LAB} + \beta_7 LnX_{CAL} + \beta_8 Ln_{FARMSIZE} + \beta_9 Ln_{HHSIZE} + U$$

Where:

Ln=Natural logarithm

Y=Output of paddy rice (Tonnes per hectare)

AGE=Age of rice farm owner

SEX=Sex of rice farm owner (SEX=1, if male and SEX=0, if female)

EDUYRS=Rice farmer education level in terms of physical years in school

SEED=Quantity of seed used (kg per hectare)

FERT=Quantity of fertilizer used (kg per hectare) LAB

LnLAB=Hired labour input (man-days per hectare)

XCAL=Quantity of agrochemical used (litres per hectare)

FARMSIZE=Size of the rice farmland (hectare)

HHSIZE=Household Size of the rice farm owner

Results and Discussion

Rice production characteristics at farm level across production systems

The distribution of rice production and yield across rice production systems in Nigeria corroborates previous studies and followed a priori expectation except that there was no evidence of the presence of farmers employing deep water and mangrove production systems. The predominant rice production system in Nigeria from our study was rainfed lowland and this was reported by 52% of the sampled farmers concentrated in Niger (Southern Guinea Savannah), Ebonyi (Humid Forest) and Nasarawa (Derived Savannah) States. Interestingly, some rice farmers reportedly employ a combination of one or more of the other major rice production systems. Irrespective of the type and combination of rice production systems employed by rice farmers, the percentage breakdown of rice production costs in Nigeria is shown in **Figure 3.** The figure shows that labour cost constitutes more than half of the total production costs (50.4%) per hectare, in some studies it was revealed that this may be up to approximately 40% [9]. The other major production costs associated with rice production irrespective of the production systems employed include fertilizer costs (NPK, urea and manure) – 23.2%, seed cost – 9.9% and agrochemical costs (herbicides and pesticides) – 5.1%.

Table 3 reveals that, as expected for the major rice production

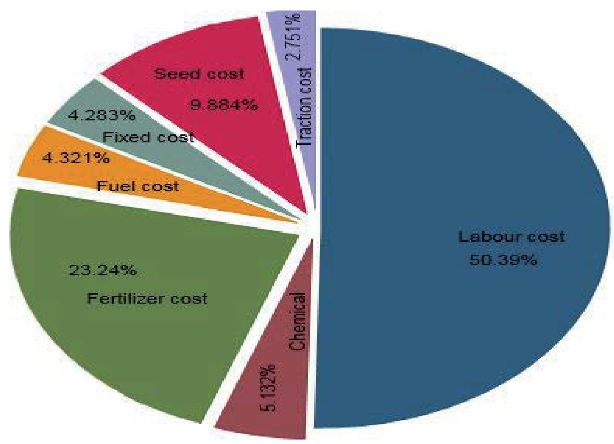

Figure 3 Breakdown of rice production cost in Nigeria. *Source: Field Survey (2016).*

systems, average yields was highest for irrigated fields (average of about 3.7 tonnes per ha) compared to those of rainfed lowland (average of about 3.5 tonnes per ha) and rainfed upland (average of 3.3 tonnes per ha). The difference in average yields of rainfed upland and lowland systems were marginal. Though, for this study, average yield was highest (3.7 tonnes per ha) amongst production systems, which is in line with some of the research data, this is still below potential yield of the system (6-7 tonnes per ha) as argued [5,10]. Furthermore, for farmers that had a combination of one or more of the other major rice production systems, average yields were higher. For example, a combination of rainfed upland, lowland and irrigated had average yields of about 5 tonnes per ha while farmers who combined rainfed upland and lowland had average yields of just over 3.5 tonnes per ha. While these results follow expectations from available literature, however, it also indicates improvement from results in the last one decade. Studies reported lower aggregate yields across the major rice production systems in the past [5,6,11]. However, recent study reported an average yield of about 3.2 tonnes per hectare [9].

Profitability indicators for rice production systems in Nigeria

We observe that rice production is profitable across all the identified production systems in Nigeria. Profitability indicators as shown in **Table 4** show that all production systems were profitable at market prices with some systems more profitable than the others.

Rainfed upland system: The average farm size recorded for rainfed upland system was 2.3ha. Farmers employing rainfed upland rice production systems had the least paddy yield (3.31 tonnes per ha) and revenue per hectare (N407027.74) compared with other production systems in Nigeria. Other studies however

Table 3 Rice production characteristics at farm level across rice production systems.

Variables	Rainfed Upland	Rainfed Lowland	Irrigated	Rainfed upland and lowland	Rainfed upland, lowland and irrigated	Overall	Difference test
Total Rice Production (MT paddy)	7.61	5.56	4.74	10.78	13.15	6.85	382.1***
Average Rice Area (ha)	2.3	1.6	1.3	3.05	2.55	1.94	108.8**
Average Rice Yield (MT paddy/ha)	3.31	3.48	3.65	3.53	5.16	3.5	
Source: Computed from Field Data, 2016; Difference test: ***Significant at 1%; **Significant at 5%							

Table 4 Profitability indicators for different rice production systems in Nigeria.

Farm Budget in Selected Fields at Private Prices (N/ha unless indicated otherwise) per Cropping Season						
Variables		**Rainfed upland**	**Rainfed lowland**	**Irrigated**	**Rainfed upland and lowland**	**Rainfed upland, lowland and irrigated**
Paddy Revenue		407027.74	408104.62	407816.67	514019.17	576790.36
Fertilizer	NPK	18640.8	12991.22	17311.11	10109.09	15495.36
	Urea	16249.66	13116.12	11544.44	12743.94	14899.17
	Agrochemicals	4902.28	6335.44	3768.89	6473.64	2322.4
	Seed	7685.74	12805.73	4950	12114.31	5663.85
	Fuel	6394.23	222.08	6794.39	218.18	6368.61
	Traction service	1923.08	7148.05	-	15111.37	6195.11
Variable input costs		55795.79	52618.64	44368.83	56770.53	50944.5
Hired labour	Land Preparation	9060.98	15790.18	3721.11	13453.03	4825.35
	Crop care*	20882.14	26706.66	7511.12	22919.7	16889.44
	Harvesting	13432.44	21741.28	4808.89	16675.5	9757.87
	Threshing	3074.69	3464.08	4010.65	2905.06	4498
Total operating cost		102245.06	120320.84	64420.6	112723.82	86915.16
Family labour (imputed)		5408.68	4433.2	5741.83	14683.77	9287.41
Land		24728.25	16460.76	16833.33	20545.45	12473.68
Fixed cost		8014.06	7187.35	1666.67	23077.27	4989.97
Total Production Cost	-	140396.05	148402.15	88662.43	171030.32	113666.22
Operating ratio (%)		25.11	29.48	15.8	21.93	15.07
Avg. production cost (N/kg paddy)		42.42	42.64	24.29	48.45	22.03
Gross Margin (including land)		266631.69	259702.47	319154.24	342988.85	463124.14
Source: Computed from Field Data, 2016;						
*Includes labour for seeding, weeding, bird scaring, fertilizer and agrochemical applications						

have reported lower gross revenue [12]. Operating ratio was also high (25.11%) implying that over 25% of paddy revenue was used to offset operating cost of producing paddy per hectare. More so, average production cost was also high (N42.42/kg paddy) with the system having one of the highest average variable cost of production (N55795.79 per ha) compared to the other rice production systems in Nigeria. Gross margin was high (N266631.69 per ha); however, the high production costs combined with low paddy yield of the system do not allow benefits to be effectively seen amongst farmers employing the system.

Rainfed lowland system: The average farm size observed from rainfed lowland was 1.6ha. The production system had one of the highest paddy revenue (N408104.62 per ha). Nonetheless, the high paddy revenue was overshadowed by the seemingly high operating costs (N120320.84 per ha) resulting from high labour costs associated with the system. Operating ratio was also high (29.48%) compared to rainfed upland system. The high production cost (N148402.15 per ha) also implies that average gross margin was lowest (N259702.47 per ha) of all the different rice production systems. To this end, benefits that inadvertently should be accruable to farmers employing the system was however used to cover the high operating costs. Average paddy production was also high – N42.64 per kg of paddy produced. Other studies have corroborated the inherently high yield with rainfed lowland production system [5,6,11].

Irrigated system: The average farm size recorded for irrigated system was about 1.3ha thereby laying credence to the fact that the potential of this system was largely unexploited in Nigeria. This notwithstanding, the irrigation production system had been adjudged to offer more returns to farmers compared to other known production systems [6,8]. From our study, irrigated rice production systems enjoyed better yield, optimal input level and high returns compared to rainfed upland and lowland production systems in all agroecological zones in Nigeria. Paddy revenue was higher (N407816.67 per ha) compared to rainfed upland and variable input costs was lowest (N44368.83 per ha) compared to all other identified production systems. Although, for the study, we have assumed the initial costs of installing the irrigation system as a sunk cost since most of the irrigation systems from majority of the representative farmers used in our study were built either by the government or through community self-help efforts. Furthermore, for this system, operating ratio was quite low (15.80%) compared to other systems and total production cost (N24.29 per kg of paddy) was the lowest of all production systems taking our assumption of sunk cost into consideration. The low operating ratio implies that farmers employing the system had better compensation for their efforts since just over 15% of paddy revenue was enough to cover operating costs and this therefore correspond to higher gross margin (N319154.24 per ha). There are strong indications that irrigated rice production system is associated with high gross margin as confirmed by many researchers [6,11,12].

Rainfed upland and lowland system: Our study revealed that whilst production systems may be broadly categorized into three systems, field survey revealed that some rice farmers employ a combination of one or more production systems. It was observed that farmers employing these systems had better farm returns. The average farm size recorded for farmers employing a combination of rainfed upland and lowland systems was about 3ha. Cumulative average yield per hectare was higher (3.5 tonnes per ha) with farmers employing this system compared to those employing either rainfed upland or lowland. Farmers also enjoyed better revenue from paddy sales (N514019.17 per ha) when compared to the other production systems. Furthermore, variable input and cumulative total production costs were high (N56770.53 and N171030.32 per ha respectively). In view of this, the average production cost per kg paddy of this system was high (N48.45). Nonetheless, the high paddy revenue was able to compensate for the production costs and to this end, operating ratio (21.93%) was low and gross margin high (N342988.85 per ha). The high production costs associated with this system could be attributed to the high labour costs inherently observed with this system and this was however compensated by high revenue from paddy sales. It may make more economic sense for farmers to combine both rainfed lowland and upland production systems as the weakness of one was compensated by the strength of the other.

Rainfed upland, lowland and irrigated system: Our survey revealed that a combination of rainfed upland, lowland and irrigated rice production systems provide the best returns to rice farming enterprise. Average farm size recorded for this production system was about 2.5ha. Cumulative average yield per hectare (5.2 tonnes per ha) was highest compared to any other recognizable systems. More so, paddy revenue (N576790.36 per ha) was also highest compared to any other system. The operating ratio of 15.07% and cumulative average production cost of N22.03 per kg paddy were lowest compared to the other identified systems, implying that, farmers who are able to combine rice production on irrigated, rainfed upland and lowland have better compensation for their farm enterprise as only about 15% of revenue from paddy sales was enough to cover operating costs. Furthermore, gross margin from the system was highest (N463124.14 per ha) compared to the other sampled rice production systems. Employing a combination of rainfed upland, lowland and irrigated system was therefore more profitable and therefore more competitive.

Factors influencing rice yields amongst rice production systems in Nigeria

We estimated the factors influencing rice yields amongst the identified five production systems in Nigeria in order to adequately inform policies in this regard. Using a double log model for our production function, **Table 5** reveals the estimates of the regression analysis conducted. The double log model employed implies that the coefficients in the regression results are elasticities.

In rainfed upland fields, results showed that the quantity of seed used was the only significant variable influencing rice yield across all the agroecological zones at 5% level of significance. To this end,

Table 5 Factors influencing rice yields among different production systems in Nigeria.

Variables	Rainfed Upland		Rainfed Lowland		Irrigated		Rainfed Upland and Lowland		Rainfed Upland, Lowland and Irrigated		Pooled	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Age	-0.630 (0.46)	-1.38	1.173** (0.47)	2.47	-2.671 (2.28)	-1.17	-	-	-7.561** (3.32)	-2.28	-0.233 (0.46)	-0.52
Eduyrs	0.120 (0.30)	0.39	-0.257 (0.27)	-0.95	-1.354 (0.87)	-1.56	1.568** (0.63)	2.49	-1.438 (0.97)	-1.48	-0.08924	-1.68
Seed	-0.827** (0.34)	-2.43	-0.846** (0.32)	-2.65	-0.961 (1.48)	-0.65	1.914* (1.01)	1.9	7.17 (4.52)	1.59	-1.49*** (0.30)	-4.94
Fert	0.117 (0.17)	0.68	-0.047 (0.18)	-0.26	-0.035 (0.60)	-0.06	-0.93	-1.65	-0.316 (0.88)	-0.36	0.329* (0.19)	1.76
Lab	-0.244 (0.19)	-0.46	-0.3003	-1.99	-0.880 (0.78)	-1.13	1.270* (0.63)	2	0.151 (0.99)	0.15	-0.918** (0.38)	-2.42
Chemical	0.250 (0.19)	1.3	0.123 (0.34)	0.36	0.506 (0.74)	0.68	-1.882** (0.82)	-2.28	-0.919 (0.92)	-1	0.416* (0.23)	1.83
Farmsize	0.005 (0.52)	0.01	-0.192	-1.85	0.880 (0.78)	1.13	-	-	-	-	0.037 (0.32)	0.12
hhsize	-0.359 (0.31)	-1.14	-0.134 (0.26)	-0.52	0.911 (0.88)	1.03	-	-	0.187 (1.14)	0.16	-0.056 (0.29)	-0.23
Sex: Female	-0.078 (0.25)	-0.32	0.526 (0.32)	1.63	-1.238 (0.87)	-1.42	0.016 (0.83)	0.02	1.407 (1.06)	1.33	0.532* (0.28)	1.91
F ratio	1.04	-	3.69	-	3.4	-	1.95	-	2.5	-	6.05	-
R2	0.3684	-	0.3942	-	0.8448	-	0.7448	-	0.7377	-	0.367	-

Source: Computed from Field Survey (2016).

Functional form=Double-log production function; Figures in parentheses are standard errors

***1% significance level; **5% significance level; *10% significance level

a one percent increases in the quantity of seed used decreases the paddy yield by about 0.827 percent. On the contrary, in rainfed lowland fields, age of the rice farmer, quantity of seed used, labour use and size of the rice farm were significant variables influencing paddy yield at 5% and 10% level of significance. While quantity of seed used, number of labour use and size of the rice farm negatively influence paddy rice yield, the age of the rice farmer had a positive influence. A one-year increase in age of the rice farmer would increase paddy yield in metric tonnes by about 1.173 percent at 5% level of significance. This may imply that as farmers get older and more experienced with the intricacies of rainfed lowland rice farming, they are able to manage the farm in such a way as to derive optimal output. Similarly, a 1% increase in the quantity of seed and labour used would decrease paddy yield by 0.846 percent and 0.770 percent at 5% and 10% significant level respectively. This further lend credence to the fact that in lowland rice fields, adequate management of the field may yield more benefit than increase in quantity of requisite inputs. For irrigated rice fields, none of the variables included in the model significantly influence paddy yield as indicated by the result. Nonetheless, while the age and years of education of rice owner, quantity of seed, fertilizer and labour used including being a female rice farmer negatively affected paddy yield, the quantity of agrochemical, the size of the farmland and that of the household of the rice farm owner had positive influence. Though, they were all not significant. These results are not far from recent analysis on rice fields. For example, in some studies in Nigeria and China showed that irrigation, trained farmers, labour, and rice as a major crop production, herbicide use and household size are significant to changes in yield of rice fields [13].

A combination of one or more of the other production systems were also modelled in the analysis based on farmers employing these systems. For farmers employing both rainfed upland and lowland systems, results revealed that years of education of rice farm owner, quantities of seed, fertilizer, agrochemical and labour use significantly influenced the yield of paddy. While years of education of the rice farm owner, quantity of seed and labour positively influenced paddy yield, the quantity of fertilizer and agrochemical on the other hand, negatively influenced paddy yield. To this end, a 1% increase in years of education of a rice farmer, quantity of seed and labour used, increases paddy yield by about 1.57% (at 5% level of significance), 1.91% (at 10% level of significance) and 1.27% (at 10% level of significance) respectively. However, a 1% increase in the quantity of fertilizer and agrochemical used decreased paddy yield by about 1.24% (at 10% level of significance) and 1.88% (at 5% level of significance) respectively.

For farmers operating on a production system that combines both rainfed upland, lowland and irrigated systems, results showed that only the age of the rice farm owner was the significant variable influencing paddy yield and this was a negative influence. Therefore, a one percent increase in age of the rice farm owner decreases paddy yield by about 7.56%. All other variables in the model were not significant.

Generally, however, irrespective of the production system employed, the years of education of the rice farm owner, the quantities of seed, fertilizer, agrochemical, labour use and being a female rice farm owner significantly influenced paddy yield in Nigeria based on our data. While the quantities of fertilizer and agrochemical used including being a female rice farmer had positive influence, the years of education, quantities of seed and labour use however had a negative influence. Therefore, a 1% increase in the quantities of fertilizer and agrochemical used results in an increase of about 0.33% and 0.42% in paddy yield at 10% level of significance. More so, a 1% increase in the quantity of seed and labour used reduces paddy yield by about 1.49% (at 1% level of significance) and 0.92% (at 5% level of significance). Positive influence in the quantities of fertilizer and agrochemical use is therefore a pointer to the importance of fertilizer and agrochemical use in rice production in Nigeria irrespective of the production system. This is corroborated in the study where they indicated that fertilizer and agrochemical use had positive influence on rice yields in Nigeria and China [13].

Conclusion and Recommendations

Our study revealed that farm sizes are smaller amongst farmers employing irrigation system compared to other production systems in spite of the obvious high productivity, net returns and low operating ratio associated with the system compared to the other systems. It was also observed that a combination of rainfed upland, lowland and irrigated system offered the best returns and therefore most profitable compared to the other production systems. More so, it was revealed from the study that, irrespective of the production system employed, labour and fertilizer costs constituted about 50.39% and 23.24% respectively of the total production cost in rice production. To this end, any policy effort to boost rice output to achieve the rice self- sufficiency drive of the federal government of Nigeria must of necessity aim at reducing the price of fertilizer by making it readily available and accessible to genuine rice farmers. This is even more important since the use of fertilizer was observed to positively influence paddy yield in most of the production systems in Nigeria. More so, policy efforts must also target reducing labour cost by providing incentive through provision of credit targeted at improving mechanization of rice production among rice farmers in Nigeria.

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