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DIFFERENTIALS IN PRODUCTION EFFICIENCY AMONG ORGANIC AND INORGANIC VEGETABLE FARMERS IN ABIA STATE NIGERIA: A STOCHASTIC PRODUCTION FUNCTION APPROACH

Obasi, I.O. and Nwaogu, D.C
Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria
Corresponding Authors' email: danielchinedu32@gmail.com

ABSTRACT
The study examined the production efficiency differentials between organic and inorganic fertilizer vegetable farmers in Abia state, Nigeria. Farm-level data were obtained from 144 farm households in the state. The Cobb-Douglas stochastic production function was estimated for output and technical efficiency in single maximum likelihood estimation. The organic and inorganic farmers were able to obtain 93% and 72% of potential output from a given mixture of production inputs. The use of inorganic fertilizer had a negative relationship with output and technical efficiency of the inorganic farmers implying over-utilization of the resource while organic fertilizers and pesticides had a very strong positive effect on output of the organic farmers. It is recommended that adequate extension services geared towards enlightening the farmers on the productivity and health benefits of organic fertilizers' use be vigorously pursued. Government should make available organic pesticides and fertilizers to farmers at low costs as this will encourage organic farming in the study area. Concerted efforts and public enlightenment on benefits of organic farming practices and controlled inorganic farming methods are also recommended.

Keywords: Production, efficiency organic and inorganic, and vegetable farmers.

Introduction

Vegetables are important agricultural commodities for human consumption and industrial uses. Vegetables being a major part of Nigerian subsistence farmer's activity, serves various purposes for mankind; be it as food or as source of livelihood, their importance cannot be over emphasized as vegetable crops have been well advocated in solving the problem of food security (Abdullahi and Kutama, 2012). Changes in dietary habits, major food safety concerns, and greater personal health awareness have led to greater consumer interest in documentation of production practices for fresh fruits and vegetables.

Due to the rapid growth of the population with reduction in land, in order to feed the population, the only solution is the vertical expansion or by increasing the productivity per unit area per unit time as the potential available land and water resources and technology still remain unexploited (Delate, *et al*, 2003). These factors culminated to the use of synthetic farm inputs in growing foods with many health- related challenges.

However, over the years, awareness on the health implications of consuming synthetically grown and other inorganic foods has led to a surge in the consumption of organic vegetables (Steven McCoy, 2001). This fact is attributed to the increasing rate of nutritional diseases, cancer and food poisoning associated with consumption of agricultural products produced using synthetic inputs; thus, there has been a sudden growing interest of consumers on organic vegetables which has in turn directed farmers' attention towards organic farming (Reichard*et al*; 2000). But this fact has been largely limited to developed countries of the world.

Organic vegetable production is a system based on the principle of taking care of nature accounting all life forms by combining best environmental practices, thus engendering the preservation of natural resources (Pandel*et al*, 1994). This agricultural practice is economical and health-wise because it does not use costly synthetic and harmful toxic chemicals (Hamzaoui*et al*, 2009). There are many variants of organic farming in the rural farming environment ranging from use of animal dung, domestic waste, dried field wastes to some processed organic fertilizers and production systems and techniques.

Against this backdrop, the market for organic foods has been steadily increasing during the last decade, and recently, interest for fully organic products has increased. So, for example, whereas farmers using conventional methods might spray synthetic chemical fertilizers to promote plant growth, organic farmers would, instead, apply natural fertilizers such as manure or compost to feed the soil and the plants. Where the conventional farmer would use insecticides for pest control, the organic farmer would make use of beneficial insects, birds or traps. And where the conventional farmer might use herbicides for weed control, the organic farmer would rotate crops, till the dirt and hand-weed or mulch to manage the weeds (Savci, 2012). This study aims at examining the production and efficiency differentials of organic and inorganic vegetable farmers in Abia state, Nigeria.

Methodology

Study area

The study was conducted in Abia state of Nigeria. Agriculture is the major occupation of the people of Abia State. Cash crops, such as oil-palm, cocoa and rubber are produced while food crops such as yam, cassava, plantain and maize are produced in large quantities. Multi-stage random and purposive sampling techniques were adopted in collecting data for this research. Data were obtained from a sample of 144 farm households made up of 72 organic and inorganic vegetable- based farmers each. Two LGAs were sampled from each of the 3 agricultural zones giving 6 LGA, from where 2 communities were randomly sampled to giving 12 communities. From the 12 communities, 2 villages were purposively sampled giving 24 villages, from where 3 farmers practising organic farming and 3 farmers practising inorganic farming were purposively sampled giving a total of 144 farmers for detailed study.

Analytical framework

In order to estimate the production function and technical efficiencies of the organic and inorganic farmers, the Cobb-Douglas form of the Stochastic Production Function was employed. Generally, a stochastic frontier production function is defined by:

$$Y_i = f(X_i; \beta) \exp(V_i - U_i),\ i = 1, 2, \dots, n \qquad (1)$$

Where Y_i is output of the i^{th} farm, X_i is the vector of input quantities used by the i^{th} farmer, β is a vector of unknown parameters to be estimated, f( ) represents an appropriate function (e.g Cobb Douglas, translog, etc). The term V_i is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer e.g. weather, disease outbreaks, measurements errors etc., while the term U_i is a non-negative random variable representing inefficiency in production relative to the stochastic frontier.

The technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology. Thus:

$$\text{Technical efficiency (TE)} = Y_i/Y_i^*$$
$$= f(X_i; \beta) \exp(V_i - U_i) / f(X_i, \beta) \exp(V_i) - \exp(-U_i) \qquad (2)$$

Where Y_i is the observed output and Yi^* is the frontier output. The parameters of the stochastic frontier production function are estimated using the Maximum Likelihood method. For the purpose of this study, the production technology of vegetable farmers in Abia State, Nigeria is assumed to be specified using the Cobb-Douglas production frontier as follows (Onyenweaku and Okoye, 2007):

$$LnQ = b_0 + b_1 lnX_1 + b_2 lnX_2 + b_3 lnX_3 + b_4 lnX_4 + b_5 lnX_5 + V_i - U_i \ (4) \qquad (3)$$

Where,

Q = Total Revenue from sales of vegetables (₦)

X_1 = Seedlings (₦)

X_2 = Labour input (man days)

X_3 = Farm size (Hectares)

X_4 = Fertilizer (Kg)

X_5 = Capital (made up of depreciation charges on farm tools/equipment, interest on borrowed capital, taxes and insurance measured in naira, ₦)

$b_1 - b_5$ = Coefficients of the parameters to be estimated

Vi – Ui = as earlier stated

In order to determine factors affecting the technical efficiency of the vegetable farmers in the study area, the following model was employed:

$$TEi := a_0 + a_1Z_1 + a_2Z_2 + a_3Z_3 + a_4Z_4 + a_5Z_5 + a_6Z_6 + a_7Z_7 + a_8Z_8 + a_9Z_9 + a_{10}Z_{10} \qquad (4)$$

Where,

TE_i = Technical efficiency of the i^{th} vegetable farmer

Z_1 = Farmer's age (Years)

Z_2 = Farmer's level of education (Years)

Z_3 = Number of extension contacts with the farmer in a year

Z_4 = Household size

Z_5 = Farm size (Ha)

Z_6 = Farming experience (Years)

Z_7 = Number of days of incapacitation due to illness

Z_8 = Fertilizer (Kg)

Z_9 = Credit used (₦)

Z_{10} = Cooperative membership (Dummy: Yes=1, otherwise=0)

$a_0 \dots a_{10}$ = Coefficients of efficiency parameters to be estimated.

Results and Discussion

Determinants of output of the organic and inorganic Farmers

To determine the factors affecting the output of the vegetable farmers, the Cobb-Douglas model was estimated and the results are presented in Table 1 for the organic and inorganic farmers. This result shows that 19.6% and 78.7% of random variation in the yield of the organic and inorganic farmers respectively, was due to the farmers' inefficiency in their respective sites and not as a result of random variability. The estimated 0.645 and 0.845 production elasticity of seed for organic and inorganic farmers implies that increasing seed by 1% would increase crop output by 0.74% and 0.99% (less than 1%) which implies, all things being equal, the output is inelastic to changes in the quantity of seed used. The higher coefficient for inorganic farmers implies that the potentials of vegetable seeds have not been used to optimality, probably as a result of the poor condition of the soils. If adequate seed rates and quality seeds are not used, output will be low even if other inputs are in abundance (Sanni, 2015).

The coefficient of labour was 0.189 and 0.305 for organic and inorganic respectively which are positive and statistically significant at 1% level. This corroborates studies such as Sanni (2015), Umoh (2006), Okoye *et al.* (2006) who showed the importance of labour in farming, particularly in developing countries where mechanization is rare on small scale farms. The production elasticity of output with respect to quantity of organic fertilizer was positive (0.060) for organic farmers and negative (-0.130) for inorganic farmers at 1% and 10% statistically significant levels respectively. This implies that a 1% increase in organic fertilizer would increase organic farmers' output by 0.060% and reduce inorganic farmers' output by 0.130%. This reduction in output may be attributed to over-utilization of the input characterizing inorganic farmers. However, fertilizer is a major land-augmenting input because it improves soil quality and raises yields per hectare. This result is in agreement with the findings of Sanni (2015), Okoye *et al.* (2006) but disagrees with the findings of Onyenweaku and Okoye (2007), whose findings were in contrast.

Technical Efficiency of vegetable- based Farmers

Determinants of Technical Efficiency

The factors that influenced the technical efficiency of the farmers (organic and inorganic) are presented in Table 3. The positive coefficient of education for organic and inorganic farmers (0.039 and 0.197) implies that increasing knowledge through education will increase the farmers' technical efficiency by 0.039 and 0.197% respectively. This finding is in line with Okoye *et al.* (2006) and Nwaru *et al.* (2011) who indicated that farm level technical efficiency could be increased by additional investment in education, including schooling and training/orientation. The coefficient (0.203) for farm size was positive for organic farmers implying that technical efficiency will increase by 0.203 unit with a one unit increase in farm size. According to economic theory and in line with Onyenweaku and Okoye (2007), large farmers are usually more educated, and have more access to credit, land, and other production inputs and adopt agricultural innovations more than small farmers. These in turn make for better farm efficiency.

The coefficient for fertilizer (0.785 and -1.298) was positive for organic farmers and negative for inorganic farmers. Inorganic fertilizer, an improved technology, shifts the production frontier upwards leading to higher technical efficiency. There is likelihood that continuous application of fertilizer on farmlands would threaten the existence of soil micro flora and fauna which are responsible for plant growth and as such, additional fertilizer input could increase technical inefficiency of the inorganic farmers while additional organic fertilizer input will increase the TE of organic farmers. Additionally, Age, household size, extension visits, farming experience were negatively significant implying that an increase in these variables will negatively influence the farmers' efficiency. However, the coefficients of extension visits and farming experience being negative were against *a priori* expectation but may be a result of the farmers not maximizing these to enhance their efficiency. The coefficients of days of incapacitation and credit amount used were significant factors that influenced the organic farmers' efficiency. While amount of credit used agreed with *apriori* expectation, days of incapacitation was contrary to it which may be because the days of incapacitation of the farmers may have made the farmers to harder and more efficiency to ameliorate the effect of the incapacitation.

Conclusion

From the results, the study has further affirmed the need to revert to the use of organic fertilizers to boost food production and security. Interestingly, the disparity between the technical efficiency indices for organic and inorganic was not particularly as yawning as it ordinarily should have been, probably due to the level of use of the organic fertilizer and the inherent challenges in its access. These facts nonetheless cannot cancel the imperatives of developing a policy framework that will discourage to the barest minimum the use of inorganic fertilizers for improved food production while obscuring the health hazards associated with the consumption of chemical-fertilizer produced foods. Government should make available organic pesticides and fertilizers to farmers at low costs as this will encourage organic farming in the study area. An integrated rural development action plan capable of bringing about improvement in the market of these organically produced vegetables needs to be enunciated and implemented while concerted efforts at public enlightenment on inorganic fertilizers health-related matters will also be very useful in putting the rural farmers on their guard against associated ill-health conditions.

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Table 1: Maximum likelihood estimates of the Cobb-Douglas stochastic frontier production function for organic and inorganic vegetable farmers in Abia state Nigeria

	Organic farmers			**Inorganic farmers**		
	Coefficient	**Std. error**	**t-ratio**	**Coefficient**	**Std. error**	**t-ratio**
Intercept	11.717	0.309	37.910***	11.171	0.993	11.244***
X_1 = Seedlings	0.645	0.045	14.288***	0.845	0.061	13.948***
X_2 = Labour	0.189	0.006	32.332***	0.305	0.078	3.893***
X_3 = Farm size	-0.177	0.009	-20.64***	-0.255	0.064	-3.973***
X_4 = Fertilizer	0.060	0.002	29.191***	-0.130	0.074	-1.742*
X_5 = Capital inputs	-0.144	0.046	-3.139***	0.057	0.113	0.501
sigma-squared	0.111	0.008	13.470***	0.284	0.026	10.835***
Gamma (γ)	0.196	0.044	4.476***	0.787	0.022	35.741***
LR test	378.801			-106.478		
LL function	-87.406			387.210		
Mean efficiency	0.93			0.72		

Source: Field survey data, 2017

***, ** and * represent significant at 1%, 5% and 10%, respectively.

Table 2: Maximum Likelihood estimates of the determinants of technical efficiency of organic farmers

	Organic farmers			Inorganic farmers		
	Coefficient	**Std. error**	**t-ratio**	**Coefficient**	**Std. error**	**t-ratio**
Intercept	0.174	0.188	0.929	-3.1689	1.4132	-2.2424**
Z_1 = Age (Years)	-0.006	0.003	-1.953*	-0.0710	0.0192	-3.701***
Z_2 = Education	0.039	0.005	7.73***	0.3066	0.0640	4.7871***
Z_3 = Extension visits	-0.097	0.007	-14.79***	0.0680	0.1511	0.4504
Z_4 = Household size	-0.075	0.024	-3.171***	0.1050	0.0754	1.3930
Z_5 = Farm size (Ha)	0.203	0.105	1.941*	-0.5736	0.1617	-3.548***
Z_6 = Experience	-0.023	0.004	-5.295***	0.1292	0.0324	3.9928***
Z_7 = Incapacitation	0.026	0.002	12.479***	-0.2676	0.0603	-4.435***
Z_8 = Org. Fert. (Kg)	0.785	0.116	6.757***	-3.1508	0.5389	-5.847***
Z_9 = Credit (₦)	0.230	0.086	2.659**	-0.1493	0.3672	-0.4065
Z_{10} = Coop memb.	0.022	0.036	0.596	2.5627	0.5654	4.5323***

Source: Field survey data, 2017

***, ** and * are significant at 1%, 5% and 10% respectively