Technical Efficiency of Orange Fleshed Sweet Potato (*Ipomoea Batatas L.*) Production in Rivers State of Nigeria

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Abstract

The study examined the technical efficiency of Orange Fleshed Sweet Potato (ipomoea batatas L.) production in Rivers State. The broad objective of the study examined the efficiency of Orange Fleshed Sweet Potato Production in Rivers State, Nigeria. Multistage sampling technique was adopted in selecting 200 respondents and data were collected through the use of questionnaire. Data analysis was achieved using descriptive statistics, stochastic frontier model and a five point Likert scale. Results showed a mean age of 48 years, 60.42% female farmers, 39.58% male farmers, with an average household size of 7 persons, while about 72% had at least secondary school education, average of 8 years of farming experience, 93% sourced their finance for farming from personal savings, average farm size 0.8ha. The stochastic frontier analysis revealed a mean technical efficiency of 68.9%. Stochastic analysis result revealed that an average orange fleshed sweet potato (OFSP) farmer only required technical adjustment of 31.10% to attain full efficiency. The result revealed that gender (sex), age, family size, and level of education enhanced farmer technical efficiency. Constraints identified such as high cost of planting materials, labour, inadequate finance and poor access to credit, scarcity of processing equipment, poor extension service, destruction of crops by herders and their cattle, and insecurity in the rural areas. The study recommend improved access to farm credit and, improvement in the socio-economic status of the farmers.

Keywords: Technical Efficiency, Orange Fleshed Sweet Potato Production.

Introduction

Orange-fleshed sweet potato is a variety of sweet potato, (*Ipomea batatas L*). There are 16 kinds of orange fleshed sweet potatoes in the world today and they are grouped into three (3): Starchy Potato, Waxy Potato and All Purpose Potato. The crop ranks among the five most important food crops in over 50 developing countries, (Potato New World Encyclopedia, 2018). However, OFSP is newly introduced into Nigeria. It is highly a medicinal food and others do not have what it has. It is only a few farmers in Nigeria that are planting it on their own, in the North they do not have it, but recently a few have started planting, N.R.CR.I, Umudike (2012).

Orange-fleshed sweet potatoes offer a significant potential for increasing food production and income in Nigeria. Like other agricultural crops, orange-fleshed sweet potato has a role to play in the developing economies. Its production will provide job opportunities to the farmers, thus raising their income. Orange-fleshed sweet potato is consumed without much processing in most parts of the tropics. Although orange-fleshed sweet potato is a crop that is consumed in all parts of the country, its level of production still remains low. Worldwide, Orange-Fleshed Sweet Potato (OFSP) production and consumption is huge (Ajakaiye & Akande, 2016).

Despite the numerous potential uses and benefits of orange-fleshed sweet potato in Nigeria, the production of the crop is below the nation's potential. Orange-fleshed sweet potato has a yield potential of 20 - 50 tonnes per hectare wet weight in the tropics (Adeyonu *et al* 2019). They further asserted that farmers in Sub-Sahara Africa however produce below 10 tonnes per hectare wet weight on the average, while farmers in Nigeria recorded one of the world's lowest average potato yields of less than 3.1 tonnes per hectare. In Rivers State, OFSP had an average yield of 1546kg (1.5tonnes per 0.8hectares). The low yield of OFSP in the state was linked to technically inefficiency of the farmers in their underutilization of resources such land, fertilizer, improved OFSP materials (vies), and overutilization of finance, family labour etc (Babatunde et al., 2015). Globally, the United States of America and Japan, yields of 22.8 and 21.7 tonnes per hectare were recorded respectively. The low yields in Nigeria were due to poor and high cost of quality planting materials (vines), high labour costs, biotic and abiotic constraints. As opined by Fawole, (2017) the low productivity recorded in orange-fleshed sweet potato farms was traceable to inefficiency in resource use. Economic efficiency of OFSP is an overall performance measure of the farmer's farm or firm and is equal to the product or combination of technical efficiency (TE) and allocative efficiency (AE), represented thus: EE = TE X AE. It is the ability to produce large amount of output as possible using a given set of inputs or resources, without decreasing the total output (Olayinde and Head 2012).

Objective of the Study

The general objective of the study is to estimate the Technical efficiency of orange-fleshed sweet potato production in Rivers State, while the specific objectives were to;

i. describe the socio economic characteristics of orange-fleshed sweet potato farmers.
ii. determine technical efficiency of orange-fleshed sweet potato production in the study area.
iii. identify constraints militating against orange-fleshed sweet potato production in Rivers State.

Methodology

Study Area

This study on Technical efficiency of orange fleshed sweet potato was conducted in Rivers State Nigeria. Rivers State is situated in the heart of the South –South geopolitical zone of Nigeria. It is located within Latitude $4^0.45$' and $40^0.85$' North, and Longitude $6^0.49$' and $6^0.92$'East bounded on the East by Akwa Ibom state, in the North by Abia and Imo States, while Bayelsa, and Delta States at the west. Rivers State is bounded on the south by bight of Biafra which leads into the Atlantic Ocean (Rivers State Diary, 2012). Rivers State has a land mass of about 11,077km^2 and a home of many indigenous ethnicities or tribes such as Abual/Odual, Andoni, Ekpeye, Engenni, Etche, Ibani, Ogba/Egbema/Ndoni, Ogoni, Okrika, Kalabari, Bonny, Opobo etc, with a population of 7,034,973 (National Bureau of Statistics (2019). The people of Rivers State are predominantly engaged traditional farming, fishing, commerce and industry for livelihood.

Fig.1 Map of Rivers State

Research Design

This study adopted a survey method because of its nature in aiding to source information from the respondents via the use of questionnaire.

Sampling Procedure and Sample Size

For agricultural and administrative purposes, Rivers State is divided into three (3) agricultural zones, namely: Zone 1, 2 and 3 by the Rivers State Agricultural Development Programme (RSADP). This study employed a multi-stage sampling technique in the selection of the respondents. In the first stage, was a purposive selection of two (2) out of the three (3) agricultural zones, that is, zones 1, and 3. The purposive selection zones 1and 3 were because they are in the upland part of Rivers State where the people are predominantly farmers, including OFSP farming and for the researcher these zones were easier to cover in terms of transportation. In the second stage, eight (8) Local Government Areas were randomly selected, four Local Government Areas each from zones 1 and 3, giving a total of Eight (8) Local Government Areas, including, Obio/Akpor, Oyigbo, Tai, Etche, Ahoada East, Ikwerre, Abua/Odual, Ogba/Egbema/Ndoni. In the third Stage, 5 Clans and 5 Communities each were randomly selected from each of the Eight (8) Local Government Areas, making a total of 25 communities. In the final and fourth stage, one (1) Small scale orange-fleshed sweet potato (OFSP) farmer each, were randomly selected from a list of registered cooperative orange-fleshed sweet potato farmers in the 25 Communities. Mathematical representation:

In 1 LGA = 5 Clans selected

In 1 Clan = 5 Communities

$\therefore$ In 1 LGA = 5 Clans x 5 communities = 25 communities

In 1 community = 1 small scale OFSP farmer

1 LGA = 1 small scale OFSP farmers X 25 communities = 25 farmers

$\therefore$ In 8LGAs = 25 farmers x 8LGAs = 200 farmers/respondents.

Table 3.1 Sample Population from the Selected Local Governments Areas.

Purposive Selected of Agricultural Zones in Rivers State 1, 2 and 3	Random Selection of LGAs n = 8	Random No. of Clans Selected from each LGA n = 5	Random No. of Communities Selected from each chosen LGA Clan n = 5	Random No. of Registered OFSP farmers Selected per Community n = 1	Total No. of OFSP respondents/farmers (sample size) n = 200
1	Obio/Akpor	**5**	**5**	**1**	**25**
	Oyigbo	**5**	**5**	**1**	**25**
	Tai	**5**	**5**	**1**	**25**
	Etche	**5**	**5**	**1**	**25**
3	Ahoada East	**5**	**5**	**1**	**25**
	Ikwerre	**5**	**5**	**1**	**25**
	Abua/Odual	**5**	**5**	**1**	**25**
	Ogba/Egbema/Ndoni	**5**	**5**	**1**	**25**
	Total		**40**		**200**

Source: Field Survey 2022

Data Collection

Data for this study were collected through the administration of a well-structured questionnaire, as well as interview schedule, 200 respondents were randomly selected. The questionnaire was designed to obtain information on the socio-economic characteristics of the respondents, data included orange-fleshed sweet potato production operations or activities.

Data Analysis

The data collected for this study were analyzed using descriptive statistics such as frequencies, counts, mean, percentages and inferential statistical such as Stochastic frontier production function model, stochastic cost function model, farm budgetary and gross margin analysis techniques. A Five Point Likert Scale was used to determine the mean score of the constraints/problems of OFSP production and their ranking order.

Objective (i): Simple descriptive statistics, such as frequencies, counts, mean, percentages etc. were used to analyse farmers socio-economic characteristics in the study area.

Objective (ii): Technical efficiency was achieved using Stochastic Frontier Production function and Stochastic Cost function model.

Objective (iii) Constraints was realized using the Five-Point Likert-Scale model.

RESULTS AND DISCUSSION

1 Socio Economic Characteristics of Orange Fleshed Sweet Potato Farmers

A summary of the results of the socio economic characteristics of small scale orange fleshed sweet potato farmers in Rivers State, Nigeria.

Table 1: Socio Economic Characteristics of Respondents

Variables	Frequency	Percentage	Mean
Gender			
Male	76	39.58	
Female	116	60.42	
Total	**192**	**100**	
Age (Years)			
26-31	11	5.72	
32-37	26	13.54	
38-43	55	28.64	
44-49	51	26.56	
50-55	36	18.75	
56-Above	13	6,77	
Total	**192**	**100**	**48 years**
Marital Status			
Married	139	72.39	
Single	31	16.14	
Separated	5	2.60	
Widowed	17	8.85	
Total	**192**	**100**	
Household Size			
1-4 Persons	57	29.68	
5-9 Persons	82	42.70	
10-15 Persons	52	27.08	
16-20 persons	1	0.52	
21-above persons	0	0	
Total	**192**	**100**	**7 persons**
Level of Education			

Informal	3	1.56	
Primary	39	20.31	
Post Primary (Secondary)	138	71.87	
Tertiary	12	6.25	
Total	**192**	**100**	
Years of Experience			
1-4 years	70	36.45	
5-10 years	101	52.60	
11-15 years	21	10.93	
16-above years	0	0	
Total	**192**	**100**	**8 years**

Source: Field Survey, **2022**

Table 1 results showed that 60.42% of the farmers were female, while only about 39.58% of the potato farmers were male. This result was in contrast with the findings and assertions of most early scholars, Omojola (2014), Nlerum (2016) in their studies on yam production, who concluded that greater percentage of the farmers were male. However, our finding has gone a long way to buttress the fact earlier stressed by Etim *et al,* (2013), who highlighted the role of women in the production process of the economic implication of the gender of the orange fleshed sweet potato farmers as shown in the result (60.42%) females, meant that more female/women were involved in orange fleshed sweet potato farming in Rivers State.

The result from table 1, on age of the potato farmers varied between 26 years and 56 years. Most of the farmers were middle aged men and women. The mean age of the respondents was 48years. This finding agreed with, Tiku *et al* (2012), Matthew *et al*, (2018), Tayinde *et al* (2014) who reported mean age of 48years. The economic implication of age of orange fleshed sweet potato farmers was relevant at 44 years as shown by the results. It enhanced the farmers' active involvement, participation, planning, implementation, coordination of the farm activities to achieve maximum output and income in the area.

The result showed 72.4% of the farmers were married men and women, while only about 16.1% were single, 8.9% were widows and just 2.6% were separated single parents in the study area. Marital status played a very vital role in potato production/farming due to its labour intensive nature. Tayinde (2014) reported that 85% of yam farmers were married, while Ekunwe (2017), reported that 67% of yam farmers in Kogi State were married. Thus the use of family labour was a common practice to reduce the cost of hired labour. The economic implication of marital status of the farmers was that it enhanced large family size, which augmented or served as labour, thus saving the high cost of hired labour in the orange fleshed sweet potato farmers' production in the study area.

The results also showed 42.7% of the respondents who had household size of between 5 – 9 persons, while 27.1% had an average household size of 11 persons in all 8 LGAs of the study. Most farmers depended on family labour due to the high cost of hired labour, this also encouraged them to have large families as most of them practiced polygamy, Omojola (2014).

The result in table 1 showed 71.9% of the respondents who had at least secondary school education, while 20.3% had primary education, and only about 6.2% had tertiary education. This means, most of the farmers had gotten one form of education or the other in the study area. This was in line with Amaza (2012), Agbaje, *et al* (2005), Henri-Ukoha, *et al* (2011), who stated that most rural farmers in Nigeria had one form of education or another, and that level of education enhanced productivity.

The result also showed an average or mean of 8 years of farming experience for all respondents in the study area. The importance of years of farming experience had been stressed by Onyenweaku and Nwaru (2015), that an increase in age and years of farming experience had a positive relationship with improved productivity. This was in line with Okumadewa (2001).

The economic implication of years of farming experience was that, an increase in age and farming experience of the farmers had a positive or direct relationship with improved productivity. The results in table 1 showed that, only a few of the respondents, just about 15.1% belonged to farmers' associations or cooperatives, whereas 84.9% belonged to no form of farmers' association in all 8 LGAs of the study. Thus, the non-membership of orange fleshed sweet potato farmers in farmers' cooperative/associations deprived them access to credits/loans from banks, NGOs, Oil Companies and inputs from Government/ADP etc. to improve their farms. Hence, the result was a decreased productivity in the study area.

Technical Efficiency Estimation of Orange Fleshed Sweet Potato Production

Table 2: Maximum Likelihood Estimation of the Stochastic Frontier Production Function Analysis for Orange Fleshed Sweet Potato

Production Factor	**Parameters**	**(Coefficient)**	**(t-ratio)**
Constant	B	-(4.844)	-(4.998)***
Area Cultivated (ha)	X_1	-(0.807)	-(1.087)
Labour in Mandays(number)	X_2	(1.636)	(4.021)***
Potatoes Vine Bundle (Kg)	X_3	(0.336)	(3.769)***
Fertilizer(kg/ha)	X_4	(0.692)	(2.531)**
Inefficiency Effect			
Constant	Δ	(2.040)	(33.436)***
Gender	GEND	-(0.001)	-(0.497)

Age	AGE	-(0.004)	-(0.637)
Marital Status	MSTA	(0.003)	(1.198)
Household Size	HSIZE	-(0.002)	-(0.916)
Level of Education	LEDU	-(0.001)	-(0.368)
Years of Farming Experience	YEXP	(0.026)	(4.583)***
Sources of Finance	SFIN	(0.001)	(0.210)
Sources of Land	SLAND	(0.016)	(1.004)
Diagnostic Statistics			
Sigma Squared	σ^2	(0.531)	(8.167)***
Gamma	Γ	(1.000)	(637945.060)** *
Log Likelihood Function		-(46.925)	
LR test		(153.686)	

Source: Field survey computed output from frontier 4.1 version 2022

***** Significant at the 0.01 level, ** at the 0.05 level, * at 0.1 level**

Technical Efficiency Factors

Farm Size (β_{xi})

Table 2 showed maximum likelihood estimates of the stochastic frontier production function. The result showed a positive coefficient value for sigma squared (0.531) and t-ratio of (8.167***) This implied that there were inefficiency effects among the various variables at a very high percentage, given the t-ratio of 8.167*** significant at 1% level, because the bench mark of 3.0 was greater than 2.576 t-ratio. Again the result showed a positive co-efficient of (1.000) and t-ratio of (637495.060***) for Gamma.

Labour (β_{x2})

The co-efficient for labour usage (1.636) with a negative t-ratio value of (-4.021***) significant at 1% level. The positive co-efficient for labour usage implied that, there was a direct relationship between labour and orange fleshed sweet potato output. This meant an increase in labour resulted to an increase in orange fleshed sweet potato output, it was a case of under-utilization of farm labour. The negative t-ratio value showed an inverse relationship between labour and output of orange fleshed sweet potato. It meant that a 1% decrease in labour resulted in a 1% decrease in output, which was a case of overutilization of the input labour.

Vine Bundles (β_{x3})

Stochastic frontier production estimates showed a positive co-efficient of (0.336) for vines usage, which meant a direct relationship between the planting materials used (vines) by the farmers and their output. A

positive t-ratio value of (3.769***) significant at 1% level, also showed a direct relationship. T-ratio measures the significance of an individual variable in a model. The economic implication of this positive co-efficient, which was a direct relationship between planting materials (vine bundles) and output, was that an increase in the quantity and quality of vine bundles planted resulted to increase in output of orange fleshed sweet potato in the study area.

Sources of Inefficiency and Its Effect on Orange Fleshed Sweet Potato Farmers in Rivers State

Gender δ_1

The stochastic frontier production function analysis on table 2 showed that gender of farmers had a negative co-efficient (-0.001), which meant an indirect or inverse relationship between gender of farmers and output efficiency of orange fleshed sweet potato.

Age of the Farmers (δ_2)

Result of the stochastic frontier estimation showed that age of the farmers had negative value coefficient of (-0.004), which meant indirect or inverse relationship between age of farmers and output efficiency of orange fleshed sweet potato. The negative t-ratio value of (-0.637) also showed an inverse relationship meaning that as the age of the farmers decreased, technical inefficiency increased.

Marital Status (δ_3)

The result showed a positive coefficient of (0.003), which meant a direct relationship between marital status and output of orange fleshed sweet potato farmers. The direct relationship implied that marital status of the orange fleshed sweet potato farmers increased technical efficiency of the farmers.

Household size (Family Size) (δ_4)

Maximum Likelihood Estimation (MLE) of stochastic frontier production function in table 2 showed a negative coefficient of (-0.002) which meant indirect or inverse relationship between household size of farmers and output efficiency of orange fleshed sweet potato.

Level of Education (δ_5)

The coefficient for level of education was shown as (-0.001). This negative coefficient value meant an indirect relationship between level of education and technical efficiency. The negative t-ratio value of (-0.368) showed a 10% significant level of level education of the farmers and their technical efficiency.

Years of Farming Experience (δ_6)

Table 2 showed that there was a positive relationship between technical inefficiency and years of farming experience of farmers. The coefficients for years of farming experience was a positive value of (0.026), which meant a direct relationship between years of farming experience and output of orange fleshed sweet potato farmers.

Source of Finance (δ_7)

The coefficient for source of finance was a positive value of (0.001). This showed that a 1% increase in finance for orange fleshed sweet potato production resulted to a 1% increase in technical productive efficiency. It also showed a direct relationship between source of finance and output of orange fleshed sweet potato.

Source of Land (δ_8)

Maximum likelihood estimation of the stochastic frontier production function in table 2 showed a positive coefficient value of (0.016), which meant a direct relationship between source of land and output of orange fleshed sweet potato farmers.

Table 3: Distribution of Technical Efficiency Range for Production Estimate Among Orange Fleshed Sweet Potato Farmers in Rivers State

Technical Efficiency Range	Frequency	Percentage
0.10- 0.35	69	35.94
0.36-0.60	18	9.38
0.61-0.85	1	0.52
0.86-1.00	104	54.17
Total	192	100
Mean efficiency	0.689	
Minimum	0.331	
Maximum	1.000	

Source: Field survey computed output from frontier 4.1 version 2022

Table 3 showed the result of Maximum Likelihood Estimation of the distribution of technical efficiency range for production among orange fleshed sweet potato farmers in Rivers State. The result showed that farmers technical efficiency ranged from 0.10 to 1.00, with a mean efficiency value of 0.689, which implied about 68.9%. Examination of the overall results showed that an average orange fleshed sweet

potato farmer in Rivers State required about 31.1% improvement on technical adjustment and cost reduction practices to attain full technical efficiency in resource usage. Whereas the least efficient farmer required 66.9% improvement as to attain full efficiency. Matthew et al., (2019) had earlier reported a technical efficiency range of 54-99% among yam farmers. This result revealed a wide range of variation or gap between the least efficient orange fleshed sweet potato farmers in the State. However, the result also showed that 54.17% which represented the highest proportion of the farmers (i.e. 104) operated between the ranges of 0.86 – 1.00, while 35.94% (i.e. 69) operated between 0.10 – 0.35.

Table 4: Five Point Likert Scale Showing the Constraints/Problems of Orange Fleshed Sweet Potato (OFSP) Farmers in Rivers State.

S/NO.	Items	Extremely serious constraint (ESC)	Very serious constraint (VSC)	Serious constraint (SC)	Not very serious constraint (NVSC)	Not serious constraint (NSC)	Total	Mean	Remark	Ranking
	Constraints/Problem of Orange Fleshed Sweet Potato Formers in Rivers State	5	4	3	2	1				
1.	Insufficient capital for production	150	30	12	0	0	906	4.72	ESC	1st
2.	Lack of access to credit (loans)	110	40	40	2	0	834	4.4	ESC	3rd
3.	Scarcity of processing equipment	50	30	100	10	2	692	3.60	VSC	7th
4.	High cost of storage and processing equipment	0	0	110	90	12	482	2.5	NSC	12th
5.	Transportation problem	80	90	15	7	0	819	4.26	ESC	6th
6.	High cost of planting materials (vine cuttings)	140	20	30	2	0	844	4.39	ESC	4th
7.	High cost of land	120	50	5	10	7	842	4.38	ESC	2nd
8.	Problem of pest and diseases	0	0	22	100	70	336	1.75	NSC	14th
9.	Lack of extension service	40	30	100	10	12	652	3.39	VSC	8th
10.	High cost of labour	160	12	10	10	0	898	4.67	ESC	2nd
11.	Problem due to low yield per hectare	0	0	120	50	22	482	2.51	VSC	11th
12.	Destruction of crops by cattle and goat	0	90	75	20	7	632	3.29	VSC	9th
13.	Problem of weeds	0	0	0	150	42	342	1.78	NSC	13th
14.	Poor/low price of produce	0	50	30	100	12	502	2.61	NSC	10th

Source: Field survey 2022

In Table 4 is a Five Point Likert Scale, showing varying degrees of constraints/problems of orange fleshed sweet potato farmers in Rivers State. The table showed the level or degrees of effects by various constraints on the operations and production activities of orange fleshed sweet potato farmers in Rivers State. The bench mark mean was (3.0). Therefore, any option or item above whose mean was (3.0) or above was considered as an extremely serious constraint (ESC) or very serious constraint (VSC) to orange fleshed sweet potato farmers in Rivers State. Whereas those with mean less than (<3.0) were considered not a serious constraint (NSC) or problem to orange fleshed sweet potato farmers in Rivers State.

The result showed that, insufficient or inadequate capital, high cost of labour, high cost of planting materials (vine cuttings), lack of access to credit/loans, high cost of land for farming, transportation problem, ranked highest as extremely and very serious constraints (ESC and VSC) of orange fleshed sweet potato production in Rivers State. Other constraints were scarcity of processing equipment, lack of extension service, destruction of farm crops by cattle and goats which were also considered as very serious constraints (VSC) to the farmers. Whereas, pests and diseases, weeds, low price of produce were considered not serious constraints (NSC), low yield or poor output per hectare were ranked as a very serious constraint (VSC), cost of storage and processing equipment were considered not a serious constraint (NSC) to orange fleshed sweet potato farmers in Rivers State. This result was in line with the findings of Gbegeh and Akubuilo (2013), Izekor and Olumese (2010), who identified cost of labour, lack of inadequate finance as major constraints to yam production. In the same vein, this work also agreed with Tanko and Zaknayiba (2013) who reported that lack of access to credit/loans, had negative effects on farming activities. Adeyonu *et al* (2019) had also reported that labour shortage due to high cost of hired labour/technology was a serious constraint to sweet potato production.

Conclusion and Recommendation

1. The results from this study showed that orange fleshed sweet potato production in the study area was profitable, considering the gross marginal analysis which showed 80.20% return on investment per annum.
2. The farmers were operating at stage 1 of the production function, which showed increasing marginal return and (MVP $\neq Px$) AEI $\neq$ I). These all showed under utilization of resources (inputs), marginal value products were higher than the unit prices of inputs, which was indicative of inefficient use of resources.

3. In conclusion, this study provided information on resources use efficiency in orange fleshed sweet potato production in Rivers State, Nigeria.

Based on the findings of this study, the following recommendations have been proposed.

1. Orange fleshed sweet potato farmers should form themselves into cooperatives to be able to access bank loans for their production instead of depending on personal savings.
2. There is need for the different varieties of OFSP Vines to be made available for planting all year round.
3. Orange fleshed sweet potato farmers should optimally use production resources (land, vines, fertilizer, labour, finance etc) to enhance productivity and profit.

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