Journal of
Agriculture Policy
(JAP)

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CARI Journals

Journal of Agricultural Policy
ISSN: 2520-7458 (Online)
Vol.5, Issue No.1, pp 1 – 23, 2022
www.carijournals.org

# Analysis of Technical, Allocative and Economic Efficiencies of Vitamin A Cassava Farmers with other Improved Cassava Farmers in Benue State, Nigeria

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**Abstract**

**Purpose**: Despite that cassava is important economically and nutritionally, a gap exists between its demand and supply. Consequently, analysis of technical, allocative and economic efficiencies of Vitamin A Cassava (VAC) farmers with other improved cassava (OIC) farmers in Benue State, Nigeria was conducted.

**Methodology:** A five- stage sampling technique was employed to select 120 farmers in the study area. Primary data were obtained using structured questionnaire and interview methods to seek information on socio-economic characteristics of farmers, inputs, outputs, and constraints to cassava production. The data were analyzed using descriptive statistics, stochastic frontier production function and cost function.

**Findings:** The result revealed that profitability alone is not the only determinant for cassava cultivation, other factors were adequate finance, farmland, planting material, labour, nutrition and market. Five major determinants of cassava production were farm size, family labour, stem, herbicide and hired labour. Education, farming experience, gender and extension contacts significantly influenced farm -specific profit inefficiencies. OIC farmers showed higher allocative efficiency (0.78) than VAC farmers (0.75) and lower economic mean efficiency (0.66) than VAC farmers (0.76). The VAC farms were more profitable than OIC farms with gross margin of ₦181,120 and ₦105,620 per hectare of land, return on investment (1.68 and 0.86). The mean efficiencies of both practices were significant(p<05). The OIC and VAC farmers were operating at the second level of production frontier with return to scale of less than unity (0.457 and 0.448). Constraints identified are inadequate finance, expensive stems, inadequate extension agents' visit, low market demand, high labour cost and grazing of farmland by herders.

**Unique contribution to theory, practice, and policy:** Vitamin A Cassava and other improved cassava were smallholder farmers who were technologically inspired to transform inputs into output to earn income, food for households and poverty alleviation, and to achieve these, they need to improve on technical, allocative and economic efficiencies of production. It is recommended that cassava farmers develop saving culture and enter contract farming, multiply cassava stems, employ labour-saving technologies, government to create ready markets and encourage herders to establish ranches to prevent incursion of roaming cattle herds into farms.

**Key words**: *Technical, Allocative, Economic efficiencies, Production practices, Stochastic frontier*

Journal of Agricultural Policy
ISSN: 2520-7458 (Online)
Vol.5, Issue No.1, pp 1 – 23, 2022
www.carijournals.org

## BACKGROUND

Cassava (*Manihot esculenta Crantz*) is an important root crop grown and a major peasant food in Africa, Asia, Latin America and the Caribbean (Spencer & Ezedinma 2019). Cassava is widely produced and consumed by over 100 million people in Nigeria and Asia countries of the world for its edible products and for its income generation potentials and as a result, it has been found important as staple food for households, animal feeds and industries (Westby,2002). These various uses indicate that cassava could assume the position of food security crop and income generation for poor households.

Nigeria is presently the largest world producer of cassava with about 60 million metric tonnes of edible roots produced annually from cultivated area of about 3.7 million hectares (FAO, 2019). Nigeria accounts for cassava output of up to 20 per cent of the world, about 34 per cent for Africa continent and about 46 per cent of West Africa countries. The mean national yield as recorded by FAO (2019) is 13.63 metric tonnes per hectare which is against the potential yield of 30 - 40 metric tonnes per hectare of World average (Abolaji *et al*.& Oduola, 2007).

Aerni (2006) reported that cassava which was previously regarded as a famine reserve crop as it provides a reliable means of food during drought and hunger periods for the poor households, has suddenly become both a nutritional food, a global income earner and an export crop in the world economy. Due to the relatively high yield of cassava under conditions of unstable precipitation and poor soils, 250 million Africans rely on cassava as food. Philips *et al*. & Akoroda (2007) reported that production from over 90 % of the 117millions hectares cultivated in Sub-Saharan Africa (SSA) in 2006 is being utilized for fresh consumption and processed food.

Adeniji (2000) asserted that to increase in efficiency of cassava production and utilization in Nigeria, the Federal Government and International Fund for Agricultural Development (IFAD) partnered in the introduction' of Vitamin A Cassava multiplication programme with the aim of promoting cassava utilization as a commodity-based approach against food security. Vitamin A cassava is a different type of cassava with a deep yellow colour compared to the conventional white colour varieties. It is biofortified through traditional breeding with beta-carotene which the body converts to vitamin A precursor. It has the ability when consumed to reduce vitamin A deficiency and are at least six times more nutritious than common, white-fleshed cassava (Ilona, 2014). The purpose of Vitamin A cassava multiplication program is to improve food nutrition, reduce poverty and boost income among farmers. In alignment to these objectives, HarvestPlus Nigeria developed and disseminated Vitamin A cassava varieties to four states of Oyo, Imo, Akwa Ibom, and Benue in Nigeria for adoption by farmers to boost income of rural farmers and improve nutritional food security situation of the population.

Consequently, Vitamin A cassava multiplication programme was initially inaugurated in 2001 by the Federal Government with the purposes of increasing productivity, profitability, acceptability, and income of the farmers but failed to accomplish these objectives as the farmers refused to use improved planting stems released for them. (Ilona *et al*. & Oparinde, 2017). On 7$^{th}$ December 2011, the Nigerian government released the pro-vitamin A cassava varieties developed by International Institute of Tropical Agriculture (IITA) in conjunction with the National Root Crop Research Institute (NRCRI), Umudike and funded by HarvestPlus project and the cassava transformation agenda of the Federal Ministry of Agriculture and Rural Development of Nigeria. The first three-wave Vitamin A cassava varieties released by National Varietal Release Committee of Nigeria are UMUCASS 36, UMUCASS 37 and UMUCASS 38.

Ilona *et al.* & Oparinde (2017) reported that the pro-vitamin A cassava project commenced with 100 bundles of stems of three first-wave varieties in 2010 and with a decentralized community-based seed production scheme, the project was able to increase stem availability to 250,000 bundles by 2012. In 2011, the biofortification (Vitamin A Cassava) programme commenced with stem multiplication in ten Local Government Areas (LGAs) in each of the four states of Nigeria; Oyo in the South-west, Imo in the South-east, Akwa Ibom in the South-south and Benue in the North-central. In 2012, the programme increased in scope to six villages in each LGA making a total of 60 communities per state and 240 farming communities in the four states of Oyo, Imo, Akwa Ibom and Benue. The major objectives of this programme were to attain self-sufficiency in micronutrients such as vitamin A consumption, food security and better income for the poor in Nigeria (Ilona *et al*. & Oparinde, 2017).

Despite the economic and food nutritional relevance of cassava to the Nigerian economy, its production and utilization in the country is lacking behind because of the wide gap between the supply and demand of the products (Nweke, 2004). If Nigeria is to be self-sufficient and sustainable in cassava production, productivity and resource use efficiency must increase. This implies that the resources allocated to cassava production must be efficiently utilized and profitable to attract more producers.

The problem of cassava production in Nigeria is attributed to low resources productivity, profitability, under-capitalization and efficient use of farm-based inputs by farmers (Sanusi,2012; UNECA, 2009). Cassava also lacks essential micronutrients like iodine, calcium, zinc, iron and vitamin A resulting into an insidious type of hunger-a hidden hunger (Brenda, 2019). Hence, to examine efficiency and productivity of the resources by vitamin A cassava farmers and other improved cassava farmers in Benue State, this paper is therefore structured to: (i) evaluate the technical relationship between the inputs and output of the two cassava production practices (ii) evaluate the technical, allocative and economic efficiencies of cassava farmers in both production practices (iii) determine the profitability of cassava production under the two production practices (iv) identify the production constraints faced by farmers under the two production practices.

## THEORETICAL FRAMEWORK

### Stochastic frontier production and cost function

The magnitude of technical efficiency of a producer is distinguished by association between actual production and some ideal unrealized production. The estimation of farm-firm peculiar technical efficiency is hinged on deviations of actual yield from the greatest production frontier. If a producer's observed production rests on the frontier, it is assumed to be perfectly efficient and if is lies below the frontier, it is said to be technically inefficient where the ratio of the observed to the unrealized production describes the strength of efficiency of the specific farmer (Fuglie *etc*., & William, 2020)

The estimation of production frontier could be described under two general approaches. There is complete frontier which emphasizes all observations to be on or below and therefore, all deviations from the frontier is due to inefficiency and so the stochastic frontier where deviation from the constituents returning hypothesized error and statistical noise and a constituent returning inefficiency. The drawback of these approaches is that they are greatly sensitive to deviations. Thus, if the deviations return calculated errors, they will gradually introduce bias into the estimated frontier and the efficiency computations obtained from it. In all, the stochastic frontier approach seems better due to its involvement of traditional random error of regression. As a result, the parameter error, apart from indicating the impact of insignificant left out variables and errors of measurements in the dependent variables, could also show the impact of arbitrary failure on input supply routes not correlated with the inaccuracy of the regression as given by Jondrow *et al*., & Schmidt (1982). Farrell, (1957) began the measurement of efficiency by proposing a division of technical efficiency into two approaches. The first approach describes a producer's capacity to produce a maximum amount of yield from a bundle of inputs and secondly, allocated efficiency which he referred to capacity of a farmer to utilize inputs in optimum amounts with their corresponding prices and present technology available. From these descriptions, he came about economic efficiency

Journal of Agricultural Policy
ISSN: 2520-7458 (Online)
Vol.5, Issue No.1, pp 1 – 23, 2022 www.carijournals.org

which is the combination of the two efficiencies.

Several approaches are in use to estimate the determinants of technical efficiency from stochastic production frontier functions. Some researchers followed a two-step process in which the frontier production function is initially calculated to estimate the technical efficiency parameters, while the parameters obtained are regressed against a bundle of socio-economic explanatory variables that are normally farm-firm attributes. (Ogundele, 2003, Ben-Belhassen, 2000, Parikh, Ali & Shah, 1995). However, the approach contravenes the hypothesis of error terms of stochastic frontier production function, which is assumed to be identically, usually and independently distributed (Jondrow *et al*. & Schmidt, 1982). As a result, more development of a more reliable method that modeled inefficiency effects as an explicit function of some factor attributed the farm and all variables are measured in one step employing maximum likelihood estimate (Ajibefun and Daramola, 2003, Obwona, 2000, Battese & Sarfaz, 1998). The maximum likelihood methods of the production model are calculated employing the computer programme referred to as FRONTIER (Coelli & Battese, 1996). This approach was used by Ajibefun and Daramola, 2003 and Obwona,2000 was adopted and used in this research work.

**Model specification**

The two methods described above can be modeled into mathematical specifications. The econometric model is regarded as either deterministic frontier model or stochastic frontier model assumed that the farmer is producing single product. It is equally assumed that the quantum of inputs used to produce the single product is easily available for individual number of producers. Thus, the production frontier model is given as:

$Yj=f(X_{ij}\beta). TEij$……………………………………………………………… (1)

where $Y_j$= yield of farmer j=1……..N

$X_i$= bundle of inputs used by farmer j

$f(X_{ij}\beta)$ = production frontier

β=variable to be measured

$TE_{ij}$=yield aligned technical efficiency of farmer j

From (2)

$$TE_{ij}= \frac{Y_i}{f(X_{ij}\beta)} \quad \text{……………………………………………………………… (2)}$$

Equation (2) measures the technical efficiency on the relationship of potential yield to maximum yield possible given the available technology. $Y_i$ obtained its maximum profit of $f(X_{ij}\beta)$ only if $TE_i$=1. The amount by which a value under consideration lies below the frontier is called inefficiency when $TE_i$<1.

It can be seen from equation (2) that $f(X_{ij}\beta)$ is deterministic while in equation (3), the total deficit of actual yield $f(X_{ij}\beta)$ is related with technical inefficiency. This gave the inadequacy of this method since environmental and institutional factors outside the control of producers like bad weather, bad market, and error in model specification can lead into increasing the inefficiency estimates. With the incorporation of random variable to the production frontier equation in (1)

$Y_i=f(X_{ij}\beta)$, exp [vi]). $TE_{ij}$………………………………………………………… (3)

where $[f(X_{ij}\beta)$, exp [Vi] =stochastic production frontier.

Journal of Agricultural Policy
ISSN: 2520-7458 (Online)
Vol.5, Issue No.1, pp 1 – 23, 2022 www.carijournals.org

Thus, $TEij = \frac{Y_i}{(f(Xij\beta), \exp[vi])}$ …………………………………………………… (4)

Describing technical efficiency as the ratio of actual yield to optimal possible yield with the impact of environment by exp {Vi}.

As a result of the above equations the two-disturbance parameter of production frontier is missing, neither of them can give a vivid state of technical efficiency.

The second method is called the stochastic production frontier model. The important element of this method is that the disturbance term is made up of two forms. The first disturbance term is the symmetric part Vi which represents the random of error external to the control of farmer while the non-negative one-sided part Ui represents the random of human error, which is under the control of the farmer. The random terms are identically, independently and normally distributed (Meeusen & Broeck, 1977).

The usual equation for stochastic frontier model in term of general production function is as thus:

$Y_i = f(X_{ij}\beta) + V_i - U_i$-----------------------------------------------------------------------------------------(5)

where:

$Y_j$, = yield of farmer j =1----N

$X_i$= bundle of farm inputs used by farmer j

β = variable to be measured

Vi= is the stochastic error, which is hypothesized to be independently, identically and normally distributed with zero mean and a constant variance (σv2)

$U_i$= is a one-sided error term which is independent of Vi and is normally distributed with zero mean and a constant variance ($\sigma u^2$).

In the stochastic production frontier, the technical efficiency of the farm is described as the ratio of real physical output to the estimated potential yield subject to the amount of input used by the farmer. Thus, the technical efficiency of the cassava farm is given thus:

$$TEij = \frac{Y_i}{Y^*} = \frac{f(X_{ij}\beta)exp(Vi - Ui)}{f(xij\beta)\exp(Vi) - \exp(Ui)} \text{---------------------------------- (6)}$$

where $TE_{ij}$ = technical efficiency of farmer j

$Y_i$= actual yield from $i^{th}$ farm

$Y^*$= potential yield

$X_{ij}$, β, Vi, Ui = as given in equation 5

TE ranges between 0 and 1 and optimum efficiency has a value of 1.

## METHODOLOGY

### Study area

This study was conducted in Benue State, Nigeria. Benue State is in North Central part of Nigeria. The State lies between latitudes $6^0$ 25' and $8^0$ 8' North and longitudes $7^0$ 47' and $10^0$ 00' East. The state is often referred to as the ''food basket'' of Nigeria because of its predominantly agrarian nature, its contribution in supply of agricultural products and its rich agricultural soils (Upev, Haruna & Giroh, 2015). The major economic activities of the people in the state include crop and animal production.

**Data collection**

A five-stage sampling procedure was used to select the respondents. Benue State was purposively selected from North central zone as it represented one of the States where HarvestPlus 2011 delivered her Biofortification programme of vitamin A cassava stem multiplication and distribution and high concentration of cassava production. During the study, two Local Government Areas (Utukpo and Agatu) from Central ADP zone was obtained from HarvestPlus programme Coordinator indicating as the LGAs biofortification and multiplication of vitamin A cassava was implemented. Three communities were randomly selected in each of the two Local Government Areas given a total of 6 communities. A total of 120 farmers were then randomly selected from the 6 communities. Primary data were collected via structured questionnaire schedule and information was sought from vitamin A cassava and other improved cassava producers on socio-economic characteristics, inputs, outputs, marketing, constraints to cassava production and income generated during the 2019/2020 production season.

**Analytical Techniques**

(a) Descriptive statistical tools like frequency distributions, percentages, mean, standard deviation were used to describe socio-economic characteristics of adopters and non-adopters of vitamin A cassava and other improved cassava varieties. The tool was also used to evaluate constraints experienced by cassava farmers.

(b) The stochastic frontier production model was employed to evaluate the input-output relationship and implicit form of the stochastic frontier production model is given as thus:

$$\text{In } Q_1 = \alpha_0 + \alpha_1 lnX_1 + \alpha_2 lnX_2 + \alpha_3 lnX_3 + \alpha_4 lnX_4 + \alpha_5 lnX_5 + \alpha_6 lnX_6 + \alpha_7 lnX_7 + V_{j\,-}\,U_i \text{ ..........................(7)}$$

where *In* =the natural logarithm

$Q_1$ = total farm output of cassava in kilogramme

$X_1$ = cultivated land area for cassava in hectares

$X_2$ = family labour utilized in man- hours

$X_3$ = quantity of cassava stem cuttings in kilogramme

$X_4$ = quantity of fertilizer used in kilogramme

$X_5$ = quantity of herbicide in litres

$X_6$ = quantity of pesticides in litres

$X_7$ = hired labour utilized in man-hour

$\alpha_0$ =intercept

$\alpha 1 - \alpha 7$ = parameters to be estimated

Journal of Agricultural Policy
ISSN: 2520-7458 (Online)
Vol.5, Issue No.1, pp 1 – 23, 2022


Vi= is the stochastic error, which is assumed to be individually and normally spread with zero mean and a constant variance ($\sigma v2$)

Ui= is a one-sided error term which is independent of vi and is normally spread with zero mean and a constant variance ($\sigma u2$).

(c) The allocative efficiency was calculated using the Cobb-Douglas stochastic frontier cost function stated thus: (

$$\ln Cy = \beta 0 + \beta 1\ln X1 + \beta 2\ln X2 + \beta 3\ln X3 + \beta 4\ln X4 + \beta 5\ln X5 + \beta 6\ln X6 + \beta 7\ln X7 + Vi + Ui \quad (8)$$

where:

Cy = Total cost of production (Naira)

X1 = Cost of fertilizer (Naira)

X2 = Cost of land (Naira)

X3 = cost of herbicide (Naira)

X4 = cost of pesticide (naira)

X5= cost of stem (naira)

X6= cost of family labour (naira)

X7= cost of hired labour (naira)

β = vector of the coefficients for the associated independent variables in the production function.

Ui = are non-negative random variables, assumed to be half normally distributed

N (0, $\sigma U_2$) | and account for the cost inefficiency in production.

Vi = random variables which are assumed to be normally distributed N (0, $\sigma V2$), and independent of the Ui

The technical and allocative inefficiency model $U_j$ is defined thus:

$$U_j = \delta_0 + \delta_1 R_1 + \delta_2 R_2 + \delta_3 R_3 + \delta_4 R_4 + \delta_5 R_5 + \delta_6 R_6 + \delta_7 R_7 + \delta_8 R_8 \quad (9)$$

Where $U_j$= the technical inefficiency of the $j^{th}$ farmer

$R_1$= level of education (Number of years spent in school)

$R_2$=household size (number of persons in the household)

$R_3$= cassava farming experience (years)

$R_4$= number of contacts with extension agent (Number of visits per year)

$R_5$= sex (1-male, 0-female)

$R_6$=land ownership (1-owned, 0-otherwise)

$R_7$=membership of association (1-belong, 0-otherwise)

$R_8$= access to credit (amount of credit received for cassava production in naira)

$\delta 0$-$\delta 7$= unknown variables which are inserted in model to represent possible effect on technical efficiency of the producers.

(d) Gross margin represented by cost and returns and Return on Investment were employed for profitability analysis as defined by:

$GM = \sum n/_{i=1} P_j Q_1 - \sum n_{/j=1} P_j X_j$ ------------------------------------------- ------(10)

where GM=gross margin

$P_i$=unit price of cassava (₦)

$Q_i$ =quantity of cassava (kg)

$P_j$=unit price of jth input (₦) (j=1…2……7)

$X_j$ =quantity of the jth input (litre or kg) ( j= 1…2……7).

where $X_j$ of 1-7 are as follows:

$X_1$=cultivated land area for cassava (ha) $X_2$=family labour (man-hour)

$X_3$=quantity of stem planted (bundle),

$X_4$= quantity of fertilizer used (kg)

$X_5$=quantity of herbicide used (liters),

$X_6$= quantity of pesticide (litres)

$X_7$=hired labour (man-hour)

n = number of hectares

The calculation of the return on investment will further strengthen the decision making on the best profitable investment. Hence to strengthen the gross margin analysis, the return on capital invested in both the vitamin A cassava and other improved cassava production was calculated using the following formula thus:

Return on Investment (ROI) = GM/TVC ……………………………. (11)

where:

ROI = the return on investment and

GM and TVC is as explained in equation 10.

## RESULTS AND DISCUSSION

### Socio-economic characteristics

As presented in Table 1, are the socio-economic characteristics of other improved cassava (OIC) and Vitamin A cassava (VAC) respondents. The Table revealed male dominance for both cassava varieties with OIC producers accounting for 75.0% and VAC recorded 75.0% as well. This implies equal males' producers of OIC and VAC in the study area. Generally, the analysis revealed that cassava production is a male dominance occupation. The age distribution of the farmers in the study area showed that 30% and 31.7% respectively were obtained as the proportions of OIC and VAC farmers representing age class of 41-

50 years. The result indicates that cassava farmers were in their middle age and active in production and could be ready to accept agricultural innovations. This is in tandem with result obtained by Igbaifua (2018) in Guinea Savanah Zone of Nigeria where he had a similar result of age bracket of 41-50 years and a mean age of 44 $\pm$ 8.9 years for TME – 419 cassava farmers. The analysis also revealed that married couples (81.7% and 83.7%) comprised the majority of OIC and VAC farmers. The findings also revealed that OIC and VAC farmers were educated with each category accounting for 96.7%. The result of the analysis in Table 1 indicates that farming is the major occupation of the respondents in the study area. The result showed that 88.3% of the respondents were OIC producers and 90.0% were VAC farmers. Generally, the result of the analysis as depicted inferred that the farmers had more than ten years' experience and this agrees with Eze & Nwibo (2014) who reported that most of the cassava farmers in Delta State had more than ten years' experience in cassava business and therefore were experienced in the business which is a factor to enhance profitability and productivity. 70.0% of OIC farmers and 84.5% of VAC farmers cultivated less than 2 hectares with VAC farmers cultivating more hectares than OIC farmers. This implies that both Vitamin A cassava producers and other improved cassava farmers are smallholders in study area. The survey result reveals that majority of OIC and VAC farmers representing 76.7% and 70.0% respectively in the study area had no access to credit facilities to expand their farms. This implies that they financed their cassava production using their personal savings implying that expansion of cassava land and purchase of required inputs were constrained in both production practices. This finding agrees with Omotayo & Oladejo (2015) who reported that 75.5% of cassava farmers in Oyo State financed their cassava enterprise with their personal savings.

**Table 1: Socio-Economic Characteristics of Cassava Farmers**

| | OIC | | VAC | |
|---|---|---|---|---|
| **Characteristics** | **Frequency** | **Percentage** | **Frequency** | **Percentage** |
| **Gender** | | | | |
| Male | 45 | 75 | 45 | 75 |
| Female | 15 | 25 | 15 | 25 |
| **Age** | | | | |
| 20-30 | 9 | 15 | 7 | 11.7 |
| 31-40 | 15 | 25 | 16 | 26.7 |
| 41-50 | 18 | 30 | 19 | 31.7 |
| 51-60 | 11 | 18.3 | 11 | 18.3 |
| 61-70 | 7 | 11.7 | 7 | 11.7 |

| | | | | |
|---|---|---|---|---|
| **Marital status** | | | | |
| Married | 49 | 81.7 | 50 | 83.3 |
| Others | 11 | 18.3 | 10 | 16.7 |
| **Educational attainment** | | | | |
| Informal | 2 | 3.3 | 2 | 3.3 |
| Primary | 11 | 18.3 | 10 | 16.7 |
| Secondary | 21 | 35.0 | 22 | 36.7 |
| Tertiary | 26 | 43.3 | 26 | 43.3 |
| **Occupation** | | | | |
| Farming | 53 | 88.3 | 54 | 90.0 |
| Business/Trade | 2 | 3.3 | 2 | 3.3 |
| Civil servant | 4 | 6.7 | 3 | 5.0 |
| Others | 1 | 1.7 | 1 | 1.7 |
| **Farming experience** | | | | |
| 1-10 | 12 | 20.0 | 3 | 5.1 |
| 11-20 | 19 | 32.0 | 27 | 45.8 |
| 21-30 | 9 | 15.0 | 20 | 33.8 |
| 31-40 | 10 | 17.0 | 8 | 13.6 |
| 41-50 | 10 | 17.0 | 1 | 1.7 |
| **Farm size** | | | | |
| 0.1-1.0 | 30 | 33.3 | 61 | 67.8 |
| 1.1-2.0 | 33 | 36.7 | 15 | 16.7 |
| 2.1-3.0 | 21 | 23.3 | 7 | 7.8 |
| 3.1-4.0 | 4 | 4.4 | 4 | 4.4 |
| 4.1-5.0 | 1 | 1.1 | 3 | 3.3 |
| 5.1-6.0 | 0 | 0.0 | 0 | 0.0 |
| ≥ 6.1 | 1 | 1.1 | 0 | 0.0 |
| **Credit accessibility** | | | | |
| Yes | 14 | 23.3 | 18 | 30.0 |
| No | 46 | 76.7 | 42 | 70.0 |

Source: Survey data analysis

**Relationship between inputs and output of OIC and VAC production practices in Benue State**

Presented in Tables 2 is the hypothesized parameters for the production function of OIC and VAC production practices. The disaggregated estimates of the parameters of the stochastic frontier production model using Maximum Likelihood estimation (MLE) revealed that in both OIC and VAC in study area, the hypothesized coefficients of the production function of farm size, family labour, planting material and herbicide were positive and significantly different from zero at 1 percent level of significance. Similarly, fertilizer used, pesticide and hired labour were negative at 1 percent level of significant. The positive coefficient of the variables implies that as each of these variables are increased, cassava output equally increased, while negative coefficient of the variables is the inverse.

The return to scale (RTS) evaluation, which suggests a determination of total resource-use productivity is presented in Table 3 using the maximum likelihood estimates of the Cobb-Douglas stochastic production function indices of 0.457 and 0.448 for OIC and VAC farmers in the study area respectively were arrived at from the addition of the coefficients of the estimated elasticities or inputs. The results indicate that cassava production in both practices operated in the second level of the production frontier. Second level of the production is assumed as a stage of decreasing positive return–to-scale where resources and production were predicted to be efficient, referred to as the rational stage. Therefore, it is important that the production resource parameters should adhere to the level of input utilization at this stage since a given level of inputs will result into maximum output all things being equal. This is in tandem with the submission of Ogundari & Ojo (2007) where they indicated a decreasing positive return to scale (DPRS) of 0.840 among cassava farmers in Osun State. Ogunniyi (2015) also reported similar report in Oyo State, Nigeria. He obtained RTS value of 0.54 for cassava production. Okoh (2016) obtained RTS value of 0.824 for cassava production in Benue State, Nigeria.

The comparative estimates of the stochastic frontier cost function for OIC and VAC productions are shown in Table 4. The result indicated that all the variables acted along prior expectation due to all estimated coefficients of average cost of fertilizer, cost of land used, price of planting material, average wage rate per man days of labour and cassava yield in kilogramme gave positive coefficients, implying as these variables increased, total production cost increased if all things are equal. The result emanated from t-ratio test indicates that all variables are significant and statistically greater than zero at three levels of significance. Therefore, these parameters are drivers of OIC and VAC in the study area.

**Table 2: Maximum Likelihood Estimate for Stochastic Frontier Production Model in Benue State**

| | | OIC | | VAC | |
|---|---|---|---|---|---|
| Variables | Parameters | Coefficient | t-ratio | Coefficient | t-ratio |
| Constant | $\beta_0$ | 8.138*** | 4.340 | 7.138*** | 6.220 |
| Farm size | $\beta_1$ | 0.526*** | 5.332 | 0.426*** | 5.226 |
| Family labour | $\beta_2$ | 0.122*** | 4.412 | 0.222*** | 3.532 |
| Stem cutting | $\beta_3$ | 0.040*** | 3.449 | 0.240*** | 3.354 |
| Fertilizer | $\beta_4$ | -0.044 | 0.865 | -0.064 | 0.879 |
| Herbicide | $\beta_5$ | 0.177*** | 2.865 | 0.127*** | 2.176 |
| Pesticide | $\beta_6$ | -0.225*** | -3.238 | -0.246*** | -3.229 |
| Hired labour | $\beta_7$ | -0.139*** | -2.241 | -0.257*** | -3.446 |
| Variance Parameters | | | | | |

Journal of Agricultural Policy
ISSN: 2520-7458 (Online)
Vol.5, Issue No.1, pp 1 – 23, 2022
www.carijournals.org

| | | | | | |
|---|---|---|---|---|---|
| Sigma squared | $\sigma^2$ | 0.752* | 4.234 | 0.442* | 4.334 |
| Gamma | y | 0.667* | 5.542 | 0.547* | 5.245 |

***p<0.01, **p<0.05, *p<0.1

Source: Survey data analysis

**Table 3: Return to scale in OIC and VAC production in Benue State**

| Variables | Elasticities | |
|---|---|---|
| | OIC | VAC |
| Farm Size | 0.526 | 0.426 |
| Family Labour | 0.122 | 0.222 |
| Quantity of Stem | 0.040 | 0.240 |
| Fertilizer | -0.044 | -0.064 |
| Herbicide | 0.177 | 0.127 |
| Pesticide | -0.225 | -0.246 |
| Hired Labour | -0.139 | -0.257 |
| **Return to scale** | **0.457** | **0.448** |

Source: Field survey, 2019

**Table 4: Comparative Maximum Likelihood Estimate of Frontier Cost Function Frontier Model in Benue State for OIC and VAC Production**

| | | OIC | | VAC | |
|---|---|---|---|---|---|
| Variables | Parameters | Coefficient | t-ratio | Coefficient | t-ratio |
| Constant | $\beta_0$ | 0.146* | 0.967 | 0.159* | 0.728 |
| Cost of fertilizer | $\beta_1$ | 0.745* | 3.407 | 0.527* | 0.407 |
| Cost of land | $\beta_2$ | 0.431*** | 2.869 | 0.131*** | 1.869 |
| Cost of stem | $\beta_3$ | 0.343* | 3.264 | 0.503* | 5.236 |
| Cost of family labour | $\beta_4$ | 0.169*** | 2.223 | 0.177*** | 1.642 |
| Hired labour cost | $\beta_5$ | 0.221** | 2.212 | 0.321** | 2.032 |
| Total cassava output | $\beta_6$ | 0.128*** | 1.643 | 0.188*** | 1.546 |
| Variance Parameters | | | | | |
| Sigma squared | $\sigma^2$ | 0.825* | 44.585 | 0.838* | 46.597 |

| | | | | | |
|---|---|---|---|---|---|
| Gamma | y | 0.680* | 3.816 | 0.685* | 3.855 |

***p<0.01, **p<0.05, *p<0.1

Source: Survey data analysis

**Technical efficiency**

Analysis of OIC growers in the study area revealed that the mean, maximum and minimum technical efficiencies were 0.85, 1.0 and 0.0013 as presented in Table 5, respectively. This implies that OIC cassava growers with the best practice in the study area is 1.0 while OIC grower with least practice is 0.0013. Also, if the mean OIC cassava grower in the sample was to obtain the technical level of its most efficient counterpart, then the average OIC cassava grower could obtain a 15% cost saving [i.e., 1-(0.85/1.00) x 100]. In the same way, computation for the best technically inefficient OIC producer indicates profit of 99.9 % i.e., 1-(0.0013/1.00) x100. To show a vivid picture of the spread of the technical efficiencies of OIC, a frequency distribution of the estimated technical efficiencies is depicted in figure1. The distributions of the estimated technical efficiencies in decile ranges indicates that the greatest number of OIC cassava producers have technical efficiencies between 0.01 – 0.80. The representative frequency spread shows an aggregate of technical efficiencies in the range 0.61 – 0.80 efficiency ranges, constituting 41.7% of the OIC cassava farmers implying that OIC producers are moderately productive in the use of inputs suggesting efficiency in obtaining optimum output from minimum input with available technology. The study also showed enough gaps that are available for raising the level of productivity of OIC cassava cultivation in Benue State. Onu & Edon (2009) reported that learning, skill acquisition, education and adoption and acceptance increase productivity of producers.

For VAC producers' technical efficiency in Benue State, the predicted analysis revealed that the mean, maximum and minimum technical efficiencies were 0.88, 0.97 and 0.03 respectively as presented in Table 5. This indicated that VAC producer with the best agronomic practice in Benue State is 0.97 while VAC producer with worst technological practice is 0.03. Also, if the average VAC producer in the category was to obtain the TE level of its best productive producer, the mean VAC producer might obtain a 9.3% profit [i.e., 1- (0.88/0.97) x 100]. Similarly, calculation for the worst economically efficient VAC producer will require output gain of about 96.9% [i.e., 1-(0.03/0.97) x 100] to be able to experience the status of the best productive VAC producer in the category.

The distribution of VAC producers' frequencies of the calculated technical efficiencies in decile ranges as presented in figure 1 showed that 40% of VAC producers have technical efficiencies of 0.61 - 0.80. The result equally revealed that about 26.7% of VAC producers had technical efficiency below 60% while 73.3% had technical efficiency of 60% and above. The research therefore suggested need to close wide gap that existed in the level of technical efficiency of VAC cultivation in Benue State. The result inferred that VAC producers in Benue State are marginally efficient in cultivating vitamin A cassava for a level of output using the cost minimizing input ratio.

**Allocative efficiency**

The distributions of cassava producers' allocative efficiencies revealed that the OIC and VAC farmers of Benue State were skewed in the class of less than 0.61 and accounting for about 36.7% as presented in Table 5 and the calculated allocative efficiency distribution as presented in figure 2. The allocative efficiency distribution suggests that the sampled OIC and VAC farmers in Benue State allocated their financial resources below the optimum production cost price. This implies that producers are inefficient in their allocation of financial resources. The finding of this work agrees with Okebiorun *et al*. & Atiku (2018) where they revealed that cassava producers were not efficient in resource allocation in cassava production.

Table 5 further shows that the mean, minimum and maximum efficiencies of OIC and VAC growers were 0.76 and 0.76 ranging from 0.013 to 0.96 and 0.04 to 0.96, respectively in Benue State implying that if average OIC cassava producer in the group was to obtain the allocative efficiency magnitude of its best efficient fellow, the average OIC producer could obtain 21% cost saving [i.e. 1-(0.76/0.96) x 100], but the most allocatively inefficient OIC cassava producer could actualize cost saving of 87% if the efficiency status of the best productive producer in the partition is attained [i.e. 1-(0.013/0.96) x 100]. VAC producers in Benue State sampled allocative efficiency parameters indicates that for a standard farmer among the VAC growers to obtain the equivalent allocative efficiency level as the best efficient VAC grower, the standard grower will be saving 21% cost saving [i.e., 1-(0.76/0.96) x 100] as that of OIC farmers. Hence, the worst allocative efficient farmer among the VAC category of cassava growers will be saving 96% [i.e., 1-(0.04/0.96) x100] of the cost of producing cassava.

**Economic efficiency**

The combination of two efficiencies i.e., technical and allocative give rise to a third one referred to as Economic efficiency. Result revealed that the minimum, maximum and mean economic efficiencies of OIC and VAC producers in Benue State as presented in Table 5 are 0.02, 0.96 and 0.66 and 0.04, 0.96 and 0.75 respectively. The findings indicated that economic efficiency of OIC producers is between 0.02 – 0.96 thus implying an existence of a gap between efficiency of most economically productive producers and that of the worst economically productive producers. The mean economic efficiency was 0.66, suggesting that OIC cassava producers in Benue State were economically effective in the utilization of limited inputs. The result also indicates that for a standard OIC grower in Benue State to obtain the status of the economically efficient producer in the group, the producer must achieve a profit of 31.3% [i.e.,1- (0.66/0.96) x 100]. The findings also show that the worst economically productive OIC producer require profit of 97.9% [i.e., 1.00 - (0.02/0.96) x 100] to achieve the status of the best economically productive producer in the group.

The calculated economic efficiencies (EE) which is an inverse of cost efficiencies varies widely between the cassava producers in Benue State. The disposition of the frequency of the calculated economic efficiency in decile range suggests that 40% of the OIC producers have economic efficiencies of 0.61 – 0.80. It also revealed that about 18.4% of OIC producers have productivity lower than 0.61 while 81.6% of OIC producers had EE above 0.61% implying that OIC producers in Benue State are economically efficient. This indicates that OIC producers are productive in growing cassava at a minimum cost for a determined technology. The economic efficiency of OIC in Benue State decile range is presented in figure 3. Similarly, for VAC farmers in Benue State, the mean, minimum and maximum efficiencies were 0.75, 0.04 and 0.96 respectively. The mean economic efficiency is 0.75, indicating that VAC producers in Benue State were economically productive in the utilization of limited resources. The predicted result revealed that for an average VAC producer in the State to achieve the status of the best economically efficient producer in the category, the producer must obtain a profit of 21.9% [i.e., 1.00 – (0.75/0.96) x 100].

The analysis equally shows that the worst economically VAC producer will require a profit of 95.8% [i.e., 1.00 - (0.04/0.96) x 100] to achieve the status of the best economically producer in the category. The estimated economic efficiency in decile range as revealed in figure 3 shows that 41.7% of the VAC farmers had a cluster of economic efficiencies in a class of 0.61 – 0.80. The result equally showed that about 18.3 % of VAC producers have economic output below 0.61, while 81.7% of VAC producers have EE above 0.61 implying that VAC farmers in Benue State are reasonably economically efficient. This infers that VAC producers are productive in growing quantum of vitamin A cassava at lowest cost for a determined level of technological practice.

**Table 5: Distribution of Efficiencies between OIC and VAC Cassava Production in Benue State**

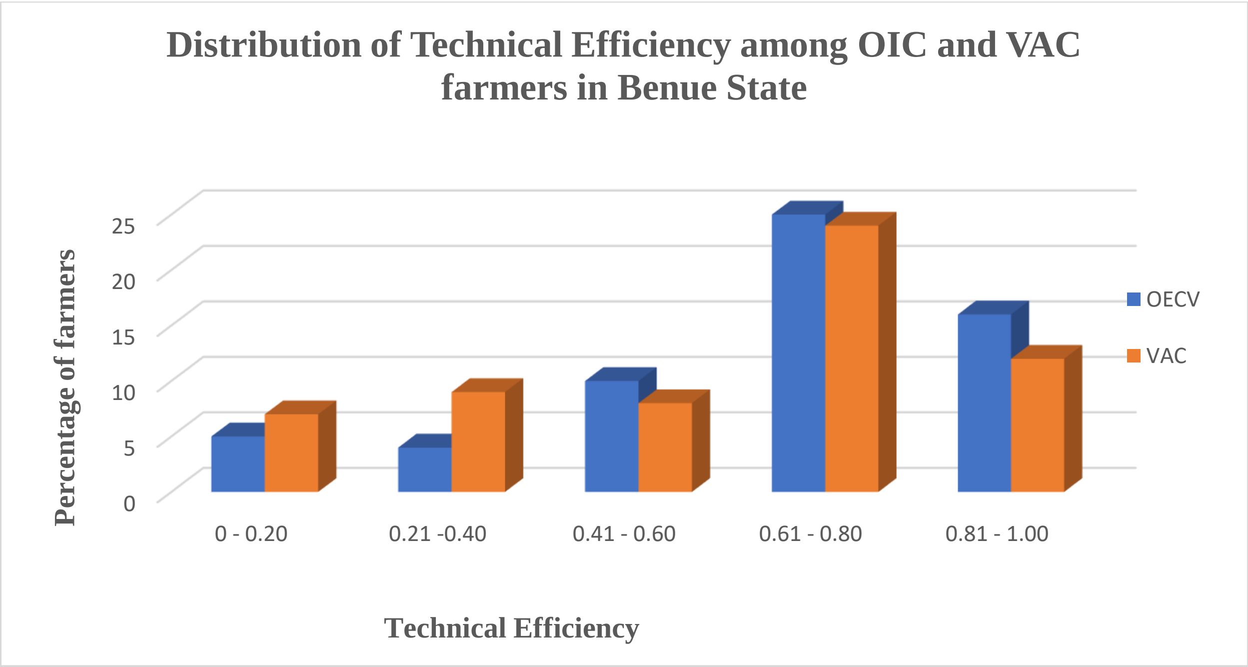
Journal of Agricultural Policy
ISSN: 2520-7458 (Online)
Vol.5, Issue No.1, pp 1 – 23, 2022


| Efficiency Level | OIC TE | | OIC AE | | OIC EE | | VAC TE | | VAC AE | | VAC EE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | f | % | f | % | f | % | f | % | f | % | f | % |
| ≤ 0.20 | 5 | 8.3 | 6 | 10.0 | 6 | 10.0 | 7 | 11.7 | 4 | 6.7 | 3 | 5.0 |
| 0.21-0.40 | 4 | 6.7 | 5 | 8.4 | 5 | 8.4 | 9 | 15.0 | 7 | 11.7 | 8 | 13.3 |
| 0.41-0.60 | 10 | 16.7 | 11 | 18.3 | 11 | 18.3 | 8 | 13.3 | 12 | 20.0 | 12 | 20.0 |
| 0.61-0.80 | 25 | 41.7 | 24 | 40.0 | 24 | 40.0 | 24 | 40.0 | 26 | 43.3 | 25 | 41.7 |
| 0.81-1.00 | 16 | 26.6 | 14 | 23.3 | 14 | 23.3 | 12 | 20.0 | 11 | 18.3 | 12 | 20.0 |
| Total | 60 | 100 | 60 | 100 | 60 | 100 | 60 | 100 | 60 | 100 | 60 | 100 |
| Mean | 0.85 | | 0.76 | | 0.66 | | 0.88 | | 0.75 | | 0.67 | |
| Std. Deviation | 0.024 | | 0.021 | | 0.034 | | 0.032 | | 0.028 | | 0.029 | |
| Minimum | 0.0013 | | 0.013 | | 0.02 | | 0.03 | | 0.04 | | 0.05 | |
| Maximum | 1.00 | | 0.96 | | 0.96 | | 0.97 | | 0.96 | | 0.89 | |

Source: Computed from maximum likelihood estimation result of survey data analysis

TE= Technical Efficiency, AE= Allocative Efficiency, EE=Economic Efficiency

**Figure 1**



Journal of Agricultural Policy
ISSN: 2520-7458 (Online)
Vol.5, Issue No.1, pp 1 – 23, 2022
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**Figure 2**

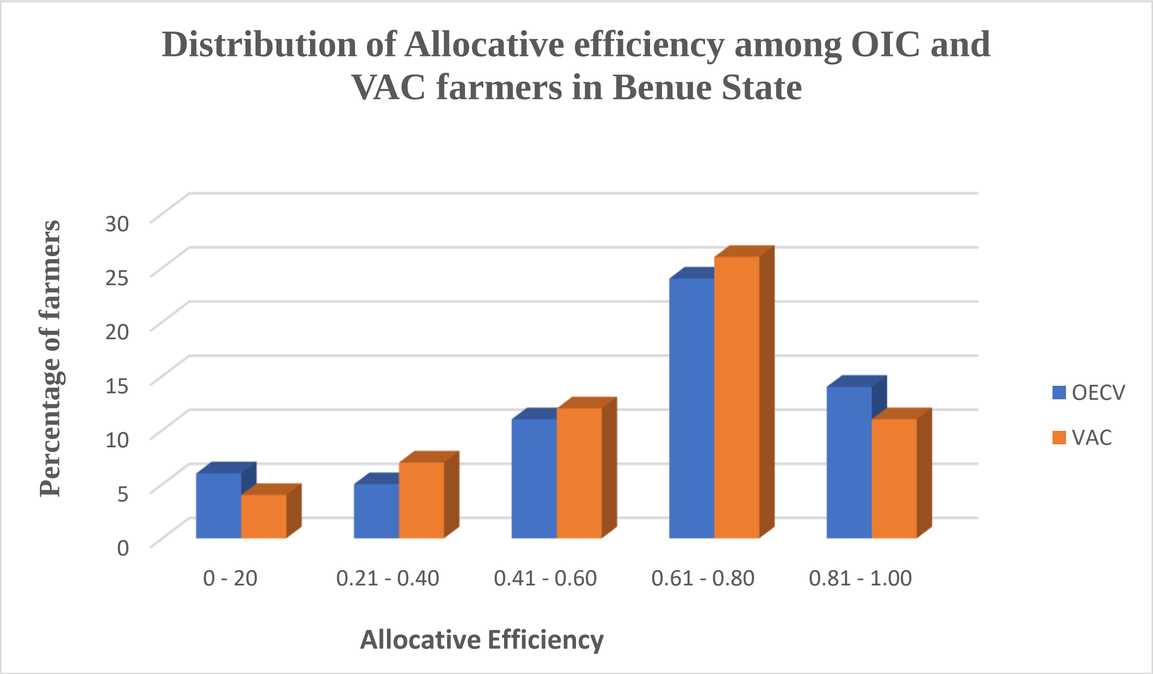
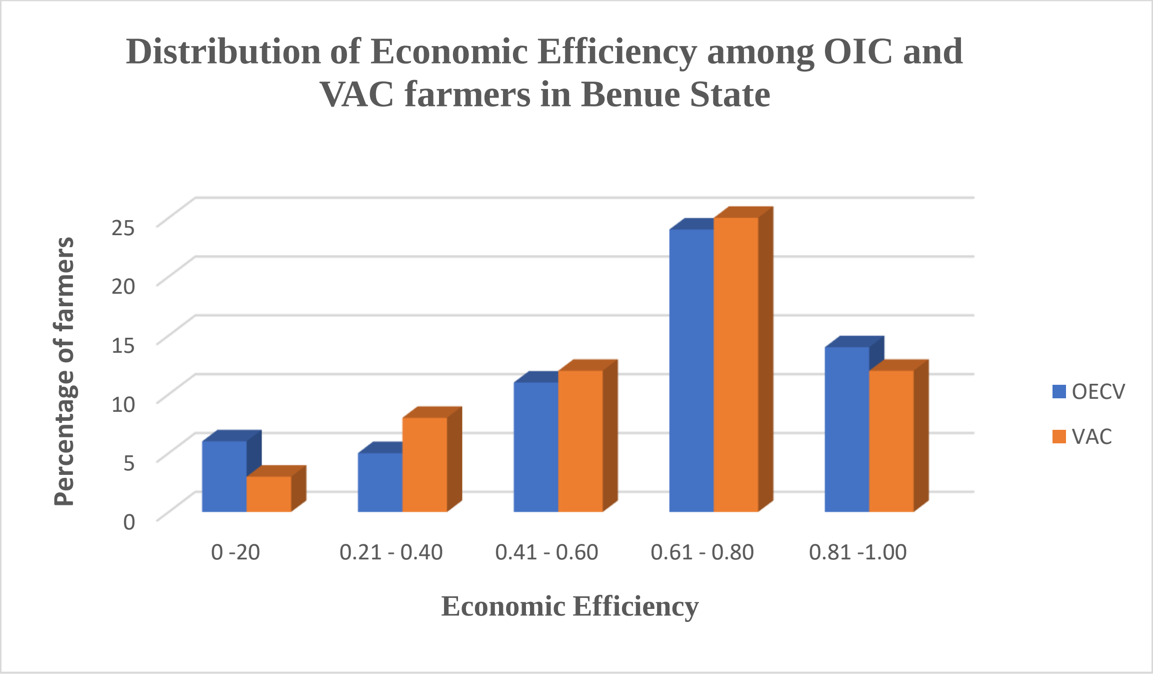



**Figure 3**



Journal of Agricultural Policy
ISSN: 2520-7458 (Online)
Vol.5, Issue No.1, pp 1 – 23, 2022


**Gross Margin Analysis**

As presented in Table 6 is the result gross margin analysis as represented by cost and returns of OIC and VAC per hectare of land in Benue State. The profitability analysis in the study area revealed a Gross Margin (GM) of N105,620 (OIC) and N181,120 (VAC) and ROI were 0.863 and 1.679 respectively. The results indicated that VAC cultivation is more profitable than OIC. The table also showed a higher return on investment in like order.

**Table 6: Gross margin analysis per hectare of OIC and VAC in Benue State**

| Variables | OIC (₦) | VAC(₦) |
|---|---|---|
| Total variable cost (TVC) | 122,400 | 107,900 |
| Total Revenue | 258,020 | 289,020 |
| Gross margin (TR-TVC) | 105,620 | 181,120 |
| Return on Investment (ROI) GM/TVC | 0.863 | 1.679 |

Source: survey data analysis

**Constraints in OIC and VAC Production practices in Benue States**

The results of the evaluation of constraints of production practices in Benue State as presented in Table 7 indicated that the respondents faced several challenges in their cassava production practices. The constraints were ranked based on their severity and seriousness as perceived by producers. These are ranked in percentages ranging from the most severe to least critical constraints. The constraints include low market demand, inadequate finance, high cost of herbicide and pesticides, high cost of labour, inadequate farmland and poor transportation. Others were poor market pricing, insufficient planting stem, pests and diseases infestation, weed infestation and control, and illegal grazing of farmland by irate cattle. The most serious constraint recorded by the OIC and VAC producers of both production practices in the study area were inadequate finance and low market patronage respectively.

**Table 7: Constraints Associated with OIC and VAC Production in Benue State**

| Constraints | OIC | | | VAC | | |
|---|---|---|---|---|---|---|
| | *F | % | Rank | *F | % | Rank |
| Low market demand | 2 | 1.0 | 11th | 59 | 24.2 | 1st |
| Inadequate finance | 46 | 23.4 | 1st | 36 | 14.8 | 2nd |
| Agrochemicals cost | 35 | 17.8 | 3rd | 31 | 12.7 | 3rd |
| High labour cost | 16 | 8.1 | 5th | 29 | 11.9 | 4th |
| Inadequate farmland | 10 | 5.1 | 8th | 24 | 9.8 | 5th |

| | | | | | | |
|---|---|---|---|---|---|---|
| Poor transportation system | 19 | 9.6 | 4th | 19 | 7.8 | 6th |
| Poor market pricing | 36 | 18.3 | 2nd | 16 | 6.5 | 7th |
| Insufficient planting stem | 3 | 1.5 | 10th | 12 | 4.9 | 8th |
| Pests and disease | 12 | 6.1 | 7th | 9 | 3.7 | 9th |
| Weed infestation | 14 | 7.1 | 6th | 6 | 2.5 | 10th |
| Grazing of farmland by Cattle | 4 | 2.0 | 9th | 3 | 1.2 | 11th |
| Total | 197 | 100 | | 244 | 100 | |

*Multiple responses

Source: survey data analysis

## CONCLUSION

Profitability level alone is not the only determinant of choice of farmers for going into any of the cassava production practices, other factors were observed to be adequate finance for production, farmland acquisition and planting material accessibility, labour availability, physical and nutritional characteristics, and market driven factors for output. The statistically significant result of efficiency levels suggests that the farmers in both production practices did not produce at the frontier level hence signifying the existence of inefficiency among the producers. The result emanating from the return to scale inferred that both production practices need to work more on technical and allocative efficiencies to reach the optimum production level using the present production technology at stage II of production level. The study also observed that five major inputs are important in both production practices viz: farm size, family labour, stem, herbicide and hired labour. This indicates that for an increase in the production output of cassava, the five inputs must be ready and efficiently used. VAC was found to be most profitable cassava production than OIC. Analysis of socio-economic characteristics revealed that most respondents of the two production practices were males, married, educated, had long years of farming experience, were in their productive age and smallholder farmers in both production practices. Also, most respondents used their personal savings for production and cassava farming as the main occupation. Two topmost constraints of cassava farmers were inadequate finance and low market demand.

## RECOMMENDATION

Thus, the following recommendations are suggested to raise the production of cassava based on the results obtained. (i) Cassava planting stem was found to be a significant hindrance to both the production practices of cassava with more on the VAC production practice. It is recommended that cassava farmers are encouraged to multiply their planting stems with the support of extension agents. (ii) Finance was found to be a major determinant factor of cassava productivity and a major challenge in both OIC and VAC production practices. Farmers are advised to develop saving culture and enter contract farming with reputable companies and individuals to overcome this challenge. (iii) The government should make agricultural policy measures towards the provision of a ready market with stable prices for cassava roots as low market demand was one of the topmost constraints identified. (iv) Labour cost was found to be very high and accounted for the highest cost of production input, it is recommended that the farmers venture into labour – saving technologies and small-scale mechanization to reduce production cost such as encouraging efficient use of agro-chemical like herbicides for weed control.

**DECLARATIONS**

**ETHICS APPROVAL AND CONSENT:** Not applicable

**CONSENT FOR PUBLICATION:** Not applicable

**AVAILABILITY OF DATA AND MATERILAS:** All data generated or analyzed during this study are original data.

**COMPETING INTERESTS:** The authors declare that they have no competing interests

**FUNDING:** No external funding or grants received.

**AUTHORS CONTRIBUTION:** All the authors contributed to this work.

**ACKNOWLEDGEMENTS:** Not applicable

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