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PRODUCTIVITY RESPONSE OF AMARANTHUS CRUENTUS TO ORGANIC AND ORGANOMINERAL FERTILIZER APPLICATION IN SOUTHWEST NIGERIA

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Abstract: The study examined the economic analysis of organic and organomineral fertilizer on the productivity of *Amaranthus cruentus* in South-western States of Nigeria. Two hundred and forty respondents were selected using multistage sampling technique with the aid of a well-structured questionnaire. Data were analyzed by using descriptive statistics, budgetary techniques and stochastic frontier production. The result shows leafy output/yield of *Amaranthus cruentus* ranging between 6.5kg and 170 kg for organomineral farmers and 20-210 kg for organic farmers. The farm size was small and ranged between 0.07-0.4 ha for organomineral and organic farmers with the mean size of 0.21 and 0.20 ha respectively. Also results obtained from various profitability ratios showed that organic amaranthus production is more profitable than organomineral amaranthus production. The technical efficiency score showed a mean score of 0.814 and 0.706 for organomineral and organic farmers and sources of inefficiency are education, experience and extension visit.

Keywords: Organic, organomineral, productivity, amaranthus, profitability

INTRODUCTION

Republic of Benin, Cote d'Ivoire, Tanzania, Zimbabwe, and Nigeria are some of the African countries where *Amaranthus cruentus* features are predominantly in their vegetable farming systems. This is

widely grown in family gardens or in small commercial holdings around the major urban and peri-urban areas (De Lannoy, 2001). *Amaranthus cruentus* is grown for its leaves and is among the highly prized leaf vegetables in Nigeria due to their high nutritional and commercial significance. The fresh leaves are excellent sources of plant protein, iron, calcium, fibre, beta-carotene and folate (Okokoh and Bisong, 2011).

Organic manures are made from plant and animal waste, this are used as source of plant nutrient. Examples of this include compost, farmyard manure and the green manure. They are bulky in nature due to their composition- animal dung, left over material from roughages or fodder fed to the cattle, and so on. They improve soil structure and plant nutrient which might include micronutrient. Evaluating the performance of different brands and composition of organic and organomineral fertilizers in relation to conventional mineral fertilizers become necessary since different organic wastes influence nutritional quality of crops differently, (Ipinmoroti et al., 2002; Fagbola and Dare, 2003). According to Preetha et al. (2005) compost, a product of the decomposition of cattle dung or poultry manure and maize stover, can be used as alternative, cheap and sustainable source of fertilizer for maintaining soil fertility and improving crop yield on continuous basis.

Organomineral or synthetic fertilizers are chemical substance which could be prepared in liquid forms, powder, granules, pellets or crystals. They are produced for three major plant nutrients (nitrogen, phosphorus, potassium), the secondary plant nutrients (calcium, sulphur, magnesium) and others are the trace elements such as boron, chlorine, manganese, iron, zinc, copper and molybdenum. They are easily absorbed and utilized by crops. However, these fertilizers are believed to contribute substantially to human, animal food intoxication and environmental instability (Olufolaji et al., 1990).

Many crop species respond well to the application of organic manure and it can sustain yield under continuous cropping through the high potential of gradual nutrient release to the soil that can help to improve the fertility of a degraded soil (Egharevba and Ogbe, 2002; Ibeawuchi et al., 2006; Mbonu and Afrifalo, 2006). Both organic and synthetic fertilizers were found to increase significantly yield of maize and vegetables such as pepper, tomato, okra and amaranthus (Adeoye et al., 2008). However, this study examines the profitability ratio, gross margin and net returns of *Amarantus cruentus* in the study area. Also the technical efficiency of the farmers was estimated.

MATERIALS AND METHODS

The study was carried out in southwest Nigeria. The region has six states: Ekiti, Lagos, Ogun, Ondo, Osun and Oyo. It is majorly Yoruba speaking area, although there are different dialects even within the same state. A multistage random sampling technique was used to select *Amaranthus* farmers (both organic and organomineral fertilizers users) in the study area. In the first stage, two (2) states (i.e Ekiti and Ogun) were randomly selected from six (6) states in the southwest geopolitical zone. The second stage involved random selection of thirty (30%) percent of the local government area (LGAs) in each state with six from 20 LGAs in Ogun state and five from 16 LGAs in Ekiti state (approximately). The third stage involved random selection of two political wards from each LGAs of each state, while the

last stage involved the selection of eleven respondents from each political wards, totalizing two hundred and forty (242) respondents, but only 240 questionnaires were good enough for the analysis.

Method of Data Analysis

(1) Descriptive statistics such as mean, minimum, maximum, standard deviation, percentage and frequency were used to describe the socio-economic characteristics of Amaranthus farmers using organic and organomineral fertilizers.

(2) Gross margin analysis and profitability ratios were used to determine the profitability level of the enterprise. $\ln Y_i = \ln \beta_0 + \sum_{k=1}^n \beta_k \ln X_i + V_i - U_i$ (7)

Where $\ln$: denote natural logarithms, Y is the dependent variable, X is the independent variable and β is a parameter vector to be estimated that captures the influence of the determinants on the level of inefficiency.

X_1 =Farm size (ha), X_2 = Seeds (Kg), X_3 =Family labour (Man day), X_4 = Hired labour (Man day), X_5 =fertilizer/manure (Kg), e =Error term. V is assumed to be independently and identically distributed random error, having $N(0, \sigma_v^2)$ distribution; and the U is non-negative one-sided random variable, called technical inefficiency effect, associated with the technical inefficiency of production of the farmers involved. It is assumed that the inefficiency effects are independently distributed with a half normal distribution, $(U | \sim N(0, \sigma_u^2) |)$. The model for the technical inefficiency effects in the stochastic frontier of equation (1) is defined by;

$$U_i = \alpha_0 + \alpha_1 \text{Age} + \alpha_2 \text{Educ} + \alpha_3 \text{Hhsize} + \alpha_4 \text{Exp} + \alpha_5 \text{Ext visit} + W_i \quad \text{..... (8)}$$

where, Age = age of the farmers, Educ = education status of the farmers, Hhsize = households size, Exp = year of farming experience of the farmers, Ext visit = number of times of extension worker's visit and W_i are the unobservable random variables assumed to be independently distributed with a positive half normal distribution. The β and α coefficient are unknown parameters to be estimated, together with the variance parameters.

RESULTS AND DISCUSSION

The summary statistics of variables used in the stochastic frontier model is presented in Table 1. the output/yield (leaf) ranged between 6.5kg and 170kg for organomineral farming and 20-210kg for organic farming showing that vegetable yields were moderately. The farm size was small and ranged between 0.07-0.4 ha for organomineral and organic farmers with the mean size of 0.21 and 0.20 ha respectively. This significantly indicated that most of the farmers were cultivating amaranthus on small scale. This echoed the findings of Kassie et al. (2009) where about 1.09 ha were under organic farming in semi-arid region of

$$GM = TR - TVC \quad \text{.....(1)} \quad \text{Ethiopia. The quantity of seed sown ranged between 1} \quad -7$$

Where, GM = Gross margin (\$), TR = Total revenue (\$), kg/ha with a mean of 3.4 kg/ha for organomineral farmers

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TVC = Total variable cost (\$) and of between 1 -
8 kg/ha with a mean of 2.9 kg/ha for
NFI = GM – TFC(2) organic farmers, depicted
that the more quantity of seed is
NFI = Net farm income and TFC = Total fixed cost used, the more output is obtained. In this case, farmers
The profitability ratios examined were: should plant more viable seeds and increase their farm
1. Benefit cost ratio (BCR) = TR/TC (3) plot(s). The mean of family labour
for organomineral and 2. Gross ratio (GR) = TC/TR (4)
organic farmers are 72 and 71.3 man -days, respectively.
3. Rate of return = NR/TC = NFI/TC (5) The hired
labour varied significantly among the
4. Expense structure ratio = TFC/TC(6) organomineral and
organic farmers with the mean of 49.5
TC = Total cost = TFC + TVC and 55.3 man -days,
respectively. Family labour contributes
(3) Stochastic frontier production model was used to majorly to the production of amaranthus, as we know that determine the technical efficiency of the respondents in the amaranthus production is labour intensive because almost studied area. The explicit Cobb-Douglas stochastic frontier all the operations involved in it could be performed production function is given below: manually. The fertilizers used for organomineral farmers Ogunniyi et al. 110

Table 1. Summary statistics of Socioeconomic Characteristics of the Respondents in the study area

Variables	Organominerals		Organic	
	Mean	Standard deviation	Mean	Standard deviation
Output(kg)	41.27	66.34	35.84	
Farm size (Ha)	0.21	0.11	0.20	0.09
Seed (kg)	3.4	1.82	2.95	1.45
Family labor (Man-days)	72.00	20.87	71.34	20.21
Hired labor (Man-days)	49.53	12.04	55.32	8.54
Fertilizer/Manure (kg)	45	22.02	399.29	132.83
Age (years)	43.66	5.37	42.90	4.79
Education (years)	5.16	4.98	4.5	4.35
Household size	6.44	2.15	11	6.33
Experience(Years)	13.48	5.14	12.87	4.64

Source: Field survey, 2013.

Table 2. Total revenue and Total Cost Analysis

Items	Organominerals		Organic	
	Cost(\$)	Percentage	Cost(\$)	Percentage
A. Total revenue	98.80		82.92	
B. Variable cost				
Rent	4.54	6.6	4.78	11.00
Labour cost	7.64	11.2	5.12	11.8
Fertilizer/Manure cost	23.54	34.4	7.12	16.4
Seed cost	19.71	28.8	17.18	39.5
Transaction cost	2.52	3.7	1.91	4.4
Total variable cost	57.94	84.7	36.13	83.0
C. Fixed cost				17.0
Depr. implements cost	10.44	15.3	7.39	4.64
Total cost	68.38	100.00	43.52	100.00

Ranged between 25-100 kg/ha with the mean of 45 kg/ha and between 150-750 kg/ha with the mean of 399.3 kg/ha for organic farmers. The respondents age range between 29-57 years with the mean of 43.7 years for organomineral farmers and between 30-54 years with the mean of 42.9 years for organic farmers, which showed that farmers were in their active age. This is in line with the study of Lakner and Brummer (2008) who reported a mean age of 43.5 years in their study in Germany. The years spent on education ranged between 0-15 years for both organomineral and organic farmers with the mean of 5.2 and 4.5 years, respectively. This indicated that the literacy level of the farmers (organomineral and organic farmers) in the studied area was very low. The household size varied significantly with the mean of 6.4 and 6.3 members for organomineral and organic farmers. The organomineral and organic farmers were well experienced with the mean years of experience of 13.5 and 12.9 years, respectively.

Costs and Return Analysis

The items of costs were divided into fixed and variable costs. The fixed costs included depreciated cost of implements which is \$10.44 for organomineral and \$7.39 for organic farmers while the variable cost items included cost of fertilizer/organic manure, labour, seeds, land rent and transaction cost. Table 2 shows the total variable costs of the materials used for production with a total value of \$57.94 for organomineral and \$36.13 for organic farmers. The total revenue of the organomineral farmers is \$98.80 and \$82.92 for organic farmers while the total cost is the sum of total fixed cost and total variable cost. The total cost of producing amaranthus for organomineral and organic farmers was \$68.38 and \$43.52, respectively. The total percentage of variable cost and fixed cost were 84.7% and 15.3% for organic farmers and 83.0% and 17.0% for organomineral farmers, respectively.

Gross Margins and Net Farm Income Analysis

Table 3 indicates a gross margin of \$40.82 and net farm income of \$30.38 for organomineral farmers and a gross margin of \$46.79 with net farm income of \$39.39 for organic farmers. The result implied that organomineral and organic amaranthus production was a profitable venture in the study area with organic farms being more profitable than organomineral farms.

Profitability Ratios

Table 4 revealed benefit cost ratio of above one (1.71) for

Table 3. Gross Margin and Net Returns Analysis

	Organominerals	Organic
Variables	Average Amount(\$)	Average Amount(\$)
Total revenue	98.80	82.92
Total variable cost	57.94	36.13
Total fixed cost	10.44	7.39
Gross margin	40.82	46.79
Net farm income/Profit	30.38	39.39

Source: Field survey, 2013. (1\$) =
₦160

Table 4. Profitability Ratio

	Organominerals	Organic
Ratio	Value(\$)	Value(\$)
Benefit cost ratio (TR/TC)	1.71	1.91
Rate of return (NR/TC)	0.44	0.91
Gross ratio (TC/TR)	0.64	0.52
Expenses structure ratio (TFC/TC)	0.15	0.17

Source: Field survey, 2013.

organ mineral farmers and (1.91) for organic farmers which indicated that both organic and organomineral vegetable farming were profitable. The rate of returns (ROR) was 0.44 for organomineral and 0.91 for organic farmers and implies that for every one dollar invested on amaranthus production 44cents and 91cents were gained by the respondents. The gross ratio (GR) was 0.64 for organomineral and 0.52 for organic farmers. Also the expenses structure ratio (ESR) was 0.15 for organomineral farmers and 0.17 for organic farmers. The result indicated that on every \$1 returned to organomineral and organic farmers, 69 cents and 52 cents were being spent and 15% and 17% of the

total cost of production was made up of fixed cost items. In essence organic amaranthus production is more profitable than organomineral amaranthus production.

Estimates of the Stochastic Frontier Production Function

The Cobb-Douglas production function was adopted compared to the ordinary least square (OLS) functional form because of the higher number of significant variables. Moreover it depicts scale dynamic clearly unlike the linear functional form which considers only the constant returns to scale which rarely exist in agricultural production. The parameters and related statistical test results obtained from the stochastic frontier production function analysis are presented in Table 5. There is a positive and significant relationship between farm size and vegetable output for organomineral and organic farmers in the area. This is in line with the findings of Kyalo et al. (2009) with farm size significant at 10%, and therefore farm size was a significant factor associated with changes in output for organomineral and organic farmers in the studied area. The coefficient of seeds is positive and statistically significant for both organomineral and organic vegetable output in the studied area. This implies that seed is a positive factor influencing vegetable output for organomineral and organic farmers in the studied area. In other words, the more the quantity of seeds used in kilogram, the more the output of vegetable produced. The estimated coefficients of family labor and hired labor were negatively significant at 1% level, while fertilizer was positively significant at 1% level, in vegetable output for organic farmers. This implied that an increase in the quantity of organic fertilizer used lead to an increase in the output for organic farmers in the studied area. The returns to scale (RTS) for organomineral and organic farmers were estimated to be 0.694 and 0.636 respectively. The result indicated a positive decreasing return to scale in this area, which implied that amaranth production was in stage II of the production region where resources and production were believed to be efficient. This shows that there is more room for expansion of *Amaranthus cruentus* production using either organic or organomineral fertilizer in order for it to actualize its full potential. That is, more of the variable inputs should be employed to achieve more output for organomineral and organic amaranth farmers.

Inefficiency model

The analysis of inefficiency model is depicted in Table 6. The explanatory variables of the inefficiency model show that the signs and significance of the estimated coefficients in the model have important implication on the technical efficiency of the productivity of *Amaranthus cruentus* in the studied area. The estimated coefficient of education is negatively and appropriately signed (*a priori* expectation)

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Table 5. Maximum Likelihood Estimates for Parameters of Cobb-Douglass Stochastic Frontier Function

Variables	Parameters	Organominerals		Organic	
		Coefficient	t-value	Coefficient	t-value
Constant	β_0	4.663	7.33	4.714	23.0
Farm size	β_1	0.245	1.82*	0.254	2.91***
Seed	β_2	0.562	3.82***	0.545	15.0***
Family labor	β_3	-0.008	-0.09	-0.072	-19.0***
Hired labor	β_4	-0.079	-1.03	-0.254	-6.0***
Fertilizer	β_5	-0.026	-0.32	0.163	3.0*
RTS		0.694		0.636	

Source: Field survey, 2013.

* 10%, ** 5% and *** 1% Significance level

Table 6. Inefficiency Model

Variables	Parameters	Organominerals		Organic	
		Coefficient	t-value	Coefficient	t-value
Constant	α_0	6.284	1.55	-0.432	-0.25
Age	α_1	-0.052	-0.50	-0.011	-0.20
Education	α_2	-0.514	-1.90*	-0.031	-0.62
Household size	α_3	-0.244	-1.06	-0.155	-1.15
Experience	α_4	-0.339	-2.92***	.048	1.41
Extension visit	α_5	-0.036	-0.05	-0.909	-2.27**
Sigma σ^2		-4.282	-7.33	-39.33	-0.07
Log likelihood function		15.815		8.215	

Source: Field survey, 2013.

* 10%, ** 5% and *** 1% Significance level

Table 7. Decile Ranges of Frequency Distribution of Technical Efficiency

TE class	Organominerals		Organic	
	Frequency	Percentage	Frequency	Percentage
≤ 0.30	-	-	2	1.4
0.31-0.40	6	6.0	4	2
0.41-0.50	8	8.0	16	11.4

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0.51-0.60	4	4.0	20	14.3
0.61-0.70	9	6.0	24	17.1
0.71-0.80	9	6.0	26	18.6
0.81-0.90	16	16.0	20	14.3
0.91-1.0	54	54.00	28	20
Total	100	100	140	100.0
Mean		0.814		0.706
Minimum		0.375		0.308 1
Maximum		0.999		0.182
<u>Standard deviation</u>		0.182		

Source: Field survey, 2013

In this study and statistically significant for organ mineral farmers and insignificantly for organic farmers. This implies that the technical efficiency tends to increase with increase in the years of schooling of organ minerals' farmers. The estimated coefficient of farming experience is negatively and statistically significant at 1% level for organ mineral farmers and insignificantly for organic farmers, which indicated increase efficiency in production. Also, the negative sign of extension visit indicated that inefficiency in production of amaranth farmers tends to decline with an increase in extension visit. The negative sign of variables in inefficiency model means that these variables are positive determinants of technical efficiency of the productivity of amaranth in southwest Nigeria. This implied that increases in the aforementioned variables will results to a reduction in technical inefficiency of amaranth farmers. The log likelihood functions for organ mineral and organic farmers were estimated to be 15.815 and 8.215 respectively. This value represents the value that maximizes the joint densities in the estimated model.

Technical Efficiency Scores

The distribution of the respondents' Technical efficiency (TE) class interval is presented in Table 7. The result revealed that the TE indices for both organomineral and organic farmers varied widely with a minimum of 0.375 and 0.308 and the maximum of 0.999 and 1.00, respectively. The average TE for both organomineral and organic farmers was 0.814 and 0.706, respectively. This indicated that if average farmer in the sample was to achieve TE level of its most efficient counterpart, then average farmer could realize 18.6% and 29.4% cost saving, respectively. Technical efficiency indices of both organomineral and organic farmers are closely clustered between 0.91 and 1.0. This also indicates that

there is a wider distribution of technical efficiency among the organomineral and organic farmers in the study area. The result negated the findings of Poudel et al. (2012) with 45% TE between 0.90-1.00, in their work of comparing the technical efficiency of organic and conventional coffee farms in Nepal using data envelopment analysis (DEA) approach.

Conclusion

In conclusion, *Amaranthus cruentus* production is a profitable venture, though they are highly perishable, but good for human diet as they are source of vitamins; therefore efforts should be made in expanding the scale of production throughout the year; farmers should improve their educational status through adult education as this will help them to increase their efficiency.

Competing interests

The authors declare that they have no competing interests.

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