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PROFITABILITY AND EFFICIENCY OF SWEET POTATO PRODUCTION IN NORTH CENTRAL AND NORTHWESTERN NIGERIA: A POTENTIAL FOR ENHANCING FOOD SECURITY

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ABSTRACT
This study examined efficiency and profitability of sweet potato production in north central and northwestern Nigeria as a potential for enhancing food security. Primary sources of the data were gathered by field surveys in 2016/2017 farming season through questionnaire and interview. A multistage sampling procedure was used to select 200 respondents comprising 100 farmers each from kwara and katsina states. Data collected were analyzed using descriptive statistics, net farm income and stochastic frontier functions. The results revealed that area devoted to sweet potato farming, level of education, access to credit, and farming experience were found to be higher in kwara state. However, household size, family labour involvement in farming and quantity of fertilizer used per ha was found to be higher in katsina state compared to kwara state. Sweet potato production was profitable in both states with an average return of ₦2.35and ₦1.66on every ₦ 1 invested in kwara and katsina states respectively. The results of the stochastic frontier model showed that there are significant differences in the technical and allocative efficiency of both kwara and katsina sweet potato farmers, and the pooled data in the study area. The pooled technical efficiency index of the farmers is directly proportional to level of education and years of sweet potato production. This suggests that farmers with more years of experience and education are likely to have higher yields whichare sine quo non to food accessibility and affordability among households. Farmers are encouraged to increase the hectarage of sweet potato production to increase profit. The sustainable increased in output could be achieved if farmers adopt a new techniques and improved their technical efficiency through training and workshops on input acquisition, inputs combinations and utilization as ample opportunity still exist to move closer to frontier.

Keywords: Efficiency, food security, profit, sustainable, sweet potato

Introduction

In view of the serious challenges of feeding a world population that reached about 7.55 billion in 2017 and is likely to approach 9.772 `billion in 2050 (United Nations, 2017) and the target of reducing extreme poverty rates by half is said to have been met five years ahead of the 2015 deadline, it has become relevant to pay more attention to food production issues to achieve Sustainable Development Goal (SDG) 1 to end extreme poverty including hunger by 2050. Globally, about 795 million people are still estimated to be undernourished and more than 90 million children, under age five, are still undernourished and underweight (United Nations, 2016). World Bank suggests that the share of the African population in extreme poverty did decline from 56 percent in 1990 to 43 percent in 2012 (Beegle *et al.*, 2016).

Food security has become one of the major challenges for the development of African countries especially Nigeria, largely due to population and population growth. Food security exists when all people at all times have access to safe nutritious food to maintain a healthy and active life. Food security entails ensuring sustainable production, food accessibility, affordability of adequate quantity and quality food to all citizens to meet up with their physiological requirement (Okuneye, 2014). The main goal of food security is for individual to be able to obtain adequate food needed at all times, and to be able to utilize the food to meet the body's needs (Ojeleye *et al.*, 2017). In Nigeria and more commonly in most developing countries, the demand for food products has outstripped supply creating a huge deficit (Oladimeji, 2017). Nigerian population has increased from about88.5 million in 1987 to a recent estimated figure of over 184 million in 2016 (NPC, 2016). Food production is a necessary condition in reducing hunger and ensuring food security, especially to the poor rural dwellers that are vulnerable to misfortune (Verter and Becvarova, 2014). If food production is to keep pace with rapid population growth and demand for food, a new and creative approach to agricultural development must be developed. In a country where millions of

people are not adequately fed, Nigeria's unexploited food resources must be unearthed and utilized. The rural farmers constitute the backbone of the Nigerian agricultural sector producing about 80 percent of the total national agricultural output (Fayinka, 2004) by using traditional methods under rain-fed conditions. It is important to emphasize that despite the potential benefits stemming from the expansion of the agricultural sector through various government efforts, its overall productivity remains low and the poor performance of agriculture is most clearly evidenced by the low standards of living of these small-scale rural farmers (Dogon-daji, 2005). However, high agricultural productivity is a necessary ingredient for sustainable food supply and food security.

Sweet potatoes (*Ipomoea batatas*) offer a particularly significant potential for increasing food production and income in Nigeria. Like other agricultural crops, sweet potato has a role to play in the developing economies. Although sweet potato is a crop that is consumed in all parts of the country, its level of production still remains low(Odebode*et al.*, 2008).The crops produce carbohydrates much faster and require less labor than other crops. The crops are used to restore access to food for resetting populations and alleviate future agro-climatic or political shocks. The most commonly cultivated sweet potato varieties in Nigeria are white and yellow/orange-fleshed. Initiatives have spawned to encourage the production and consumption of orange-fleshed sweet potato varieties that are rich in beta-carotene (a carotenoid or plant pigment responsible for the yellow and orange coloration of some tuber varieties) and help fight vitamin A deficiencies (Anderson *et al*., 2007). In Nigeria, most of the sweet potato land races (local varieties developed by natural processes and adaption to the local environment) have white-fleshed roots with negligible amounts of beta-carotene (Ukpabi*et al*., 2012).

The poor output realized by farmers may be an indication that resources needed in the production of the crop are not being used at their optimal levels. The relatively little emphasis laid by farmers on the crop raises the question as to whether it is profitable to grow the crop or not. This situation calls for an assessment of the resources needed for its production and how these resources are managed by its cultivators. This vital information which is lacking at the moment particularly in the study area and this has created a vacuum which this research has the main objective of filling. The study therefore assessed the profitability of sweet potato production in the study area, determined the levels of technical and allocative efficiency, estimated the factors that determined inefficiency of sweet potato farmers and examined how the inefficiency factors (socio-economic characteristics) relate to food security status of sweet potato' farming households.

Justification of the Study

Efficiency measurement is very important, because it is the first step in the process that might lead to substantial resource savings and increase profitability, and can also assist in exploring and achieving the micro level food security as well as nation objectivity of sustainable food production and food security.

Research Methodology

Study Area

The study employed primary data gathered during field surveys in 2016/2017 farming season from kwara and katsina states through questionnaire and interview. Kwara state is situated in north central has a land mass of 32,500 km^2 located between latitude 70 45" and 90 30" N and longitude 20 30" and 60 25" E. The state's population and farm families were projected at 3.2 percent per annum in 2019 to be about 3,562,313and 358,880 respectively with average density of about 106 km^{-2}. The annual rainfall ranges from 800mm to 1500mm and varies from 1000mm to 1500mm in the southern western part of the State (NPC, 2006; ADP, 2017).

Katsina state is situated in north-west with a total land size of 25,938 km^2out of which 1.64 million are arable. It lies between latitudes 11^0 03" and 13^0 05'N and longitudes 07^0 W and $09^0$02'E with a projected population at 3.2 percent per annum (NPC, 2006) to be 8,723,845 in 2019and average density of about 353 km^{-2}. The mean annual rainfall ranges from 400 mm to 1300 mm with highest amount recorded in August, while the mean annual temperature ranges between 29-39 ^{0}C (NPC, 2006).

The vegetation in the two states consists largely of derived savannah with a great expanse of arable land and rich fertile soil with crops like grains, roots and tubers mostly cultivated and tree crops like cocoa and cashew thrive fairly well in some parts of kwara state while grain crops thrive well in katsina state. Jones (1966) and Odebode *et al.* (2008) stated that sweet potato has advantages over other root and tuber crops because of low demand on soil nutrient, tolerance of drought, capability of providing reasonable yields in agro-ecological zones where other crops would fail, low requirements for external inputs such as fertilizer and flexibility in planting and harvesting period.

Data Collection and Sampling Size

Socio-economic characteristics of farming households and information on quantities, acquisition of inputs such as stem seedling, fertilizer, agrochemical, labour and fixed items especially knapsack sprayer used in sweet potato production and their economic life span as well as output in value and kilogramme were sought from respondents.

A multistage sampling procedure was used for selecting the respondents. Two regions north central and north-west were purposively selected to compare sweet potato production parameters such as socio-economic and institutional characteristics, agronomic practices, inputs-output analysis, profitability and efficiency

between the two regions. This may enable agriculture policy makers to give sound judgments and decisions on which of the regions have comparative advantages in sweet potato production.

Katsina and kwara states each were purposively selected from the list of states in north central and north western Nigeria due to large concentration of sweet potato farmers in the two states and the fine sandy loam, good for cultivation of the crop (Adefila, 2014). The second stage involved random selection of three LGAs each from the two states. These LGAs were Dandume ,Funtua and Malum-fashi (katsina state) and Irepodun, Offa and Oyun (kwara state). Thirdly, five villages each were randomly selected from the list of villages involved in cassava production in the two states. The selected villages in katsina State include Maska, Mahuta, Goya, Tumburkai and TudunIya. While Adeleke, Ajasse-ipo, Erin-ile, Igbodun, and Ira were the villages randomly selected in kwara State. Subsequently, 20 sweet potato farming households were randomly selected from each of the village to make a total of 200 respondents.

Analytical Tools

Descriptive statistics, net farm income and stochastic frontier were used to analyse the data.

Net farm income (NFI) was expressed as follows:

NFI = TR – TC (1)

TC= TVC + TFC (2)

NFI = TR- (TVC+ TFC) (3)

Where: TR = Total Revenue; TVC = Total Variable Cost and TFC = Total Fixed Cost

Total Variable Cost (₦) is expressed as

$$\sum_{i=1}^{n} PiXj = (PX_1 + PX_2 + PX_3 + PX_4) \quad (4)$$

Where: = total cost of inputs; PX_i = unit cost of stem seedlings (₦/bundle/ha); PX_2 = unit cost of fertilizer (₦/kg/ha); PX_3 = unit cost of herbicide (₦/litre/ha) and PX_4 = unit cost of labour (₦/ Man-day/ha).

Depreciation values were estimated using a straight line method under the assumption that knapsack sprayer and other equipment were used for a period of 3 years before being scrapped without salvage values.

Profitability indices were also computed as:

$$ROI = \frac{gross\ income}{total\ cost} \quad (5)$$

$$PM(\%) = \frac{net\ farm\ income}{gross\ income} * 100 \quad (6)$$

$$GR(\%) = \frac{total\ cost}{gross\ income} * 100 \quad (7)$$

$$\frac{NFI}{TC} = \frac{net\ farm\ income}{total\ cost} \quad (8)$$

Where R0I= gross ratio.

The stochastic frontier production (SFP) was used to determine the levels of technical and allocative efficiency of the sweet potatoes farmers. The SFP was independently proposed by Aigner*, et al.* (1977) and Meeusen and Van den Broeck (1977). The SFP is defined by $Y_{i=}F(X_i,\beta)\, e^{v-u}$ (9)

Where: Yi = observed output of the i^{th} sample farms, X_i is the vector of the inputs used by the i^{th} farms, β vector of unknown parameters to be estimated, e_i is the error term made up of two components: v_i, associated with random factors outside the farmers control and $u_i$is associated with technical inefficiency of the firm and ranges between zero and one. Both U_i follows an identical and independent half-normal distribution, N (0. δ^2u) is assumed to be an independently and identically distributed N (0. δ^2v) random variable and independent of u_i. On the other hand, u_i is a non- negative truncated half normal random, variable associated with farm-specifics factors, which leads to the i^{th} farm not attaining maximum efficiency of production.

The technical efficiency of an individual firm is defined in terms of the observed output (Yi) to the corresponding frontier output (Yi*) given the available technology.

$TEi = Yi/Yi^*$ (10)

So that $0 \leqslant TEi \leqslant 1$ (11)

The stochastic frontier cost function which is the basis for estimating the allocative efficiency of the farms is specified as follows:

$Ci = g(p_i, \alpha)\, exp(v_i + u_i)$ (12)

Where: Ci = the total input cost of the i^{th} farms; g = is a suitable functional form

pi = represents input pricesper unit employed by the i^{th} farm; α = parameters to be estimated;

$v_i + u_i$ = composed random error terms defined as earlier. However, inefficiencies are assume to always increase costs, error component have positive signs.

The allocative efficiency (AEi) of individual farms is defined in terms of the ratio of the predicted minimum cost (Ci*) to the observed cost (Ci).

Aei = Ci*/C (13)

The strength of the stochastic frontier approach is that, it deals with the stochastic noise and permits statistical test of hypotheses pertaining to the structure and degree of inefficiencies (Aigner*, et al.,* 1977 and Meeusen and Van den Broeck, 1977).

Results and Discussion

Socio-economics and Production Data Used in Efficiency Model

Summary statistics of the data reported in Table 1 revealed that farmers in kwara state were 66.0 percent male and 65.0 percent were married while all farmers in katsina state were male and about 93.0 percent were married. This implies that sweet potato farming is dominated by male headed households in the study area.

Table 1: Distributions of the variables used in the analytical techniques

Variable	Kwara State farmers			Katsina State farmers		
	%	±stdev	Min (max)	%	±stdev	Min (max)
Gender (dummy)						
Male	66	-		100		
Female	34			-		
Marital status						
Married	65			93		
Single	35			7		
Age (years)						
21 - 30	9	47±7.3	22 (72)	31	36±5.09	21 (75)
31 - 40	23			12		
41 - 50	35			35		
51 - 60	23			9		
61 & above	10			13		
Education (years)						
Nil	06	11.3±2.8	0 (16)	55	5.5±5.9	0 (12)
Primary	22			27		
Secondary	62			14		
Tertiary	10			4		
Farming experience						
1-5	8	18.9±3.5	3 (37)	12	12±1.9	4(48)
6-10	11			31		
11-15	61			20		
16 & above	20			37		
Household size						
1-5	17	6±1.7	3(27)	9	11±2.2	5(35)
6-10	58			17		
11-15	11			34		
16 & above	14			40		
Extension contact						
Contact	37	1.8±0.3	0(5)	59	2.3±0.8	0(8)
No contact	63			41		
Access to Credit						
Access ('000Naira)	72	85±5.59		87	37±9.4	0 (1.2 miilion)
No access	28			13		

Note: indicate mean, stdev: standard deviation, min: minimum and max: maximum

The mean age of sweet potato farmers were 47 and 36 years with standard deviation of 7.3 and 5.09 years in kwara and katsina states respectively. Age has a significant influence on the decision making process of farmers with respect to adoption of improved farming technologies and other production-related decisions. This implies that the farmers are strong, agile, and active and could participate adequately in farming activities. This finding is similar to that of Oladimeji and Ajao, (2014), that observed that age of 31-50 years constitute a reasonable proportion of the farmers in Nigeria and should be more flexible to new ideas and risk; hence they are expected to adopt innovations more readily than older farmers.

The result further revealed that majority of the sweet potato farmers in kwara state (72%) had at least secondary education with mean index and standard deviation of 11.3 and 2.8 years respectively. In contrast, farmers in katsina state are less educated with mean and standard deviation of 5.5 and 5.9 years respectively. Low level of education by farming households may result in their inability to embrace improved technologies and practices.

Farming experience as presented in Table 1 indicated that about 81% of sweet potato farmers had at least 11 years of farming experience with minimum and maximum of 3 years and 37 years' experience respectively. However, the result indicates that more than half (57%) of the respondents had up to 11 years with mean and standard deviation of 12 and 1.9 years respectively. The results of household size showed that the average numbers of persons per household were higher (11 persons) with less standard deviation (1.7 persons) compared to the respondents in kwara state with 6 and 1.7 persons respectively. Therefore, the size of the household affects the amount of farm and non-farm labour, determines the food and nutritional requirements of household and often affects household food security (Sani and Oladimeji, 2017).

The result of production inputs in Table 2 indicated that the sampled potato farmers in the two states are small holders cultivating less than 1 ha. The result also showed that sweet potato farmers in kwara state utilized more organic manure (93%), herbicide (72%) and less family labour (54%) compared to katsina farmers with 61.8%,

49.3% and 89.7% respectively. The findings are comparable with studies of Adewumi and Adebayo, (2012), Ahmad *et al.* (2014), Abdulkarim and Yunana, (2015) on economic analysis of sweet in in north central and north western Nigeria.

Table 2: Dominance indicators of production variables

Variable	Kwara state potato farmers Dominance indicator	Mean±std	Katsina state potato farmers Dominance indicator	Mean ±std
Farm size (ha)	51.2% cultivate ≤ 1 ha	1.27±0.35	75.6 % cultivate ⩽ 1 ha	1.05±0.32
Seed (ha))	80% practice sole cropping	2.01±0.29		1.5±0.19
Fertilizer (kg/ha)	-	-	59.4 % applied fertilizer	52.7±5.04
Organic (mangala/ha)	93 % applied manure only	30.5±0.1.95	61.8 % applied manure	61.3±3.06
Herbicide (l/ha)	72 % applied herbicide	3.9±0.17	49.3 % applied herbicide	2.7±2.08
Labour (days/ha)	54% used family labour	76.3±9.3	89.7% used family abour	123±9.65

Source: Field survey, 2016/2017; Note: ₦320 = 1US$ in 2018;

Net Farm Income Analysis

The pooled average yield of sweet potato per ha harvested in Table 3 was 5368.1 kg/ha and this translate to gross revenue of N155, 674.3 /ha. The yield per ha of sweet potato harvested in Kwara state (5769.7 kg/ha) and the price per kg (N43.0) were higher than that of Katsina state with 4883.6 kg/ha and N29.0 respectively. The implication of this is that Kwara sweet potato farmers had a higher gross return than their counterpart in Katsina state. The total cost and net farm income in Kwara state were estimated atN105731.5 and N142364.3 and in katsina state, N94419.1 and N61855.7 respectively. The pooled result showed the total cost and net farm income to be N94919.7 and N60754.6. The net farm income analyses are indication that sweet potato farming is profitable in the study area. Adewumi and Adebayo, (2012), Ahmad *et al.* (2014), Abdulkarim and Yunana, (2015) reported the farming enterprise to be profitable in their respective findings.

Profit margins were calculated at 57.38%, 39.58% and 30.03%for Kwara, katsina and pooled farmers respectively. Thus, the enterprise was found to have a relatively higher profit margin in kwara state compared to katsina state and the pooled data.

Table 3 : Estimated costs and returns per hectare of sweet potato production

Variable per ha	**Kwara state** Value (₦)	**%**	**Katsina state** Value (₦)	**%**	**Pooled data** Value	**%**
Revenue items						
Av. yield (kg/ha)	5769.7	-	4883.6	-	5368.1	
Price per kg (Naira)	43.00		29.00		29.00	
A. Gross Revenue / Income	248095.8	-	156274.8	-	155674.3	
Cost items						
Land preparation	9700.00	9.17	6500	6.89	7300	7.69
Stem cuttings	4540.1	4.29	1500	1.59	3456.8	3.64
Fertilizer	3450.8	3.26	12503.8	13.24	5640.2	5.94
Manure	7268.0	6.88	3000	3.18	7268.0	7.66
Labour*	53050.0	50.18	43700.0	46.28	44650.0	47.04
Herbicide	1367.1	1.29	6534.4	6.92	3299.5	3.48
Depreciation	15000.0	14.19	10000	10.59	12500	13.17
Transport	3950	3.74	3750	3.97	3800	4
Logistic / miscellaneous	7405.5	7.01	6930.9	7.34	7005.2	7.38
B. Total cost	105731.5	100	94419.1	100	94919.7	100
C. Net farm income	142364.3		61855.7		60754.6	
D. ROI	2.35		1.66		1.64	
E. Profit margin (%)	57.38		39.58		39.03	
F. Gross ratio	0.43		0.60		0.61	
G. NFI / TC	1.35		0.66		0.64	
Total cost / kg	18.33		19.33		17.68	
NFI / kg	24.67		12.67		11.32	

Source: Field Survey Data 2016/2017; ROI denotes Return on investment

Note* labour cost include family and hired labour, and consist of labour cost of planting, fertilizer application, herbicide spraying, weeding, harvesting and transportation

The gross ratio is an indicator of the ability of farmers to control cost of operation. The pooled gross ratio of sweet potato production in the study area was 0.61; though the ratio was 0.53 and 0.60 respectively for kwara and katsina farmers. According to Gittinger, (1982), Oladimeji and Abdulsalam, (2014), enterprises with very high gross ratios in the neighborhood of 0.9 have difficulty in making adequate returns on investment, due to triple effects of high operating expenses, fluctuating yield, and falling prices; while an abysmally low ratio, say 0.50, implied that some costs may have been omitted or grossly underestimated. Return on investment (ROI) is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of different investments. ROI of pooled result was 1.64. This indicated that for every N1.00 invested in sweet potato farming, there was a N1.64 return to profit. The ROIs of the farmers in kwara and katsina states were 2.35 and 1.66 respectively. Accordingly this is an indication that the sweet potato production in kwara state is more efficient than their counterpart in katsina State.

Distribution of Technical Efficiency Indices of Sweet Potato Farmers and its Implications on Food Security

The distribution of pooled technical efficiency data indices is presented in Figure 1. The technical efficiency ranged between 0.21 and 1.00. Expectedly, respondents with higher efficiency index are expected to produce higher output which implies food accessibility, affordability and utilization to the households. It is pertinent to mention that increased productivity is directly related to production efficiency. An efficient use of the existing resources by farm households will improves their productivity, may increase their output thereby improve food security status.

The result in figure 2 also indicated that efficiency index is directly proportional to years of sweet potato production. This suggests that farmers with more years of experience are likely to have higher yields which *sine quo non* to food availability among the sweet potato farming households.

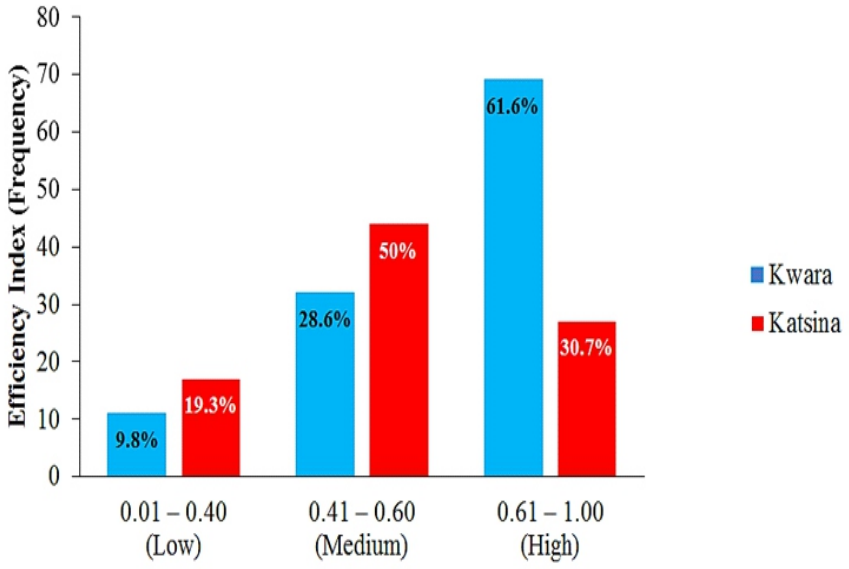

Figure 1: Distribution of efficiency index of sweet potato farmers

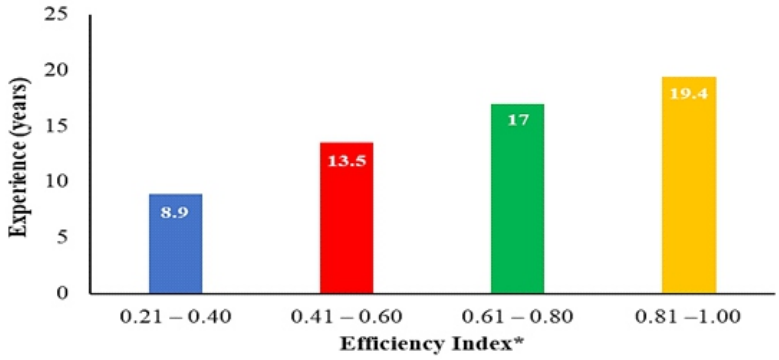

Figure 2: Distribution of efficiency index of sweet potato farmers by experience

Figure 3 depict relationship between efficiency index and level of education. The result showed that majority of pooled respondents with at least secondary education (75.6 percent) has efficiency range of 0.61-1.0 compared with respondents with neither years of schooling (19.4 percent) or only primary schooling (35.2 percent).

Figure 4 showed the distribution of age and technical efficiency of pooled and state respondents. The pooled result showed that respondents with age range 31-40 and 41-50 years had higher average technical efficiency of 74.8 and 83.8 percent compared with either respondent with age > 60 years (56.4 percent) or 21-30 years (58.4 percent). The result of Kwara and Katsina states disaggregation followed the same pattern.

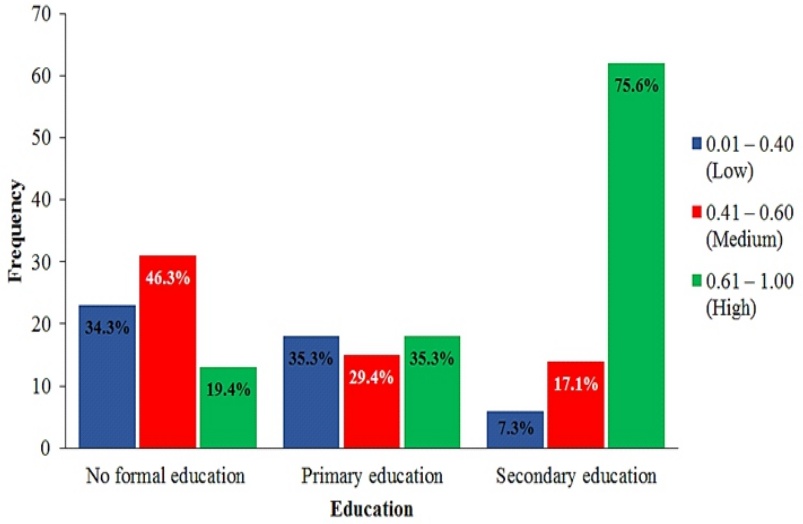

Figure 3: Distribution of relationship between efficiency index and level of education

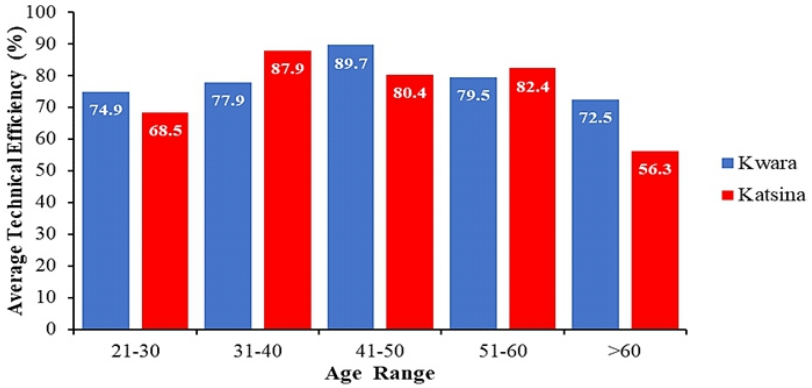

Figure 4: Distribution of age and technical efficiency of pooled and state respondents

Determinants of Technical Efficiency of Sweet Potato Farmers in the Study Area

Table 4 which shows the estimated technical efficiency model for both Kwara and Katsina sweet potato production and pooled data revealed that sigma squared (σ^2) was statistically significant, which shows the correctness of the specified distribution assumption of the composite error term in line with study by Oladimeji*et al.* (2017). The gamma (γ) value for the respondents, which is the ratio of the variance of farm-specific technical efficiency to the total variance of output, was 0.501 for the pooled data. This means that 50% of the variation in output among the farms is due to differences in technical efficiency.

The results of the stochastic frontier model estimated further showed that there are differences in the determinants of potato farmers' technical efficiency in both Kwara and Katsina states and also in the pooled data in the study area. Farm size ($p<0.01$), labour employed ($p<0.01$), fertilizer application ($p<0.05$) and herbicide application ($p<0.05$) were found to be the significant factors that were associated with technical efficiency of sweet potato production in Kwara state, while farm size ($p<0.05$) and labour employed ($p<0.01$) were the significant factors in katsina state. The pooled result also indicated that farm size in hectare and labour employed in man-days were found to be positive and both statistically significant at 1 percent. This implied that a unit increase in these coefficients that were positive led to corresponding increase in output.

However, herbicide was negative which indicate that a unit increase in the volume of this variable led to corresponding decrease in output by 0.998 units.

Herbicide was not a major input in sweet potato in the study area probably because it is a cover cropping that prevent weed and improves the quality of land by raising yields per hectare. The result is comparable to studies by Adewumi and Adebayo, (2012), Ahmad *et al.* (2014), Abdulkarim and Yunana, (2015) that found labour and farm size to be positiveon technical efficiency of sweet potato production north central and

Table 4: MLE of the cobb−douglas stochastic frontier model for technical efficiency

Variables	β_i	Kwara state		Katsina state		Pooled	
		β_i	t-value	β_i	t-value	β_i	t-value
Efficiency model							
Constant	β_0	-0.012	-4.50***	-0.004	1.89*	-0.321	-1.70
Ln farm size (ha)	β_1	0.435	2.98***	0.307	2.06**	0.108	2.73***
Ln labour (man-days)	β_2	0.151	3.34***	0.078	2.51***	0.221	3.98***
Ln stem vines (kg)	β_3	0.109	-0.23	0.003	0.76	0.075	1.43
Ln fertilizer (kg)	β_4	0.105	2.05**	0.237	1.28	0.004	0.95
Ln manure (mangala)	β_5	0.206	1.87*	0.018	0.74	0.110	1.08
Ln herbicide (litre)	β_6	-0.998	-2.18**	0.093	1.06	0.050	0.78
Inefficiency model							
Age (years)	Z_1	0.157	1.09	0.242	1.90*	0.202	1.69*
Education (years	Z_2	-0.981	-2.23**	-0.189	0.99	-0.007	1.05
Experience (years)	Z_3	-0.122	-2.74***	0.054	1.08	-0.118	-1.93*
Household Size (no)	Z_4	0.383	1.02	-0.003	-3.03***	-0.003	-2.03**
Co-operative (years)	Z_5	-0.203	1.27	0.205	1.00	0.063	1.00
Access to credit (N)	Z_6	0.228	1.89*	0.009	1.37	0.004	0.67
Extension (number)	Z_7	-0.312	0.65	0.024	1.32	0.001	0.56
Diagnostic statistic							
Sigma^2 $\sigma^2 = \sigma_v^2 + \sigma_u^2$		0.007	2.02**	0.150	2.05**	0.005	1.86*
Gamma $\gamma = \sigma_u^2/\sigma^2$		0.609	1.98*	0.502	1.31	0.501	1.79*
Likelihood ratio test		11.9		17.05		34.06	
log likelihood function		-65.08		39.01		-79.06	
no of observation		100		100		200	
average TE		0.792		0.751		0.689	

Source: Field Survey 2016/17. *Asterisk indicate statistical significance ***1%,**5%, *10%.*

The pooled data in Table 4 revealed that the average technical efficiency score of 0.689 implies that on the average farmers could increase output by 0.311 by means of improving their technical efficiency. Similarly, the technical efficiency distribution of Kwara and Katsina state also revealed that farmers in their respective state could increase output by 0.208 and 0.249 units.

Estimated Inefficiency Parameters: Socio-economic and Institutional Characteristics

The parameters estimates for determinants of technical inefficiency were also reported in Table 4. The results indicate that the technical inefficiency of Kwara farmers were negatively influenced by education ($p<0.05$), experience ($p<0.01$) and access to credit ($p<0.10$). Only household size was found to statistically influence technical inefficiency of Katsina farmers. However, in the pooled result, technical inefficiency were negatively influenced by farming experience ($p<0.10$) and household size (0.05). The negative coefficients of the three variables indicate a decrease in technical inefficiency while the positive sign on coefficients connotes a decrease in technical inefficiency. The estimated coefficient for years of education that depicts negative relation with technical inefficiency among Kwara farmers indicates that a high level of education results in a reduction in technical inefficiency of sweet potato farmers. Sani and Oladimeji (2017) observed that education sharpens managerial input and leads to a better assessment of the importance and complexities of good decisions in farming. The negative coefficient of experience in sweet potatao production implies that increase in the number of years of experience in would reduce technical inefficiency. Farmers' experience could be associated with skill accumulation which could enhance productivity and resource allocations thereby reduce technical inefficiency.

Determinants of Allocative Efficiency of Sweet Potato Farmers in the Study Area

Allocative (cost) efficiency results in Table 5 also revealed that rent on land, expenses on stem vine (seed), labour and manure were found to be significant variables in Kwara state. Similarly, rent on land, expenses on labour and manure were found to be the significant factor in both katsina and pooled data. These imply that these variables determine the total cost of production of sweet potato. Thus, an increase in in the cost of these inputs may lead to an increase in the total cost of production and invariably reduce the net farm income.

Table 5: MLE of the cobb−douglas stochastic frontier model for allocative efficiency

		Kwara state		Katsina state		Pooled	
Variables	β_i	β_i	**t-v**	β_i	**t-v**	β_i	**t-v**
Constant	β_0	0.096	1.04	0.206	1.92*	0.312	2.00**
Ln C farm size	β_1	0.304	2.67***	0.101	1.84*	0.426	2.08**
Ln C labour	β_2	0.047	1.95*	0.200	2.54***	0.086	1.74*
Ln C stem vine	β_3	0.298	2.05**	0.004	1.02	0.006	0.74
Ln C fertilizer	β_4	0.005	0.48	0.320	0.49	0.002	1.05
Ln C manure	β_5	0.004	1.90**	0.503	4.06***1	0.319	2.56***
Ln C herbicide	β_6	0.062	0.71	0.008	1.03	0.94	0.75
Diagnostic statistic							
Sigma^2: $\sigma^2 = \sigma_v^2 + \sigma_u^2$		0.197	2.09**	0.267	3.11***	0.250	2.74***
Gamma: $\gamma = \sigma_u^2/\sigma^2$		0.533	1.85*	0.602	2.06**	0.415	2.41**
Likelihood ratio test		19.06		21.31		16.09	
log likelihood function		53.00		42.92		29.74	
no of observation		100		100		200	
average AE		0.814		0.872		0.825	

Source: Field Survey 2016/17. *Asterisk indicate statistical significance ***1%, **5%, *10%.*

Conclusion and Recommendations

Segregating data of sweet potato production in two states as well as pooled data, the study finds that the two states exhibit different degrees of efficiencies and profitability. This suggests that the factors that contribute to technical and allocative efficiencies cum profit differ considerably between sweet potato farmers in the two states. However, sweet potato production in the two states was profitable. The disparity in profit and efficiency of sweet potato production in the two states was due to difference in socio-economic characteristics. The technical efficiency index of the sweet potato farmers is directly proportional to level of education and years of sweet potato production. This suggests that farmers with more years of experience and education are likely to have higher yields which *sine quo non* to food accessibility and affordability among households. Farmers are encouraged to increase the hectarage of sweet potato production to increase profit. The sustainable increased in output could be achieved if farmers adopt a new techniques and improved their technically efficiency through training and workshops as ample opportunity still exist to move closer to frontier.

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