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# Technical Efficiency of Orange-Fleshed Sweet Potato Root Production in North Central, Nigeria

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**Abstract**

The paper analysed the technical efficiency and its determinants in orange-fleshed sweet potato root production system in North central, Nigeria. A multistage sampling was used to select 174 OFSP root entrepreneurs in Benue, Nasarawa and Kwara States from whom data were collected on input-output, farmer and farm characteristics with the aid of a structured questionnaire. A Cobb-Douglas stochastic frontier production function was used to analyse the data. The results of the analysis showed that the mean technical efficiency of OFSP root entrepreneur was 76 percent. The study found that the coefficient for household size was negatively assigned and significant at 5 % while age, education, farm experience, extension visits and access to credit were positive and have significant influence on technical efficiency at 5 % level of probability respectively. The study recommends policy decisions that encourage new entrepreneurs to take up OFSP root production and existing ones to remain in business through increased access to education, extension services and credit.

(**Keywords**: Technical efficiency, orange-fleshed sweet potato, root, North central)

## Introduction

Orange-Fleshed Sweet potato (OFSP) is an improved breed of sweet potato (*Ipomea batatas* [L.] *Lam.*) cultivated in tropical and semi-tropical regions of the world for food and source of income especially among the rural dwellers (Adebisi, *et al.,* 2015; Padmaja, 2009; Mitra, 2012). All varieties of OFSP are rich in beta carotene, which is a precursor of vitamin A. Because of the high content of beta carotene, OFSP is considered as a key crop to combat vitamin A deficiency (VAD) problem in the Sub-Saharan Africa (Adebisi *et al*., 2015; Low *et al.*, 2007; Low *et al.*, 2015).

In Nigeria, OFSP like other breeds of sweet potato is grown in all parts of the country, however commercial cultivation appears to be concentrated in Northern, semi-arid agro ecological zone of the country covering Benue State,

Nasarawa State, Plateau State, Kogi State, Kwara State, and Niger State (Amienyo and Ataga, 2007; Sweet potato Support Platform for West Africa, SSP-WA, 2012 in Anderson and Gugerty, 2012). Orange-fleshed sweet potato is economic and nutritional crop. All parts of the sweet potato crop have value and can be processed into diverse products of economic or food value (Afuape *et al*., 2014).

However, it has been observed that the potentials of OFSP in Nigeria have not been realized due to inefficiency in production, low level of investment and other factors. Some researchers have broadly classified these factors into socio-economic, biotic, and abiotic constraints. Socio-economic constraints in the production of OFSP include: low quality vine (seed) and poor vine delivery system and poor agronomic practice varieties (Ames, 1996; Njeru *et al*., 2004; Gichuki, *et al.*, 2006; Kivuva, *et al.*, 2014).

Farm efficiency has fuelled a large body of literature globally and is of importance both from microeconomic and macroeconomic points of view. Improving the efficiency with which farmers use the available resources is very crucial to increasing output, productivity, household income, food security, poverty reduction and overall economic growth. An efficient OFSP enterprise will naturally attract more investment. This opinion is corroborated by the assertion of Farla (2013), that investors' confidence in making profit is fundamentally important to economic success and long-term development of economy.

In spite of the importance of farm efficiency, there is limited research on the technical efficiency of orange-fleshed sweet potato root production in North central, Nigeria. Orange-fleshed sweet potato is a promising root crop for combating vitamin A deficiency (VAD), generating employments for farm households and source of income. Previous studies on orange-fleshed sweet potato, for example, Low, *et al*., (2015); Laurie, *et al*., (2015); Agili, *et al*., (2015); Abidin, *et al*., (2015); Chima, *et al*., (2015) did not focused on efficiency. This current study aims to fills this knowledge gap.

The objective of this study is therefore to estimate the technical efficiency and its determinants in orange-fleshed sweet potato root production in North Central Nigeria using the stochastic frontier Cobb-Douglas production function. Efficiency is an important factor of productivity as well as stability of production (Hong and Yabe, 2015).

## Methodology

The study was conducted in the North Central geo-political zone of Nigeria. The geo-political zone comprises six states, namely:

Benue, Kogi, Nasarawa, Plateau, Kwara and Niger. This geo-political zone was chosen based on the intensity of orange-fleshed sweet potato root production.

Multistage sampling procedure was employed to select the respondents in this study. The first stage involved the purposely selection of three states out of six states in the North central based on their distinct OFSP production (National Root Crops Research Institute, NRCRI, 2012). The three selected states were Benue, Nasarawa and Kwara. The second stage involved the purposely selection of Local Government Areas (LGAs) from the three selected states based on the intensity of OFSP production. Thus, in the second stage, Gboko, Konshisha, Vandeikya, and Makurdi were selected from Benue state while Karu, Lafia, JDA, and Nassarawa Egon were selected from Nasarawa state while Ilorin East, Ifelodun, and Patigi, were selected from Kwara state. The third stage involved the random selection of 174 (consisted of 87 root entrepreneurs from Benue, 33 from Nasarawa and 54 from Kwara States) farm households from the selected local government areas based on sampling frame from the respective ADPs. Data were collected on inputs, output and farm-farmer socioeconomic characteristics with aid of structured questionnaire. The Cobb-Douglas stochastic frontier production model was used to analyse the data.

**The empirical model**

Since orange-fleshed sweet potato root production is classical example of single output and multiple-input production, this study employed an econometric approach for measuring technical efficiency based on the Cobb-Douglas stochastic frontier function. Cobb-Douglas stochastic production function model was employed according to Seyoum, *et al*., (1998) in estimating the technical efficiency of OFSP root entrepreneurs and expressed thus:

$$\ln y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + (v_i - u_i) \quad \ldots 1$$

Where ln is natural logarithm, Y represents OFSP root output in Kg of the $i^{th}$ farm, $X_1$ is farm size in hectares, $X_2$ is farm labour input in man-days, $X_3$ is fertilizer used in kg, $X_4$ is pesticide in liters, $X_5$ is quantity of planting material in kg, $V_i$ is error term beyond the control of the OFSP root entrepreneur, $U_i$ is error term under the control of the OFSP root entrepreneur, $\beta_0$ - $\beta_5$ are regression parameters to be estimated.

The determinants of technical efficiency of OFSP root entrepreneurs were modeled in terms of socio-economic variables and farm specific factors. Following Battese and Coelli (1995), the determinants of technical efficiency model was simultaneously estimated with Exp ($-\mu_i$) defined by:

$\text{Exp}(-\mu_i) = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 + \delta_5 z_5 + \delta_6 z_6 + \delta_7 z_7 + \delta_8 z_8 + \delta_9 z_{9+} \delta_{10} z_{10}$ …2

Where $\text{Exp}(-\mu_i)$ is the technical efficiency of the $i_{th}$ OFSP root entrepreneur, $Z_1$ is the age of the household head in years, $Z_2$ is gender of the household head, a dummy variable, 1 for male and 0 for female, $Z_3$ is household head level of education in years, $Z_4$ is household size in number, $Z_5$ is farm experience of household head in years, $Z_6$ is access to credit, a dummy variable, 1 for access and 0 for no access, $Z_7$ is number of times visited by an extension agent per farming year, $Z_8$ is membership of cooperative societies, a dummy variable, 1 for member and 0 for non member, $Z_9$ is production system, a dummy variable, 1 for sole cropping and 0 for mixed cropping, $Z_{10}$ is farm size in hectares, while $\delta_0$,…, $\delta_{10}$ are regression parameters to be estimated.

## Results and Discussion

Estimation of technical efficiency is presented in Table 1. The result shows that the coefficients estimated in the model were positive and statistically significant at 1 % probability level. The elasticity of farm size (0.6352) was highest followed by planting material (0.5561). This explains the importance of farm size and planting material in OFSP root production in the study area. The positive coefficients of farm size, planting material, and labour indicate that 1 % increase in the amount of these variables would increase OFSP root output by 0.6352 %, 0.5561 %, and 0.3844 % respectively. The return to scale parameter is 1.9368, implying increasing return to scale. The implication is that OFSP root entrepreneurs in the study area are operating in the irrational stage of production, stage one thereby underutilizing productive resources.

The estimated variance parameter ($\boldsymbol{\sigma^2}$) was significantly different from zero indicating goodness of fit and the correctness of the distribution assumption of the composite error term specified in the model. The variance ratio ($\boldsymbol{\gamma}$) was also significantly different from zero. This shows that the farm specific variability contributed about 43% variation in yield among the OFSP root entrepreneurs. This implies that 43% of the differences between the observed and the maximum production frontier output were due to differences in farmers level of technical efficiency and not related to random variability. Thus, these factors are under the control of the OFSP root entrepreneur and the influence of which could be reduced to enhance technical efficiency of the OFSP production in the study area. This result is consistent with the findings of Mbanasor and Kalu (2008); Gbigbi (2011).

The result of the frequency distribution of technical efficiency estimates is presented in Table 2. The result shows that the technical efficiency of OFSP root production ranges from 0.51 to 0.95 with a mean of 0.76. Thus, the most technically efficient OFSP root entrepreneur is operating below the frontier level under the current technology. Therefore, if an average OFSP root entrepreneur in North central, Nigeria was to achieve the technical efficiency level of the most efficient counterpart, then the average OFSP root entrepreneur could realise about 20 percent cost saving (i.e., 1-[0.76/0.95]100) (Bravo-Ureta and Pinheiro, 1997) without reducing output. Similarly, for the most technically inefficient OFSP root entrepreneur in the study area will have an efficiency gain of about 46.30 percent (i.e., 1-[0.51/0.95]100), in OFSP root production if he or she is to attain the efficiency of the most technical efficient root entrepreneur in the study area. The study reveals that OFSP root entrepreneurs in the sample were technical inefficient. This result is consistent with the finding of Aye and Mungatana (2012).

**Table 1**: Maximum Likelihood Estimates of the Cobb-Douglas Stochastic Production Function for Orange-Fleshed Sweet potato Root (n=174)

| Production factor | Parameter | Coefficient | Standard error | t-value |
|---|---|---|---|---|
| Constant term | $\boldsymbol{\beta_0}$ | 8.6245 | 0.7665 | 11.2524*** |
| Farm size ($X_1$) | $\boldsymbol{\beta_1}$ | 0.6352 | 0.0732 | 8.6784*** |
| Planting Materials ($X_2$) | $\boldsymbol{\beta_2}$ | 0.5561 | 0.0532 | 10.4536*** |
| Labour ($X_3$) | $\boldsymbol{\beta_3}$ | 0.3844 | 0.0746 | 5.1538*** |
| Fertilizer ($X_4$) | $\boldsymbol{\beta_4}$ | 0.0097 | 0.0136 | 0.7155 |
| Pesticides ($X_5$) | $\boldsymbol{\beta_5}$ | 0.3514 | 0.0486 | 0.7231 |
| Diagnostics statistics | | | | |
| Log-likelihood function | | 85.6151 | | |
| Sigma Square | $\boldsymbol{\sigma^2}$ | 0.2720 | 0.0757 | 3.5935*** |
| Gamma | $\boldsymbol{\gamma}$ | 0.4315 | 0.1386 | 3.1165*** |
| LR-Test | | 12.1325 | | |

*Source: Field Survey Data, (2016)*. *** indicates statistically significant at 1.0%.

**Table 2**: Frequency Distribution of Efficiency Estimates of Orange-Fleshed Sweet potato Root Entrepreneurs (n=174)

| Efficiency level | Frequency | Percentage (%) |
|---|---|---|
| 0.51-0.60 | 11 | 6.32 |
| 0.61-0.70 | 29 | 16.67 |
| 0.71-0.80 | 106 | 60.92 |
| 0.81-0.90 | 23 | 14.37 |
| 0.91-1.00 | 3 | 1.72 |
| Total | 174 | 100 |
| Mean technical efficiency | 0.76 | |
| Minimum technical efficiency | 0.51 | |
| Maximum technical efficiency | 0.95 | |

*Source: Field Survey data, (2016)*

**Table 3**: Maximum Likelihood Estimates of the Determinants of technical Efficiency of Orange-Fleshed Sweet potato Root production (n=174)

| Efficiency Factors | Parameter | Coefficient | Standard error | t-value |
|---|---|---|---|---|
| Constant Term | $\rho_0$ | 0.1230 | 0.1631 | 0.7545 |
| Age | $\rho_1$ | 0.0040 | 0.0020 | 2.0344** |
| Education | $\rho_2$ | 0.0042 | 0.0016 | 2.6383*** |
| Gender | $\rho_3$ | -0.0458 | 0.0532 | -0.8612 |
| Farm Experience | $\rho_4$ | 0.0077 | 0.0038 | 2.0341** |
| Extension visit | $\rho_5$ | 0.0212 | 0.0065 | 3.2654*** |
| Access to credit | $\rho_6$ | 0.0293 | 0.0110 | 2.6721*** |
| Membership of cooperative | $\rho_7$ | 0.0198 | 0.5616 | 0.3532 |
| Household size | $\rho_8$ | -0.0040 | 0.0021 | -1.9145** |
| Production system | $\rho_9$ | 0.0481 | 0.0592 | 0.8221 |
| Off Farm Income | $\rho_{10}$ | -0.2016 | 0.0761 | -2.6530*** |

*Source: Field Survey data, (2016).* ***, ** statistically significant at 1% and 5 % respectively

## Determinants of Technical Efficiency

Table 3 shows the factors influencing technical efficiency of OFSP root entrepreneurs in North central, Nigeria. The variables with positive signs suggest that increase in these variables would lead to increase technical efficiency while with negative coefficients, increase in technical inefficiency. The result shows that age, educational attainment, farm experience, extension visit and access to credit have positive coefficients. This suggests that these variables had positive influence on technical efficiency of OFSP root production in the study area.

Educational level has a positive coefficient that is statistically significant at 1.0% level, which agrees with the *apriori expectations*. This suggests that education is critical in managing farming business and thus, has positive influence on technical efficiency.

Farm experience has a positive coefficient as expected and as such has a positive influence on technical efficiency and statistically significant at 5% level of risk. The implication is that the more experienced a farmer is, the higher his level of technical efficiency. This result is consistent with Bravo-Ureta and Pinheiro (1997) who identified positive impact of farm experience on efficiency. The coefficient of the visit by extension agent was positive and statically significant at 1 % probability level which implies more visit of an extension agent will lead to increase in technical efficiency of the farmer. Off-farm income was highly significant at 1% and has a negative coefficient, which agrees with *apriori expectations* that engagement in non-farm activities would lead to less attention to farm business, thus reducing technical efficiency.

The coefficient of gender is negative. The negative coefficient of gender implies that male headed households in the study area are relatively more technically inefficient than their female counterparts. This suggests that OFSP root production is women's business. This result is consist with a long held view that sweet potato production is women's affair. Household size has a negative coefficient and is significant at 5%. This implies that OFSP entrepreneurs with large household sizes will experience lower level of technical efficiency. Large household sizes are expected to enhance labour availability (Nwaru, 2004). However, the use of available family labour on small sized farms would result in under-utilization of labour and hence, inefficiency.

## Conclusion

The study showed that OFSP root production system was not fully technically efficient. The return to scale parameter was found to be 1.9368 implying increasing return to scale. The implication is that OFSP root entrepreneurs in the study area are operating in the irrational stage of production, stage one thereby underutilizing resources.

The individual technical efficiency of OFSP root entrepreneurs ranges between 0.51 to 0.95 with a mean of 0.76 which reveals substantial technical inefficiencies in the system, thus considerable room for increasing profitability by reducing cost. For an average OFSP root entrepreneur to be fully technical efficient, he or she would be able to reduce cost by 20 percent under the current technology.

The study revealed the important factors directly related to technical efficiency in orange-fleshed sweet potato root production in the study area as age, education, farm experience, extension visit, and access to credit. These results call for policy decisions that would encourage new entrepreneurs to take up OFSP root production through enhanced access to education, extension services and credit.

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