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EFFECT OF AGROCHEMICAL USE ON ALLOCATIVE EFFICIENCY OF LOWLAND RICE FARMERS IN NIGER AND OGUN STATES NIGERIA

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Abstract

The study determined the effect of agrochemical use in rice production in Niger and Ogun States, Nigeria. A cross sectional survey was conducted to obtain primary data from 304 rice farmers selected through a multi-staged sampling procedure in the study areas. Data such as socio-economic characteristics, rice production activities, agrochemical application practices were obtained using a structured questionnaire complemented with interview schedule. The collected data were analyzed using frequency count, mean, percentages, Data Envelopment Analysis (DEA) and Tobit regression. The results showed that rice farming was popular among male farmers (91.2%) who had primary education (63.8%) and are within the active age bracket (mean age of 44 years).The DEA result indicated that the rice farmers in the study area were allocative inefficient (0.58). Furthermore, The Tobit regression result showed that allocative efficiency was influenced negatively by education ($p<0.01$), sex ($p<0.10$), extension contact ($p<0.10$) and number of farm plots ($p<0.10$) while credit ($p<0.01$), use of herbicides ($p<0.10$) and insecticides ($p<0.10$) influenced it positively. The study therefore concludes that agrochemical use helps to minimize cost of production while increasing output. Also, female rice farmers are more cost effective than their male counterparts. Thus, the study recommends that policy makers in agriculture should promote the use of certified agrochemical and also policies promoting female farmers' access to production inputs which will be very useful since they are able to produce at minimal cost.

KEYWORDS: Agrochemical, DEA, Allocative, Efficiency, Rice; Nigeria

Introduction

The use of agrochemicals for crop production has been on the increase with an estimated 2.5 million tonnes of pesticides being applied to agricultural crops worldwide each year (Nnamonu and Onekutu, 2015). Also, in Nigeria alone, an estimated 125,000-130,000 metric tonnes of pesticides is applied every year (Hayo and Van 1996; Asokwa*et al*. 2009). The case is not different for rice production enterprise as the use of agrochemical has also been on a steady increase. Food and Agriculture Organization (FAO, 2012) reported that an average of 167,000 tonnes of fertilizer was used by rice farmers in Nigeria in addition to pesticides in 2012. Similarly, the World Rice Statistics (WRS 2017) reported that 605,228tonnes and 369,957 tonnes of fertilizer were used for rice production in Nigeria in 2013 and 2014 respectively. Increased use of agrochemical in rice production is necessitated by the fact that rice has become an economic crop and efforts abound by researchers to increase rice yield and improve market access. (West Africa Rice Development Association (WARDA) 2004; Nwilene*et al.*, 2006; Kuponiyi and Adewale 2008).

In the world over, rice has become a highly important crop. International Rice Research Institute (IRRI)(2016), reported that rice provides an average person about 21% of the caloric energy requirement and about 14% of the total dietary protein. Ricestat (2014), reported that Nigeria is the highest rice producer in West Africa, with an increase in the production from 2.9million tonnes in 2005 to 4.1million tonnes in 2014. This has further increased to 4.3 million tonnes in 2015 but suddenly dropped to 4.2 million tonnes in 2016 (WRS, 2017).Despite this, her productivity level is low when compared to neighbouring countries (Cadoni and Angelucci, 2013). For instance, the productivity of Nigeria for year 2016 was 1.71tonnes/ha, Ivory Coast 2.02tonnes/ha while that of Ghana was 2.85tonnes/ha even though they produced the lowest quantity of rice (603000 tonnes) when compared to the other countries. Rice may be prone to negative effects of pests,diseases, insects, rodents and weeds amongst others.

In addition to the use of insecticides and herbicides as mentioned above, rice farmers apply fertilizer to enhance soil fertility which further translates to growth and production. Similarly, the AFRGM pestcan be controlled through application of fertilizer. In order to improve rice production, there is need for rice farmers to combine the available resources better while having in mind the cost of these resources. Agrochemical have been found to be a labour saving technology since they help to reduce energy expenditure as well as the risk of farm injury (Otto 2015). More so,fertilizer can be extremely economical, and it can increase rice yield enormously which can also result to a substantial increase in profit(Uphoff and Dazzo 2016).In view of this, the study determined the effect of agrochemical use on allocative efficiency of rice farmers in Niger and Ogun states, Nigeria.

Research methodology

Area of study

The study was in Niger and Ogun states in the North Central and South West zones of Nigeria respectively.Niger State is located between Latitude 8^{o}22’N and 11^{o}30’N and Longitude 3^{o}30’N and 7^{o}20’E and it covers about 86,000 sq. km (about 8.6 million hectares), representing 9.3% of the total land area of the country. Out of this, about 7 million hectares (80%) are arable from which not more than 20% or 1.7 million hectares are actually cultivated for production of various food and cash crops (Niger State GIS, 2007) The State experiences distinct dry and wet seasons. The mean annual rainfall varies 1100mm in the north to 1600mm in the south while the mean minimum and maximum temperature is 26^{0}C and 36^{0}C respectively. The 2006 census, puts the population at 3.950 million people with a projection of about 5.214 million people in year 2016 based on the 3.2% growth rate (NPC, 2011) and a population density of 284 persons per square km. Several ethnic groups are found in the State.

Ogun State is located in the south western part of Nigeria and it lies between Latitude 6.9098^{0}N and Longitude 3.2584^{o}E,and it covers about 16,980 sq. Km. About 1.2 million hectares (74%) are arable from which not more than 29% or 350,000 hectares are actually under cultivation for various food and cash crops. The State experiences distinct dry and wet seasons. The mean annual rainfall varies between 1050mm in the north to 1280mm in the south while the mean minimum and maximum temperature is 23^{0}C and 32^{0}C respectively. The rainy season starts in March and ends in November and it is followed by the dry season which starts in November/December and extends to March/April of the succeeding year. The state characterised by its rain forest, swampy forest and derived savannah vegetation. The 2006 census, puts the population of Ogun State at 3.751 million people with a projection of about 4.951 people in year 2016 based on the growth rate of 3.2% (NPC, 2011) and a population density of 222 persons per square km.

Method of data collection

This study was based on primary data collected by the administration of questionnaire coupled with interview guide on the rice farmers (who constituted the study population) located in the states of Niger and Ogun States.

Sampling Technique

In the first stage, proportionate sampling technique (on a ratio 1:1.5) was used to select two zones (zones 1 and 3) out of the 3 agricultural zones in Niger State while 3 zones out of the 4 agricultural zones were selected from Ogun State. In the second stage, proportionate sampling technique (on a ratio 5:1) was also used to select five (5) Local Government Areas (Bida, Gbako, Katcha, Lavun, Mokwa) from zone 1 given that it is the major rice producing zone in the State, and 1 Local Government Area namely, Wushishi from zone 3 in Niger State. In Ogun State, Yewa North (under Ilaro zone), Ifo (under Abeokuta zone) and ObafemiOwode (under Ikenne zone) Local Government Areas (LGAs) were selected using simple random sampling technique from a list of rice producing LGAs which served as the sampling frame. This gives a total of 9 LGAs altogether.In the third stage, four villages were randomly selected in Bida, Lavun, Katcha, Gbako and Mokwa LGAs) while 5 villages were selected from Wushishi LGA through simple random sampling technique. With respect to Ogun State, 5 villages each were chosen through simple random sampling technique from each of the LGAs.

In the fourth stage, 10 respondent households were sampled through systematic sampling technique in each village. This gives a grand total of 250 respondents for Niger State.

Further, in Ogun State, systematic sampling was used to select 10 respondents each from the 5 villages of Ifo and Yewa North LGAs (giving a total of 100 respondents) while 20 respondents were selected through systematic sampling technique (giving a total of 50 respondents) for ObafemiOwode LGA thus, giving a grand total of 200 respondents for Ogun State. However, only 302 respondents provided information and subsequently subjected to analysis.

Method of data analysis

The data collected were analysed by a combination of descriptive statistics, DEA estimation and tobit regression.

Data Envelopment Analysis

Estimates of technical efficiency for the pooled data were obtained by estimating an input oriented DEA

$TE_n = \min_{\lambda_i \theta_n} \theta_n$………………………………. (1)

Subject to;

$$\sum_{i=1}^{I} \lambda_i x_{ij} - \theta_n x_{nj} \leq 0$$

$$\sum_{i=1}^{I} \lambda_i y_i - y_n \geq 0$$

$$\sum_{i=1}^{I} \lambda_i = 1$$

$$\lambda_i \geq 0$$

θ_n= a scalar less or equal to one and it defines the TE of field n.

Where; Y is rice output (kg)

X is a vector of inputs and it includes;

X_i= Seed (kg)

X_2= Land (ha)

X_3= Fertilizer (kg)

X_4= Land (ha)

X_5= Pesticide (g/a.i)

X_6= Labour (mandays)

When θ_n= 1, it indicates that field n is technically efficient. However, a value less than 1 indicates that field n is technically inefficient.

The inclusion of $\sum_{i=1}^{I} \lambda_i = 1$ in equation 1 implies that TE for field n is calculated under variable returns to scale

The estimation of the DEA model under the CRS and VRS assumption is quite similar. The only difference is the addition of the convexity constraint $\sum_{i=1}^{I} \lambda_i = 1$ in the VRS model.

The economic efficiency score for a given field n is calculated by solving the following cost minimization problem.

$MC_n = min_{\lambda_i x_{nj}^*} \sum_{j=1}^{J} P_{nj} x_{nj}^*$………………………….. (2)

Subject to;

$$\sum_{i=1}^{I} \lambda_i x_{ij} - x_{nj}^* \leq 0$$

$$\sum_{i=1}^{I} \lambda_i y_i - y_n \geq 0$$

$$\sum_{i=1}^{I} \lambda_i = 1$$

$$\lambda_i \geq 0$$

Where; MC_n= the minimum total cost for field n; P_{nj}= the price (₦) for input j (seed, land, fertilizer, pesticide and labour) on field n and x_{nj}^*= the cost minimizing level of input j on field n given its input price and output levels. Other variables are as defined in equation1.

model and it is specified as;

The economic efficiency for each field n is calculated as follows;

$EE_n = \frac{\sum_{j=1}^{J} P_{nj} x_{nj}^*}{\sum_{j=1}^{J} P_{nj} x_{nj}}$……………………………………….. (3)

Where; $\sum_{j=1}^{J} P_{nj} x_{nj}^*$ is the minimum total cost obtained for field n using equation 2 and $\sum_{j=1}^{J} P_{nj} x_{nj}$ is the actual total cost obtained for field n. When EE_n= 1 it implies field n is economically efficient but a value less than 1 implies otherwise.

Allocative efficiency can be measured once the TE and EE have been calculated since EE is the product of TE and AE. Therefore;

$AE_n = \frac{EE_n}{TE_n}$…………………………………….. (4)

The interpretation of AE_n is same as that of EE_n and TE_n in equations 1 and 3 above.

Tobit Regression

The tobit regression was used to determine the factors that influenced technical, allocative, economic and scale efficiencies respectively. The model is as expressed as;

$y_i^* = q_i\beta + \varepsilon_i$………………………………………………... (5)

Where;

y_i^* = is the observed allocative efficiency score obtained from equation 4 and it was left censored at the minimum efficiency score

q_1= Age of the rice farmer (years)

q_2= Education (years)

q_3 = Sex of the rice farmer (1=male and 0 otherwise)

q_4 = Household size (number of persons)

q_5= Marital status (1= married and 0 Otherwise)

q_6= Farm distance (km)

q_7= Number of extension visits

q_8= Amount of credit received (₦)

q_9= Number of farm plots

q_{10}= Cost of illness (₦)

q_{11}= Location (1= Niger, 0 otherwise)

q_{12}=Farm size (ha)

q_{13}= Use of fertilizer (1 if used and 0 otherwise)

q_{14}= Use of herbicides (1 if used and 0 otherwise)

q_{15}= Use of insecticide (1 if used and 0 otherwise)

Results and Discussion

Personal Characteristics of the Rice Farmers

The socio-economic characteristics of the respondents are presented in this section. The socio-economic characteristics of an individual have been found to influence his/her decision making capacity in any business venture (Vukelic and Rodic, 2014). As shown in Table 1,majority (31.6%) of the rice farmers were between the ages of 31 and 40 years. However, the mean age of the farmers in the study area was 44years. This suggests that the rice farmers were in their active labour age group and as such have the energy that could possibly translate to higher efficiency in rice production. This result corroborates the findings of other scholars, for example Kuponiyi and Adewale (2008); Ayoola*et al.*(2011) and Bello *et al.*(2011) who in their various studies found the mean age of rice farmers in the Northern Guinea savannah to be around 41 years. Also, majority (91.2%) of the farmers were males. This indicates that rice farming around Niger and Ogun states was popular among the men in the study area.

The results indicated that few (36.2%) of the rice farmers in the study area had no formal education. There is a high tendency that these farmers who had no formal education would have inadequate knowledge of managing use of agrochemical in terms of inability to read and follow agrochemical label instructions. This view is also corroborated by Ayinde (2007) and Banjo *et al.* (2010). It is interesting to note that 13.3% and 4.5% of the farmers in Niger and Ogun states respectively, had tertiary education. This appears desirable, in that these categories of farmers can bring their knowledge and expertise to bear in decision making on rice production and efficiency.

This finding conforms to Oluwatayo (2014) who found that 33.3% of the rice farmers in the southwest had no formal education. Also indicated in Table 4 is the fact that majority (88.9%) of the rice farmers were married with a mean household size of 5 persons in the study area. With few members in the household, the rice farmers may depend on the use of hired labour for most of their farm activities including agrochemical application.

Table 1: Distribution of respondents by personal characteristics

Description	Niger State	Ogun State	All
Age			
Less or Equal to 30	17(9.8%)	21(15.7%)	38(12.4%)
31-40	54(31.2%)	43(32.1%)	97(31.6%)
41-50	57(32.9%)	36(26.9%)	93(30.3%)
51-60	30(17.3%)	18(13.4%)	48(15.6%)
Above 60	35(8.7%)	16(11.9%)	31(10.1%)
Mean	**44 years**	**45 years**	**44 years**
Sex			
Female	10(5.8%)	17(12.7%)	27(8.8%)
Male	163(94.2%)	117(87.3%)	287(91.2%)
Educational Status			
None formally	78(45.1%)	33(24.6%)	111(36.2%)
Primary	39(22.5%)	59(44%)	98(31.9%)
Secondary	33(19.1%)	36(26.9%)	69(22.5%)
Tertiary	23(13.3%)	6(4.5%)	29(9.4%)
Marital Status			
Single	15(8.7%)	14(10.4%)	29(9.4%)
Married	158(91.3%)	112(83.6%)	270(87.9%)
Widow	0(0.0%)	4(3.0%)	4(1.3%)
Divorced	0(0.0%)	4(3.0%)	7(1.3%)
Household Size			
1-3	61(35.3%)	43(32.1%)	104(33.9%)
4-6	75(43.4%)	70(52.2%)	145(47.2%)
7-9	27(15.6%)	14(10.4%)	41(13.4%)
10-12	10(5.8%)	4(3.0%)	14(4.6%)
Above 12	0(0.0%)	3(2.2%)	3(1.0%)
Mean	**5**	**5**	**5**

Source: Field Survey 2015

Allocative efficiency of Rice Farmers

Table 2 gives a summary of the allocative efficiency of the rice farmers in the study area. As shown, the allocative efficiency of the farmers ranged from 0 to 1 with a mean value of 0.58. This means that the rice farmers could still improve their allocative efficiency by 42%. Also, if an average rice farmer saves about 42% of his cost, he will be able to attain the same allocative efficiency level of the best practiced farm. The mean allocative efficiency of rice farmers in Ogun state (0.61) fell short of what was obtained by Akinbode*et al.* (2011), who found the average efficiency score of rice farmers to be 0.928. This indicates a kind of retrogression among rice farmers in the State. However, the allocative efficiency scores are in line with that obtained by Musemwa (2013) for rice production among small-scale farmers in Zimbabwe and Thabethe*et al.* (2014).

Table 2: Distribution of rice farmers by allocative efficiency scores

AE Scores	Niger State	Ogun State	ALL
Less than 0.31	31(18.7%)	7(10.0%)	38(16.1%)
0.31-0.40	13(7.8%)	7(10.0%)	20(8.5%)
0.41-0.50	16(9.6%)	0(0.0%)	16(6.8%)
0.51-0.60	35(21.1%)	14(20.0%)	49(20.8%)
0.61-0.70	31(18.7%)	21(30.0%)	52(22.0%)
0.71-0.80	19(11.4%)	14(20.0%)	33(14.0%)
0.81-0.90	17(10.2%)	7(10.0%)	24(10.2%)
0.91-1.00	4(3.4%)	0(0.0%)	4(1.7%)
Minimum	0.0.0	0.27	0.0.0
Maximum	1.00	0.89	1.00
Mean	0.56	0.61	0.58

Source: Field Survey 2015

Determinants of Allocative Efficiency

In order to determine the factors that influenced the allocative efficiency of rice farmers, the Tobit regression censored at minimum was estimated and the results are presented in table 3 While education ($p<0.01$), sex ($p<0.10$), extension contact ($p<0.10$) and number of farm plots ($p<0.10$) influenced allocative efficiency negatively, credit ($p<0.01$), use of herbicides ($p<0.10$) and insecticides ($p<0.10$) influenced it positively. It is expected that an increase in the number of years spent acquiring formal education should enhance allocative efficiency, but the results showed that the higher the number of years of formal education, the lower the allocative efficiency. This could be associated with the fact that farmers with higher education tend to shift to non- farm activities therefore undertaking farming as a secondary occupation and sometimes pay less attention to it. More so, with income from other sources they can afford to buy inputs at higher cost. In addition, the coefficient of sex is negative, implying that the female rice farmers are more efficient in taking management decisions that pertain to input selections in relation to the market price compared to men. This finding is line with Galawat and Yabe (2012) who also found that female rice farmers in Brunei had positive effect on allocative efficiency.

Furthermore, the results revealed that farmers who used herbicides and insecticides had higher level of allocative efficiency. This finding supports the work of Damalas *et al.* (2011) who confirmed that pesticides use is an efficient tool for pest management for increased revenue. This implies that use of agrochemical for weeding and pest control in rice production enhance cost saving. As stated by Matthias (2014), approximately ₦12, 000 is expended when manual labour is used for rice weeding operation as against ₦4, 800 that is spent on herbicide application. However, agrochemicals have to be used in accordance with safety principles for maximum efficiency.

Furthermore, allocative efficiency decreased with increase in the number of extension contacts. This is an indication that farmers may not have obtained, analysed and understood the information passed by extension agents to reduce their production cost. Besides, the information delivered may not be well timed and this can have little or no effect on farmers' decision on input cost management. It could also imply that information obtained from the extension agents may not be in accordance with their information needs or that the extension officers may be ineffective. On the other hand, there is a possibility that farmers ignored recommendations of the extension agents.

The amount of credit received also had a significant and positive effect on allocative efficiency. This indicates that rice farmers who had access to higher amount of credit had higher level of allocative efficiency. This could be attributed to their ability to overcome their financial constraints which in turn enhances timely acquisition and use of inputs. Also farmers who have borrowed funds may be motivated to allocate farm resources so as to achieve maximum returns in order to meet-up with the terms of payment of the loan. Land fragmentation enhanced allocative inefficiency as the coefficient of number of plots was significant but negative ($p<0.10$). This implies that as the number of plots increases, the farmers' allocative efficiency decrease. This is however not surprising because most times, the farm plots are not located in one place and this makes the management of resources difficult.

Table 3: Determinants of allocative efficiency

Variables	Coefficient	Z-value
Age	-0.001	-0.47
Education	-0.008***	-2.67
Sex	-0.129**	-1.70
Household Size	-0.005	-0.65
Marital Status	0.073	1.25
Farm Distance	0.004	1.07
Extension Contact	-0.001*	-0.01
Credit	7.15e-06***	2.69
Number of farm plots	-0.037*	-1.08
Cost of Illness	-4.280e-07	-1.58
Location	-0.093	-1.21
Farm size	0.021	1.00
Use fertilizers	0.036	0.40
Use herbicides	0.183*	1.81
Use insecticides	0.254*	1.88
Constant	0.482	3.09
Sigma	0.199	
LR $Chi^2(13)$	47.74***	
Log Likelihood	33.19	

****, **, * implies significance at 1%, 5% and 10% respectively*

Source: Field Survey 2015

Conclusion and Recommendation

The study concludes that agrochemical use helps to minimize cost of production while increasing output. Also, female rice farmers are more cost effective than their male counterparts. In addition, land fragmentation promotes allocative inefficiency. Thus, the study recommends that policymakers in agriculture should promote the use of certified agrochemical and also policies promoting female access to production inputs since they are able to produce at minimal cost. Furthermore, land reform policies should be such that disfavours land fragmentation.

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