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RESOURCE USE EFFICIENCY IN ORGANICALLY PRODUCED FLUTED PUMPKIN AMONG SMALL HOLDER FARMERS IN ANAMBRA STATE, NIGERIA

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Abstract

As against conventional produce, certified organic produce gives higher net incomes, but fewer farmers engaged in its production. Efficient allocation of resources at the farm level has implications for investment, as it evaluates the success of production units, thereby enabling the formulation of sound policies. Thus, the technical and allocative efficiency (TAE) of organically produced Fluted Pumpkin farmers were examined in Anambra state, Nigeria. Three-stage sampling technique was used. Awka South, Anaocha, Ogbaru, Anambra west, Idemili North and Ihiala, Local Government Areas (LGAs) were purposively selected due to high number of organic vegetable producers. From each LGA, three villages were then randomly selected. Ten farmers were then selected by random sampling technique. Thirty farmers were sampled per LGA, totalling 180 farmers with the aid of structured questionnaire. Ordinary least square was employed to estimate the Cobb-Douglas production function (CPF) from the farm production data. The TAE were estimated using Ordinary Least Square regression. The summation of the CPF factors coefficients (1.90) implied that farmers were operating in the increasing returns to scale stage. Resources were managed inefficiently as underutilization was established. There are gaps in resource use efficiency. Mechanization, access to productive resources, increase land use intensity and training were recommended to improve efficiency.

Keywords: Organic, fluted Pumpkin, production efficiency, Nigeria

INTRODUCTION

Organic farming advocates healthy farm products. It depicts the practices of using green manure, crop rotation, compost, crop rotation technique, biological pest control, and mechanical cultivation in maintaining soil productivity and control pests, excluding the use of inorganic pesticides, fertilizers, plant growth enzymes, genetically modified crops and animals and livestock feed additives, (Toungos &Tanko, 2018).

The goals motivating organic farmers were production of contaminant-free foods, reduced exposure to harmful chemicals, and price incentives. Most studies on farm resource use efficiency contrast the conventional against the organic farming method. Comparing organic farming with conventional farming systems, showed organic farming to be more resilient to changes in weather conditions. Meta-analysis studies have shown organic farms to sustain 30% more biodiversity than conventional farms (Tsiafouli *et al.,* 2015). Organically grown crops were more resistance to pests and diseases due to greater soil microbial biomass slower growth of the plants, and improved soil quality. In addition, organic systems enable crops to develop its own chemical defenses against pests and diseases and enhanced biodiversity. Also, organic farming reduces runoff and increases infiltration and reduces soil erosion and prevents flooding. Certified organic farmers sell their farm produce at higher prices, despite their lower input costs resulting in higher net incomes compared to conventional agriculture. Conventional farmers depend solely on products supplied by agrochemical companies and are obliged to pay fixed prices, but organic farmers have greater sovereignty and better control on their production processes and the associated costs (Trewavas, 2002; Andres and Bhullar, 2016; Hendrani 2022).

Fluted pumpkin (*Telfairia occidentalis*) is an important tropical vine that belong to the family *Cucurbitaceae* (Time &Chikezie, 2016). It is a very important vegetable crop cultivated in the eastern Nigeria both for its leaves and edible seeds (Annih etal, 2020). Fluted pumpkin is highly nutritious and medicinal; it improves blood production, fertility and useful in the treatment of convulsion (Ibironke and Owotomo, 2019). It contains 39.2 percent crude protein, which is 9.5 percent, 18.11 percent, and 8.2 percent higher than the crude protein in Amaranthus (sp.), *Talinum triangulare* and *Solanum marcrocarpon* (L.) (Meemken and Qaim, 2018). It also plays an important role in high income generation and employment generation for the rural farmers (Time and Chikezie.2016). The oil of Fluted Pumpkin oil has high molecular weight fatty acids; therefore, it is a good feedstock, and can be used for candle and soap production (Meemken and Qaim, 2018).It equally has a high unsaturated fatty acid, therefore its use for cooking-oil or margarine production. Fluted Pumpkin oil is better for human consumption than palm oil because of its lower saponification value and a higher specific gravity. It is richer in iron than other leafy vegetables with dry matter concentration of 969.92 mg·kg_1 (Mariette and Kebei, 2020).

Farmers in Nigeria preferred to expand their farmland to achieve their household's food security. This practice is a factor of environmental degradation and weather variability, (Piedra-Bonilla et, al,.2020).. Farming practices and the use of farming technology in Nigeria is at lower level of development despite the country's potential of producing adequately for her market. This is achievable if proper research-based assistance is provided to the farmers, to increase productivity and efficiency of factors of production, thus, to adequately design better policy measures to increasing productivity, it is important to understand how to efficiently allocate resource in farm enterprises**.**

Theoretical framework for production function, short run output production theory

The firm as a unit of production manage production process by engaging entrepreneur with the objective of profit maximization. In agriculture, the physical inputs are usually land, labour, capital, management, and water resources. The production function stipulates that technical relationship between inputs and output in any production process is based on the follow assumptions: Input and output are nonnegative (q≥0), there is technical efficiency (any combination of inputs generate maximum output possible; a production function is single valued continuous and twice differentiable, a production function is characterized by diminishing marginal productivity. Diminishing marginal productivity reduces the rate of technical substitution and increases the rate of product transformation. there is decreasing return to scale ($Eq < 1$), inputs and outputs are perfectly divisible, a production function is chosen (assumed) to be constant overtime and is not random (probability of occurrence is one).

$Q = f(X_i \dots \dots \dots .. X_n)$ ………………….. (1)

$Q =$ output of fluted pumpkin

X_i, i = 1, 2….n where X_i are variable inputs. This shows the path of the locus of maximum output that can be produced at every level of variable inputs

Factor - product relationship

$Q = f\ (X_1/X_2\ \dots \dots .X_n)$………………… (2)

Where $Q =$ output of fluted pumpkin

X_i is varied input of capital services

$X_2\ X_3 \dots \dots \dots .. X_n$ are fixed amount of inputs

The singular concern of the factor product relationship is essentially that of the transformation of single factor into single product. For practical purpose, therefore the relevant short run production function will be of form

$Q = f(X_i)$ ……………….........................(1)

$\frac{\partial q}{\partial x} = f(x)$ - Marginal physical product (MPP)

$\frac{Q}{X} = \frac{f(x)}{X}$ – Average product (AP)

If we employ these two measures as the frame of reference, we can undertake a quantitative interpretation of the three stages of production.

Technical efficiency

Efficiency implies the realization of a production goal of output maximization without waste.

The producer production efficiency is of the ratio of observed output, cost or profit to potential output, minimum cost, or maximum profit that a producer can attain (Ferdushi, *et al* 2013). Consequently, agricultural sector policies are targeted at eliminating constraints to increased productive efficiency. These constraints among others include high price and inadequate inputs such as fertilizer (manure), vegetable seeds, herbicides, insecticides, lack/ inadequate access to farm credits, land tenure, extension services, irrigation facilities and poor rural infrastructure, market failures and poor store facilities (Nwinya, Obienusi and Onouha, 2014). Farrell (1957) identified three types of efficiency namely: Technical Efficiency (TE): the ability of an entrepreneur to produce the maximum possible output from a given level inputs or using the minimum feasible quantity of inputs in producing a given level of outpuAllocative/ Price Efficiency (AE): the ability of a technically efficient an entrepreneur to use inputs in proportions that minimize production costs at a given input price and Economic Efficiency /Overall Efficiency (EE): an entrepreneur attained both technically and allocative efficiency. Economists' argument is the achievement of greater efficiency from scarce resources therefore, the need for firm's efficiency calculations. Parametric and nonparametric approaches were the two common approaches for estimation of efficiency in the literature. Parametric methods entail ordinary least square (OLS) and the stochastic frontier (SF) models that were components of classical regression estimation procedures (Aigner, Lovell and Schmidt, 1977; Rapu, 2016) unlike commonly used nonparametric approach; data envelopment analysis (DEA) first used by Charnes, Cooper and Rhodes (1978). Data envelopment analysis uses linear programming procedure as its estimation procedure.

METHODOLOGY

Sampling technique and sample Size

Multistage sampling technique was adopted for the study. In the first stage, the study purposively selected Ogbaru, Anambra west, Ihiala, Awka South, Idemili North and Anaocha Local Government Areas (LGAs). Enquiries from Anambra State Agricultural Development Program (ASADP, 2019) showed high dominance of organic farmers involve in fluted pumpkin production in these areas. In the second stage, three (3) villages were randomly selected from each LGA and in the third stage; ten (10) organic pumpkin farmers were randomly selected. Total of thirty (30) farmers were sampled per LGA, in all, one hundred and eighty (180) were sampled. Structured questionnaire was used to collect data on farmers' characteristics, farm enterprises and farmers' challenges. Data were analyzed using

Analytical Framework

Measurement of Technical efficiency

The production function summarizes the conversion of inputs of land, labour, capital, management and water resources into outputs of goods and services and stipulates that technical relationship between inputs and output in a production process. Technical efficiency depicts ratio of output to the factor inputs Sadhu and Singh (1995; Owusu-Ansah Aneani, 2011)

The production function approach is commonly employed to examining the effect of physical inputs on output. A stochastic frontier model (Cobb-Douglas production function) is specified as Battese and Coelli, (1995; Owusu-Ansah Aneani, 2011)

Yi = Xi β_0 + e_i ……………….. (3)

Where,

Yi = output of Fluted pumpkin farmer

Xi = a (1 x k) vector of farm inputs (in natural logarithm)

β = a (k x 1) vector of parameters to be estimated

e_i error term = vi – ui

vi = the random variation in output (Yi) by factors beyond the control of the farmer examples are weather and natural disasters.

µi = the factors (within the farmer's control) that were responsible for his inefficiency example is management.

vi is assumed to be identically and independently distributed as N (0, δv^2) random variables, independent of ui which is truncated normally at zero. ui is independently, but not identically distributed. The technical inefficiency can only be estimated if and only if the efficiency effects are present. With the absence of one-sided error term in the production function then the model is an ordinary production function, that can only be estimated by Ordinary Least Squares (OLS) regression, but if ui is present it is justifiable to employ the stochastic frontier approach.

A Cobb-Douglas production function was fitted to the stochastic frontier production and estimated. The specified multiplicative production function was:

$Q = A. X_1^{\beta 1}. X_2^{\beta 2}. X_3^{\beta 3}. X_4^{\beta 4}. X_5^{\beta 5}. e$ ……………………………. (4)

The linear transformation of equation (4) by taking the natural logarithm of the two sides of the equation (4) to give equation (5).

In Q = β0 + β1 InX1 + β2 InX2 + β3 InX3 + β4 InX4 + β5 InX5 + β6 InX6 + e …………… (5)

Where:

Q_i = Fluted pumpkin output (Kg), X1 = farm size (X_i), Labour-man-days (X_2), organic fertilizer in Kilograms (X_3), Education in years (X_4) , Farming experience(X_5) and Harvesting rate(Counts) (X_6) farm size (X_i), Labour-man-days (X_2), organic fertilizer (X_3), Education in years (X_4) , Farming experience(X_5) and Harvesting rate(Counts) (X_6) farm size (X_i), Labour-man-days (X_2), organic fertilizer (X_3), Education in years (X_4) , Farming experience(X_5) and Harvesting rate(Counts) (X_6) βi = Parameters (elasticities) to be estimated; e = error term,

defined in equation (1). The technical efficiency of a firm is defined in terms of the observed output (Y_i) to the corresponding frontier output (Y_i*) given the available technology, that is, $TE = Y_i/Y_i*$ (Agom, Ohen, Itam, and Inyang, 2012; Rapu, 2016). In this study, a Cobb-Douglas function was fitted to the production function of the farmers using the Ordinary Least Square model. In this study, Cobb Douglas and maximum likelihood was used to estimate resource use efficiency in organically produced fluted pumpkin among small holder farmers in Anambra state.

Economies of scale

Increase factors of production, implies a change in the scale of operations (economies of scale). This change in economies of scale would lead to one of these outcomes: For constant returns to scale, $\sum \beta xi$ = 1, implies that increasing all the inputs by a factor of *n*, will increase the output by a factor of *n*. For increasing returns to scale, $\sum \beta xi$ > 1, implies that increasing all the inputs by a factor of *n*, will increase the output by an amount greater than *n*. For decreasing returns to scale, $\sum \beta xi$ < 1 implies that increasing all the inputs by a factor of *n*, will increase the output by an amount less than *n*.

Estimation of allocative efficiency was done using marginal analysis, the ratio of marginal value of product (MVP) and marginal factor cost (MFC). A ratio of each factor indicates an efficient utilization of resource provided its marginal value product (MVP) is equal to its marginal factor cost (MFC)

(Sadhu, and Singh, 1995; Ogundari, 2008). MVPi = MFCi = Pxi
efficiency utilization of resource was determined by the ratio of MVP to MFC of inputs
from the estimated regression coefficients. The efficiency of resource utilization, r, was
calculated as Onyenwaku, **(**1994), **r** = MVP/MFC ……………………………………… (5)
when r = 1, implied efficient use of a resource; r > 1, implied underutilization; while r < 1, implied over utilization of resource. The values of MVP
and MFC were estimated as follows:
MVP = MPP. PQ
MPP = _Q/Xi
MPP = βi. Qm/Xmi
MFC = Pxi
Where,
r = efficiency ratio
MVP = marginal value product of input
MPP =marginal physical product
MFC = marginal factor cost
Pxi =Unit price of input Xi
Ym = mean value of output
Xmi = mean value of input considered
PQ = unit price of output
βi = output elasticities.

RESULTS AND DISCUSSION

Functionality

Table 1 presented the result of the Ordinary Least Square (OLS) estimates of Cobb-Douglas production function. Estimation of the stochastic frontier model based on Cobb-Douglas production function failed due to the absence of the one-sided error term, μ_i, in the model. This is shown by sigma-squared (δ^2) and gamma (γ) that were statistically insignificant in (Table 3). Therefore, the ordinary least square model adequately estimated the data (Idiong 2007; Udoh and Etim, 2008; Owusu-Ansah Aneani, 2011). Consequently, fluted pumpkin production function was estimated using the OLS regression analysis which is adequate. The F-test was statistically significant at the 1% level, this implied the existence of production function where all the independent variables jointly explained the variations in the output. The R-squared was 0.93, indicating 93% variation in the fluted pumpkin output was explained by the independent variables in the model. Durbin-Watson value of 2.48, it implies the absence of first order serial autocorrelation. Four explanatory variables out of six were significant. These were farm size (X_1), labour (X_2) and price of organic fertilizer (X_3) were statistically significant at the 1% level, but farming experience was statistically significant at the 10% level. education and harvesting rate were positive, but not significant. The equation is presented as: $Y=1.24+0.03\ln X_1+0.32\ln X_2+0.31\ln X_3+0.22\ln X_4+0.16 X_5+0.51 X_6$ The coefficients estimated the elasticity of fluted pumpkin output. For instance, a 1% increase in farm size, labour and organic fertilizer resulted in 3 %, 32 % and 31%, increase in fluted pumpkin output, respectively. All variables had positive relationship with output showed that as their quantity used increase, yield of fluted pumpkin will equally increase. The increased output is assumed to keep the costs and other inputs at their mean levels. Summation of the coefficients gave an estimated return to scale of 1.9 which was greater than one, this implies that as all the variables included were increased, there would be more than a single unit increase in yield (increasing returns to scale).

Table 1: Ordinary Least Square (OLS) estimates of Cobb-Douglas production function

Variable	Coefficient	Standard Error
Intercept	1.24	0.33
Farm size (ha) X_1	0.03***	0.01
Labour(man-days) X_2	2.10***	0.17
quantity of organic fertilizer (kg) X_3	0.31***	0.10
Education (Years) X_4	0.22	0.03
Farming experience (Years) X_5	0.16*	0.06
Harvesting rate (Counts) X_6	0.50	0.74
R	0.95	
R^2	0.93	
F Ratio	52.76	14.19***
Durbin-Watson	2.48.	

* sig. at 10 % level, ** sig. at 5% level, ***sig. at 1% level

Price efficiency of resource utilization*:* The efficiency of resource utilization among farmers was presented in Table 2. The efficiency ratio compares the MVP with the MFC. This gives the opportunity cost of the input. Efficiency ratio of 1 implies efficient producers because the MVP is an indicator of what the use of an additional unit of the input will add to the output. An efficiency ratio of more than 1 implies overutilization, while a value of efficiency ratio less than 1 implies underutilization. To ascertain if resources were efficiently utilized the marginal value products of land, labour and organic fertilizer were calculated and compared with their marginal factor products. The marginal value product of labour was less than its marginal factor product this showed that labour was under-utilized. This maybe because most of the producers were female, who pampered hired labour that were mostly men, so that they will be ready to work for them any other time their services are needed. Also, the enterprise is labour intensive, without mechanization, therefore the efficiency level is lowered. Equally, female farmers are not in control of the production resources, therefore, they are constrained in transforming the production efficiently. The use of labour for clearing, weed, irrigation and harvesting were inefficient underutilization. Use of additional unit of labour will increase the output than the cost of hiring the labour therefore, more labour should be hired since the producer stands to benefit more from additional units of the labour used. The marginal value product of land and organic fertilizer were equally less than their respective marginal factor products this implied that land and organic fertilizer were underutilized in the study area. The use of additional unit of these inputs will increase the output than the cost of the inputs. This agrees with the work of HendranNugraheni & Karliya, (2022). The results showed that producers were most efficient in the use of organic fertilizer.

Table 2: ***Price efficiency of resource utilization***

Resource	MFC	MPP	MVP	Efficiency ratio
Farm size	5000	71.03	689.02	2.3 $\times 10^{-5}$
Labour X_2 (man-days)	4000	221.02	773554.77	5.17 $\times 10^{-3}$
Organic fertilizer X_3 /kg	4.31	0.05	3.30	0.77

Table 3 Maximum likelihood estimated parameters of the Cobb-Douglas function (stochastic production frontier)

Variable	**Coefficient**	**Standard Error**	**T- value**
Intercept	4.50	0.39	11.6
Ln Farm size β_1	0.45	0.10	4.56***
Ln labour β_2	0.30	0.09	3.33***
	0.33	0.11	2.90***
Ln Organic Fertilizer β_3			
Ln Weeding rate β_4	0.21	0.17	1.21
Ln Harvesting rate β_5	0.26	0.08	3.25***
Seed β_6	0.32	0.11	2.96***
Inefficiency functions			
Intercept	2.01		36.50
Age	-0.002	0.01	0.27
Farming experience	-0.67	1.0 x 10^{-3}	2.66
Education	0.03	5.9 x10^{-3}	3.60
Sigma square (δ)	0.32	0.30	1.07
Gamma (γ)	0.53	0.91	0.59
Log-likelihood function	-28.592		
L R Value	0.08		
L R Statistics	3.5		

* Significant. at 10 % level, ** sig. at 5% level, ***sig. at 1% level.

Technical efficiency of fluted pumpkin farmers

The maximum likelihood estimates of the parameters of the stochastic production frontier identified farm size, labour, organic fertilizer, weeding rate, harvesting rate and seed as important variables influencing technical inefficiency. The variance ratio (γ) = 0.53 indicate that farm specific factors contributed to the variation in yield. The (γ) value implies that majority of the total variation in output from the frontier is attributable to technical inefficiency. Fifty-three percent of the difference between the observed and maximum production frontier output were due to difference in producer technical efficiency. Most of the variation in yield was due to factors under the farmer's control. To increase technical efficiency of farmers the influence of these variables should be reduced. That the sigma square value of 0.32 is not significantly different from zero signified that Ordinary Least Square (OLS) estimates is adequate for this analysis. The negative sign of the coefficient of inefficiency function implied that as farming experience and farmer's age increases the efficiency level of farmers improves, and that older farmers with enough farming experience were more efficient than young farmers that were just entering into the enterprise this corroborate the work of (Ayanwale, and Abiola, 2008). The positive sign of the coefficient of education implies that with increase in formal education in the efficiency level of farmers decreases. This implies that training is the most important factor rather than formal education. The inferences from these observations were that even the most efficient producer could improve efficiency by training on the job, availability of inputs and returning to improve the allocative efficiency.

CONCLUSION AND RECOMMENDATIONS

The role of organically produced vegetable in the nutrition and health of human cannot be over emphasized. It is therefore important that farmer's production should be efficiently done This study estimated resource use efficiency of organically produced fluted pumpkin in Anambra state, Nigeria. The findings revealed that the resources were inefficiently utilized; labour, land and organic fertilizer were underutilized in the study area. This study established gaps in resource use efficiency in the production of organic fluted pumpkin. The following recommendations were made to improve resource use efficiency:

1. Mechanization of the enterprise should be encouraged by stakeholders.
2. Female farmers that were the main producers of fluted pumpkin should be able to access the required production resources through the agencies of government and other stakeholders.
3. Increase land use intensity by farmers and reduce the long period of land fallowing during raining season because cultivation is majorly in waterlogged area that can be used only during the dry season.
4. Notwithstanding the farmer's formal educational level, they should be taught better resource management practices to ensure optimal utilization of resources.

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