Determinants of Yield Gap in Rain fed and Irrigated Rice Production:
Evidence from Household Survey in Kwara State.

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Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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Abstract
This study examines the determinants of yield gap in rain fed and irrigated rice production systems in Kwara state, Nigeria. The objectives of the research are to; estimate the Profitability of rice production under rain fed and irrigated rice production systems; determine the technical efficiency of the farmers and to assess the determinants of yield gap in both production systems. These objectives were analyzed using: Gross Margin Budgetary analysis, Stochastic Frontier and Linear Regression Model respectively. The result shows that the gross margin for rain fed production system is ₦28,147.88 per hectare while, that of irrigated rice production system is ₦45,944.91 per hectare. The technical efficiency of rain fed rice production in the study area is 0.830 while that of irrigated rice production is 0.927. The determinants of yield gap in rain fed rice production system are: household size, family labour usage, urea fertilizer usage, farm size and variety of seed planted. The determinants of yield gap in irrigated rice production system are: farming experience, membership of association, farm size, and variety of seed planted. It was concluded that rice production in the study area is more profitable under the irrigated rice production system than the rain fed production system. This research therefore recommends that irrigation facilities and farm inputs (urea fertilizer, improved rice variety) should be made available to farmers as and when due.
Key words: Yield gap, Irrigation, Production systems, Rice.

INTRODUCTION

Rice is a staple food for more than 3.5 billion people worldwide, around half of the world's population (IRRI 2013). Rice is an increasingly important crop in Nigeria and has been found to thrive under four main ecologies suitable for different rice varieties. These are: rain-fed upland, shallow swamps and inland valley swamps (rain-fed lowland), irrigated lowland and mangrove or tidal swamp ecology (Imolehin and Wada, 2005:12). Nigeria is known to have comparative resource advantage in terms of favourable climatic, edaphic and ecological conditions in the production of rice for self-sufficiency (Imolehin and Wada, 2005:12).

Yield Gap is the difference between potential and actual yields (Roetter, et al, 1998). The actual yield of rice in Nigeria is not up to its expected potential yield. This explains why the importation of rice in to the country is at an alarming rate. The level of domestic rice production in Nigeria is estimated to be around 3 million metric tons while the domestic demand for rice is around 5 million metric tons which has led to a huge demand – supply gap of around 2 million metric tons of rice annually, thereby motivating the continued dependence on importation to fill the existing gap (Akande, 2005; Erenstein, *et al.*, 2004:38; Amaza and Maurice, 2005:7-9; Daramola, 2005:1-8).

Nigeria ranks second largest importer of rice in the world, spending about N356 billion for about 2 million MT of milled rice. Though the country is the largest producer of rice in West Africa, yet it accounted for up to 20 per cent of sub-Saharan Africa's rice imports for domestic consumptions (Omotola and Ikechukwu 2006). The importation of rice to bridge the demand-supply gap is worth ₦365 billion (Ayanwale and Amusan, 2011) the implication of which is a loss of considerable foreign exchange for the country which could as well be utilized for other needs. Imported rice has affected the domestic production and marketing of Nigeria's local rice. This is due to the decreased demand for local rice by Nigerians as opposed to the imported ones. The local Nigerian variety has a lower demand due to its poor quality compared to the imported, the high price as a result of cost of production (Bamidele et al. 2007; Diagne 2011).

Rice yields are between 46 percent and 56 percent below their potential for different production systems (Ezedinma, 2005 as reported by Cadoni and Angelucci 2013.). Irrigated rice is the best performing in terms of yields (3.5 tonne/ha), followed by rain-fed lowland (2.2 tonne/ha) and mangrove swamp (2 tonne/ha) (Cadoni and Angelucci 2013).

The International Fertilizer Development Centre (IFDC), in the year 2008 estimated that given the average National yield of 0.96 MT/ha, Nigeria would need to devote additional 2.6million hectares of harvest area to achieve self-sufficiency. Alternatively if, current productivity could be raised to the world average of 4.1 MT/ha, the resulting production within Nigeria would increase to 15.2 million metric tons of rough rice, equivalent to 10.2million metric tons of milled rice, which would provide Nigeria with enough milled rice to feed its own domestic consumption needs, and to meet virtually all of the import needs of the remainder of Sub-Saharan Africa.

On more practical level, if Nigeria could achieve the world average yield of 4.1 MT/ha on the 630,000-ha irrigated segment of its production, rice production would increase by 1.7 (rough rice) or 1.1 (milled rice) million metric tons. At this level of productivity, 214,000 additional ha of irrigated production would be enough to achieve self-sufficiency (IFDC, 2008).

The present dichotomy between the actual and potential yield of rice which led to increased importation forms the thrust of this study. This research thus examines those factors that determine the yield gap in both irrigated and rain fed rice production systems in Kwara state. The specific objectives are to; estimate the Profitability of rice production under rain fed and irrigated rice production systems in the study area; determine the technical efficiency of the rice farmers in the study area and to; assess the determinants of yield gap in both production systems;

METHODOLOGY

The Study Area:

This study was carried out in Kwara State, Nigeria. Kwara State is in North central Nigeria. Kwara State is situated between parallels 8° and 10° North latitudes and 3° and 6° East longitudes, with Niger State in the north, Kogi State in the east, Oyo, Ekiti and Osun States in the south and an international boundary with the Republic of Benin in the west. The 16 LGAs are: Asa, Baruten, Edu, Ekiti, lfelodun, llorinEast, llorin West, llorin South, Irepodun, Kaiama, Moro, Offa, Oyun, Isin, Oke-Ero and Patigi.

The State has a population of about 2.37 million people (NPC, 2006), who individually consume about 24.6 Kg of rice annually (IRRI, 2001). The state is divided into four Agricultural Zones by the Kwara State Agricultural Development Project (KWADP) authority based on agro-ecological considerations. Although rice is produced in all the KWADP Zones, the KWADP Zone B produces about 90 percent of the state's annual rice production. Kwara State's annual rice production estimate ranges between 17.5-118.3 metric tonnes: 49.6 metric tonnes on average (KWADP, 2004). The target population for this study is those farmers that produce rice, in the study area.

Sampling Technique

A three stage sampling procedure was adopted to select a representative sample for the study. The first stage comprised the purposive selection Edu and Patigi Local Governments in Zone B of Kwara Agricultural development project (KWADP) because they are representative zone for rice production in Kwara State, followed by a random selection of 20 villages each from the two Local Governments. The third stage involves the random selection of 10 households across the selected villages making a total of 200 respondents.

Analytical Techniques

Gross margin and profitability index: these were used to estimate the Profitability of rice production under rain fed and irrigated rice production systems in the study area. They are specified as follows:

Gross Margin (*G.M*) = *TR – TVC*

Where;

GM = Gross Margin (N/ha)

TR = Total Revenue (N/ha)

TVC = Total Variable Cost (N/ha)

Stochastic Frontier: This was employed to measure the technical efficiency level of the farmers. The empirical specification of function is given as below:

$Y_i = X_{ij}\beta_j + (v_i - u_i)$ that is, $\varepsilon j = uj + vj$

Where, 'i' stands for ith farm and 'j' stands for jth input and β0 and βj denote intercept and coefficients of different variables respectively.

Y = Yield gap

X_1 = Farm size

X_2 = Quantity of seed

X_3= Herbicides

X_4= Urea Nutrient/farm

X_5= Labour hours/farm

X_6= Plant protection/pesticide quantity

X_7= NPK, Nutrients/farm

βj is a vector of k unknown parameters,

εi is an error term = $V_1 + U_1$

Vi = Random error

Ui is Technical inefficiency effects which are independent of Vi

Following Battese and Coelli (1995:325-332), the mean of farm specific technical inefficiency Ui is defined as:

$U_I = \sigma_0 + \sigma_1 z_{1i} + \sigma_2 z_{2i} + \sigma_3 z_{3i} + \sigma_4 z_{4i} + \ldots$ (2)

Where:

Z1 is age of farmer, a priori expectation is positive.

Z2 is educational level of farmers, a priori expectation is negative.

Z3 is household size, a priori expectation is negative.
Z4 is experience of farmer, a priori expectation is negative.
Z5 is the contact with extension agent
Z6 is the number of different rice plots

Linear regression model: This was employed to analyze the determinants of yield gap in both systems of rice production.

Model specification for the linear regression:

$Y = f(X_1, X_2, X_3, X_4, \ldots\ldots X_n)$

Y = Yield gap

X_1 = educational status

X_2 = experience in rice farming (years)

X_3 = Household size (number of people)

X_4 = membership of association (0= non-member; 1= member)

X_5 = contact with extension agent

X_6 = number of rice plots

X_7= amount labour (family) utilized

X_8 = amount labour (hired) utilized

X_9 = farm size/ha

X_{10} = fertilizer/ha (Urea)

X_{11}= fertilizer/ha (NKP)

X_{12} = herbicides (litres)

X_{13}= pesticide (litres)

X_{14}= variety of seed planted (0= traditional or local; 1= improved)

RESULTS AND DISCUSSION

Table 1 presents the Gross margin analysis for both rain fed system and irrigated system. The estimate reveals that on average rain fed rice farmers makes a gross margin of ₦28,147 per ha. While an average irrigated rice farmer makes an estimated amount of ₦45,945 per ha. This conforms to the apriori expectation that irrigated rice farmers is more profitable compared to the rain fed system. It can be deduced that rice cultivation is quite lucrative in the study area.

Table 1: Gross margin analysis for both Rain fed and Irrigated system

Items	Average Costs of variable inputs (₦/Ha)	
	Rain fed	Irrigated
- Seedlings	6,402.66	3,987.98
- Fertilizer	14,134.34	16,591.32
- Pesticides	3,003.81	4714.82
- Herbicides	9,252.06	10,417.74
- Labour	90,631.21	91,484.28
- Tractor usage	6,835.30	6,998.5
- Irrigation water	0.0000	4500
TVC =	130,259.4	138,694.7
Returns		
- Total Revenue	158, 407.30	184,639
Gross Margin	**28,147.88**	**45,944.91**

Source: Field Survey, 2014

Technical Efficiency of Rice Farmers in the study area:

Table 2 shows the distribution of technical efficiency among the respondents, which reveals that there is great variation in the levels of efficiency among the farmers which ranges from 41.1% to 97.8% with a mean of 83.0% for farmers under rain fed system while the range is between 76.8% to 98.3% with a mean of 92.7% for farmers under irrigated system. The mean level of technical efficiency indicates that on average rice output falls 17.0% short of the optimum output expected to be obtained per farmer. Therefore in the short run it is possible to increase rice production in the study area by an average of 17.0 per cent by adopting the technology used by the average farmer or best performers.

Table 2: Frequency Distribution of Technical Efficiency of Rice Farmers

	RAINFED		**IRRIGATED**	
Technical efficiency (TE)	**Frequency**	**Percentage**	**Frequency**	**Percentage**
0.401 - 0500	1	1	0	0
0.501 - 0.600	5	5	0	0
0.601 - 0.700	6	6	0	0
0.701 - 0.800	17	17	3	3
0.801 - 0.900	35	35	18	18
0.901 - 1.000	36	36	79	79
Total	100	100	100	100
Mean TE	**0.830**		**0.927**	
Minimum TE	**0.411**		**0.768**	
Maximum TE	**0.978**		**0.983**	

Source: Computed from Field data, 2014

Yield gap among the rice varieties planted under the two production systems

The mean yield gap that occurred due to technical inefficiency for each variety planted in the study area is presented in Table 3. This was achieved by finding the difference between the mean potential yield of a variety and the mean yield from the farmer's field. Under the rain fed system it was observed that the mean yield gaps were 3027 kg/ha, 2375kg/ha and 436 kg/ha for FARO 52, FARO 44 and the local or traditional varieties respectively. While under the irrigated system it was observed that the mean yield gaps were 2578 kg/ha, 2477kg/ha and 290 kg/ha for FARO 52, FARO 44 and the traditional varieties respectively

Table 3: Yield Gap Estimation for the different Rice Varieties

	(Rain fed system)			**(Irrigated system)**		
Rice variety	**MPY**	**MFY**	**MYP**	**MPY**	**MFY**	**MYP**
FARO 52	6000	2973	3027	6000	3422	2578
FARO 44	6000	3625	2375	6000	3523	2477
Traditional	2750	2314	436	2750	2460	290
Total	6000	2491	3509	6000	2890	3110

Source: Field data

MPY: Mean Potential yield

MFY: Mean farm yield

MYP: Mean yield gap

Determinants of yield gaps

Table 4 indicates that factors such as: household size, amount of family labour, fertilizer (Urea), farm size, variety planted all had significant effect on the magnitude of yield gap. Household size was found to be positively significant implying that the larger the household size the wider the yield gap, this might be because it serve as a source of family labour on the farm hence significant while its positive effect on yield gap can be as a result of over utilization. The amount of family labour and fertilizer (Urea) used are negatively significant implying that the higher the amount of these factors (family labour and fertilizer (Urea)) used, the lower the yield gap. Farm size also has significant positive effect on the yield gap that is, the larger the farm size the higher the yield gap, this is in agreement with the theory that larger farm sizes are more efficient than smaller ones. The type of variety planted also has a significant positive effect on yield gap of rice, the positive influence here indicates the fact that improved varieties tends to wider yield gap than the local or traditional varieties probably due to farmers inability to meet up with the nutrient requirement/adoption of improved practices suitable to maximize yield.

Table 4: The determinants of Yield Gap in Rain fed Rice production

Variable	Coefficients.	Std Error	t-stat
Educational status	0.100	0.077	1.298
Rice farming experience	-0.007	0.007	-0.984
Household size	0.032**	0.013	2.451
Membership of Association	-0.310	0.210	-1.477
Extension visits	0.136	0.175	0.775
Number of plots	0.056	0.083	0.673
Amount labour (family) utilized	-0.002**	0.001	-2.363
Amount labour (hired) utilized	0.000	0.001	-0.508
Fertilizer/ha (Urea)	-0.125***	0.035	-3.529
Fertilizer/ha (NKP)	0.004	0.041	0.110
Herbicides (liters)	0.003	0.005	0.645
Pesticide (liters)	0.004	0.014	0.279
Farm size/ha	0.317***	0.040	7.998
Variety of seed planted	0.983***	0.161	6.119
Constant	- 361	0.472	-0.765
R2	0.591		
F	8.78		
N	100		

* significant at 10%, ** significant at 5%, *** significant at 1%.

Table 5 shows the result of the regression analysis for the determinants of yield gap in irrigated rice farms. It reveals that; farming experience, membership of association, farm size and the type of variety planted all have positive and significant influence on the magnitude of yield gap.

Table 5: The determinants of Yield Gap in Irrigated Rice production)

Variable	Coefficients.	Std Error	t-stat
Educational status	-0.025	0.043	-0.596
Rice farming experience	0.010**	0.005	2.062
Household size	-0.012	0.008	-1.574
Membership of Association	0.216**	0.102	2.113
Extension visits	-0.19	0.091	-0.206
Number of plots	0.004	0.082	0.046
Amount labour (family) utilized	0.000	0.001	-0.631
Amount labour (hired) utilized	0.000	0.000	0.620
Fertilizer/ha (Urea)	0.007	0.022	0.310
Fertilizer/ha (NKP)	0.017	0.013	1.319
Herbicides (liters)	0.003	0.003	0.794
Pesticide (liters)	0.009	0.009	1.039
Farm size/ha	0.068**	0.024	2.900

Variety of seed planted	0.280**	0.090	3.113
Constant	-1.024	0.344	-2.977
R2	0.360		
F	3.410		
N	100		

* significant at 10%, ** significant at 5%, *** significant at 1%.

CONCLUSION AND RECOMMENDATION

From the result obtained, it was concluded that rice production in the study area is profitable, even though there is a wide yield gap in the output obtained by the farmers. Rice production has a very large profit margin and could serve as veritable avenue for poverty alleviation to the youths possessing the socio-economic characteristics outlined above. Irrigated rice production system was more profitable than the rain fed one. Nevertheless efforts should still be put in place by stakeholders to ensure that the yield gap is brought to the minimum and if possible eradicated.

This study therefore recommends that productive inputs should be made promptly available to farmers through input subsidy programme such as growth enhancement support (GES) by stakeholders for the production of rice in the study area. There should be Provision of a constant and efficient alternative source of water all year round, to supplement rain water and also to encourage irrigated dry season farming.

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