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ANALYSIS OF TECHNICAL EFFICIENCY IN SOLE YAM PRODUCTION AMONG FARMERS IN SOUTHERN ADAMAWA STATE, NIGERIA

Oaya, Daniel S.,Hayatu, Y.and Dia, Y.Z.
Department of Agricultural Extension and Management, College of Agriculture, P.M.B 2088 Ganye, Adamawa State

ABSTRACT

The study analyzed technical efficiency in sole yam production among farmers in southern Adamawa State, Nigeria. Primary data were obtained from 298 respondents, using multi-stage purposive and simple random sampling procedure. Data were analyzed using stochastic frontier production model. Results revealed that the sigma squared (δ^2) was 0.016 and statistically different from zero at 1% probability level, indicating a good fit and correctness of the distributional form assumed for the composite error term. Variance ratio was estimated at 0.866 and statistically significant at 1% probability level, suggesting that the existence of technical inefficiency among the farmers accounted for 87% variation in the output level of these farmers. Findings indicated that there was scope to increase the technical efficiency of sole yam production by 15% in the short run, since the mean technical efficiency (TE) of the farmers was estimated at 0.85, with 0.67 as minimum and 0.96 as the maximum. The technical efficiency differentials between the technically most efficient farmer and the technically least efficient farmer was 29%, indicating a wide gap. The coefficients of farm size, fertilizer, yam seed/setts and agro-chemicals had the expected positive sign, except hired labour and family labour, which had negative coefficients. This indicated that more output would be obtained from the use of additional quantities of these inputs ceteris paribus. The return to scale in the technical efficiency of sole yam was 0.965, indicating decreasing return to scale. This however, suggested that the proportionate change in output is less than that of the input and production was said to be inelastic. The return to scale of 0.965 showed that the farmers operated at the rational stage of the production function.

Keywords: Sole, Yam, Technical Efficiency, Analysis, Production,

INTRODUCTION

Yam is one of the major root crops in Nigeria both in terms of land under cultivation as well as in volume and value of production. Yam is a carbohydrate food and is nutritionally superior to most roots and tubers in terms of digestible proteins and minerals (Calcium, Magnesium and Potassium) (Ebeworee*et al*., 2020). Yam is a versatile staple which produces more food per unit area of land used in its cultivation, when compared with other crops (Nteranya and Adiele, 2020). Annual yam production in the country is estimated at 50.05 million tons (FAO, 2020). Nigeria was the top producer of yam in the world with a production value of USD 50.1M (ITS, 2019). There is need for increasing production to satisfy both domestic and export demand (Okonkwo, 2019). Production of yam in the country has not been able to meet its demand. This is due to the fact that the tuber serves as both food and seed to the farmers (Beatrice *et al.*, 2020).

Many important cultural values are attached to yam. Among Nigeria's Igbo ethnic groups, yam has a purpose in social functions such as marriage, burials and other traditional ceremonies and rituals (Obidiegwu and Akpabio, 2019). In many farm communities in Nigeria and other West African countries, the size of the yam enterprise that one has is a reflection of the person's social status. Due to the importance attached to yam, many communities celebrate the new yam festival annually (IITA, 2019).

To increase yam output, sound macro and micro-economic farm policies (such as increase budgetary allocation to the agricultural sector, adequate credit facilities at lower interest rate, provision of incentives and input subsidies, appropriate pricing and marketing policies, provision of yam processing facilities to improve quality and prolong crop life span, cropping priorities, enhance rural development to retain rural labour, etc) are needed. A better understanding of farmers' production efficiency and how well they are able to produce a given level of output using cost minimization input ratio is important for the sustenance of production system (Maurice, 2019).

Tiku and Enoibor (2020) opined that agriculture can make a significant contribution to the nation's GDP if farmers allocate resources judiciously, efficiently and sufficiently in the right proportion. Inefficient use of inputs can jeopardize food availability and its security (Otaha, 2020). This study therefore, analysed the technical efficiency of sole yam production among farmers' in southern Adamawa State, Nigeria. The specific objectives were to:

i. Determine the technical relationship between inputs used and the resultant output;
ii. Estimate the technical efficiency of the farmers (No punctuation)

METHODOLOGY

The Study Area

The study was conducted in Adamawa State of Nigeria. The State has a population of 4,248,436 people (NPC, 2016). It has 21 Local Government Areas. Adamawa state has a land area of about 38,741 km (Adebayo, 2020) shares boundaries with Taraba State in the South and West, Gombe State in the Northwest and Borno to the North. The state has an international boundary with the Cameroun Republic along its eastern border. Air temperature characteristics in Adamawa State is typical of the West African Savannah climate. The mean monthly temperature in the state ranges from 26.7^0C in the south to 27.8^0C in the northern part of the State. The mean annual rainfall pattern ranges from 700mm in the northern part of the state, to 1600mm in the southern part (UNPFA, 2020). The major economic activities in the zone are agriculture. Major food crops of the zone are cereals, legumes and root crops. The food crops grown in the state are maize, sorghum, millet, cassava and potatoes, while cash crops such as groundnuts, cowpea, rice, yam, and sugarcane are produced in large quantities. Major livestock reared in the zone are cattle, sheep, goats, pigs and poultry (Adebayo, 2020).

Sampling Procedure

Multi-stage purposive sampling procedure was used in selecting the respondents. In the first stage, 3 LGAs were purposively selected because they are high yam-producing areas. These LGAs were; Ganye, Toungo and Jada in the southern zone. In the second stage, three wards were purposively selected from each of the Local Government Areas, giving a total of nine wards. In the third stage, two villages from each of the ward were purposively sampled from the lists of yam-producing villages in each of the LGAs, making a total of 18 villages. Finally, a total of 339 respondents were selected using simple random sampling techniques through the proportional allocation sampling technique (Cochran, 2000)

Analytical Technique

Inferential statistics, such as stochastic frontier production model was used to achieve the stated objectives.

Cobb-Douglas stochastic frontier production model was used for the analysis and is presented as:

$$LogY = \beta_o + \beta_1 LogX_1 + \beta_2 LogX_2 + \beta_3 LogX_3 + \beta_4 LogX_4 + \beta_5 LogX_5 + \beta_6 LogX_6 + (V_i - U_i) \ldots \ldots (3).$$

Where:

Y = Output of sole yam (Kg/ha)

X_1 = Farm size (hectare)

X_2 = Quantity of fertilizer (Kg/ha)

X_3 = Quantity of yam sett/seed (Kg/ha)

X_4 = Agro-chemicals (Litres/ha)

X_5 = Hired labour (Mandays/ha)

X_6 = Family labour (Mandays/ha)

Bo, $\beta_1 - \beta_6$ = Parameters to be estimated

V= Systematic component which accounts for random factors such as weather and disease

U = Error due to technical inefficiency

The inefficiency model U_i is defined by:

$$U = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 \ldots \ldots (4)$$

Where:
U = Technical inefficiency
Z_1 = Age of farmer (Years)
Z_2 =Literacy level (years spent in school)
Z_3 = Farming experience (years)
Z_4 = Household size (number of persons in household)
Z_5 = Marital status (Married = 1; Single = 0)
Z_6 = Extension visit (dummy, where; Yes = 1, No = 0)
Z_7 = Membership of association (dummy, where; Member =1, Non-member = 0)
δ_0, $\delta_1 - \delta_7$ =Parameters to be estimated.
The socio-economic variables were included in the model to indicate their possible influence on the technical efficiencies of the farmers. Battese and Coelli (2019) stated that the TE of a farmer was between 0 and 1 and was inversely related to the level of ~~the~~ technical inefficiency. The technical efficiency TE was defined as the ratio of observed output to maximum feasible output. TE = 1, shows that the ith firm obtains the maximum feasible output, while TE< 1 provides a measure of the shortfall of the observed output from maximum feasible output. It is estimated as;
TE = Observed output/frontier output

RESULTS AND DISCUSSION

Technical Efficiency in Sole Yam Production

The Maximum-Likelihood Estimates (MLE) of the stochastic frontier production function and inefficiency model of sole yam crop farmers are presented in Table 1. The production estimates indicate the relative importance of factor inputs in sole yam production. From the results, most of the coefficients of the explanatory variable have the expected positive sign, except hired labour and family labour which have negative coefficients. This indicated that more output would be obtained from the use of additional quantities of these inputs ceteris paribus.

The value of sigma squared (δ^2) is 0.016 and statistically different from zero at 1% probability level. This indicated a good fit and correctness of the distributional form assumed for the composite error term. Also, the variance ratio defined by gamma (γ) was estimated at 0.866 and statistically significant at 1% probability level. The gamma (γ) estimated showed the amount of variation arising from technical inefficiency among sole yam farmers. This implies that technical inefficiency among sole yam farmers accounted for 87% variation in the output level. In other words, the existence of technical inefficiency among the farmers accounted for 87% variation in the output level of these farmers. By implication, 13% of the sole yam output was lost as a result of inefficiency among the farmers.

The estimates of the stochastic frontier production function show that the elasticity of output with respect to farm size was 0.560 and statistically significant at 1% level. This implies that a 1% increase in area under sole yam production will increase output by 0.560% in the study area. This is an indication that land as a factor of production is very vital in sole yam production. This result conformed to the findings of Tiku and Enoibor (2020) who found that an increase in farm size under static condition, would results in increase in output level. It also relates with the findings of Shehu *et al.* (2021) who reported that farm size had a positive relationship with output of yam farmers in Benue state.

The production elasticity of fertilizer was 0.084 and statistically significant at 10%. Fertilizer positively improves the productivity of existing land by increasing crop yield per hectare. One percent (1%) increase in the use of fertilizer would increase output of sole yam by 0.084%. This however indicates that fertilizer plays an important role in increasing and improving agricultural output per hectare. It also showed that fertilizer is a critical variable input in sole yam production in the study area. This agreed with the findings of Ani *et al.,* (2021) who reported a positive relationship between fertilizer use and yam output.
The coefficient of yam seed/sett was 0.187 and significant at 5% probability level. This implies that a 1% increase in the quantity of yam seed/setts use per hectare will lead to an increase in the output of sole yam by 0.187%. This means that higher seed rate would result in high yam population and subsequently higher yield. This finding is in line with that of Iduma *et al.* (2020) who found a positive relationship between the quantity of yam seed/setts used and output. This also agreed with the findings of Ibrahim (2021) who reported that the use of improve seed increased agricultural productivity of crop farming in the dry savannah ecological zones of Nigeria.

Agro-chemicals has a positive coefficient 0.154 and statistically significant at 5% probability level. This indicates that a 1% increase in the liters of agro-chemicals applied on sole yam would bring about a 0.154% increase in output. The use of agro-chemicals increases the productivity of seed inputs, which will ultimately increase output. Access to agro-chemicals has been proved as an important driver of agricultural productivity among farmers in sub-saharan Africa. This result is in conformity with Umaru (2020) who reported that the use of agro-chemicals increased agricultural productivity of crop farming in the savannah zones on Nigeria.

Technical inefficiency effects in sole yam production
The inefficiency parameters were specified as those relating to farmers' specific socio-economic characteristics and were examined by using the estimated δ coefficients. A negative δ coefficient indicates that the parameters have a positive effect on efficiency and vice versa. The result of the inefficiency model shows that all the variables used in the model excepts marital status and membership of association have the expected negative sign. The coefficient of marital status and membership of association were however not significant.

The estimated coefficient of age for sole yam farmers was found to be negative and statistically significant at 1% probability level. This implies that older farmers were more efficient than younger ones, because of the experience acquired with age. As farmers advance in age, technical inefficiency decrease. This is in tandem with the finding of Etim *et al.* (2020) who reported that age has a positive relationship to the productivity of yam farmers and the attainment of technical and economic efficiencies since older people are believed to be more responsible and experience in carrying out farm productive decision than the younger ones. The estimated coefficient of education for sole yam farmers was found to be negative and statistically significant at 10% probability level. This implies that as farmers acquire more years of formal schooling, their technical efficiency increases. Farmers with formal education are more likely to be technically efficient compared with those uneducated. It also implies that formal education enhanced farmers' ability to acquire technical knowledge and easily adopts to new innovations which makes them to be efficient in the use of productive inputs and other modern agricultural production technologies. This result is in conformity with the findings of Umaru (2020) who reported that the level of farmer's education has a positive effect on productivity and efficiency in agricultural production.

The coefficient of farming experience was found to be negative and statistically significant at 5% probability level. This implies that as sole yam farmers get more experience, they are likely to be technically efficient compared to inexperienced farmers. Farming experience enhances the managerial skills and risk-bearing capacity of the farmer. This agreed with the finding of Taphee (2020) who reported that years of farming experience increases as age of farmer's increases. Older farmers were observed to have higher productivity than younger farmers.

The coefficient of household size was found to be negative and statistically significant at 1% probability level. This indicates that increase in numbers of adult persons in household reduce inefficiency and increase productivity in sole yam production. This agreed with the findings of Maurice *et al.* (2019) who reported that large family size increases productivity and technical efficiency and also eases hiring of labour.

The coefficient of extension visit was negative and statistically significant at 1% probability level. The adoption of agricultural innovation is influence by extension contacts. This implies that the adoption of sole yam production technologies would be enhanced through extension services which will make the farmers technically efficient. The result agreed with the findings of Etim *et al.* (2020) who found that access to extension agents and attainment of efficiency among yam farmers are positively correlated. This is quite obvious, because when farmers are in constant touch with the extension agent, their production problems will be attended to, thereby leading to more efficient utilization of their production inputs.

Table 1: Maximum Likelihood Estimates of Stochastic Frontier Production Function in Sole Yam Production

Variables	Parameters	Coefficient	Standard Error	t.ratio
Production factors				
Constant	β_0	1.861***	0.173	10.735
Farm size (ha)	β_1	0.560***	0.097	5.736
Fertilizer (Kg)	β_2	0.084*	0.044	1.896
Yam seed/setts (Kg)	β_3	0.187**	0.090	2.074
Agro-chemicals (Lt)	β_4	0.154**	0.068	2.263
Hired labour (Mandays)	β_5	-0.013	0.008	-1.464
Family labour (Mandays)	β_6	-0.007	0.006	-1.166
Inefficiency Model				
Constant	δ_0	0.548	0.331	1.656
Age	δ_1	-0.435***	0.155	-2.800
Education	δ_2	-0.013*	0.007	-1.710
Farming experience	δ_3	-0.242**	0.102	-2.355
Household size	δ_4	-0.122***	0.041	-2.938
Marital status	δ_5	-0.112	0.107	-1.045
Extension visits	δ_6	-0.046***	0.017	-2.744
Membership of association	δ_7	0.008	0.016	0.486
Diagnostic Statistics				
Sigma squared	δ^2	0.016***	0.004	3.472
Gamma	γ	0.866***	0.261	3.316

Source: Field Survey, 2020*** Significant at 1%, ** Significant at 5% and * significant at 10%

Technical efficiency indices in sole yam production

The distribution of farmers technical efficiency indices derived from the analysis of the stochastic frontier production function is presented in Table 2. The result revealed that the technical efficiency of the sampled farmers was less than one (less than 100%), implying that sole yam farmers are producing below the maximum frontier output. The mean technical efficiency is estimated at 0.85, with 0.67 as minimum and 0.96 as the maximum. This implies that on ~~the~~ average, farmers in the study area were 85% technically efficient from a given mix of production inputs. This indicates that in the short run, there is scope for increasing technical efficiency in sole yam production by 15% in the study area, under the current state of technology. The efficiency differentials between the technically most efficient farmer and the technically least efficient farmer is 29% indicating a wide gap. The distribution of technical efficiency of farmers revealed that 35.29% of the farmers had technical efficiency ranging from 60 – 79%, while 64.71% of the farmers had technical efficiency ranging from 80% and above. This is in conformity with the study of Ekunwe*et al.* (2021) who reported mean technical efficiency of 0.85 in his study on resource use efficiency in yam production in Delta State of Nigeria.

Table 2: Technical Efficiency Indices in Sole Yam Production

Range	Frequency (n = 68)	Percentage
< 0.70	02	2.94
0.70 – 0.74	06	8.82
0.75 – 0.79	16	23.53
0.80 – 0.84	06	8.82
0.85 – 0.89	13	19.13
0.90 – 0.94	19	27.94
0.95 – 0.99	06	8.82
Total	**68**	**100**
Mean	0.85	
Minimum	0.67	
Maximum	0.96	

Source: Field Survey, 2020

Elasticities of production and return to scale in sole yam production

As typical with a Cobb-Douglas production function, the estimated coefficients for the specified function could be explained as the elasticity of the explanatory variables. The coefficients denoted the variation in aggregate output of crops as a result of a unit increase in inputs. From the result on Table 3, the return to scale which is the sum of the coefficients (output) of the variables of the Cobb-Douglas stochastic frontier production model was 0.965. This indicates decreasing return to scale, suggesting that the proportionate change in output is less than that of the input and production is said to be inelastic. The return to scale of 0.965 showed that the farmers operated at the rational stage of the production function (stage II). This result was in consonance with the findings of Ekunwe *et al.* (2021) who concluded that yam-based cropping system in River State was in the rational stage (stage 1) with a return to scale of 0.76.

Table 3: Elasticities and Return to Scale in Sole Yam Production

Variable	Production Elasticities
Farm size (ha)	0.560
Fertilizer (kg)	0.084
Yam seed/setts (kg)	0.187
Agro-Chemical (Lt)	0.154
Hired Labour (mandays)	-0.013
Family labour (mandays)	-0.007
Return to scale	0.965

Source: Field survey, 2020

CONCLUSION

The study estimated the technical efficiency of sole yam farmers in southern Adamawa State, using the stochastic frontier production model. The distribution of technical efficiency indices revealed that on ~~the~~ average, the farmers were moderately technically efficient with a mean technical efficiency of 0.85, which implies that there is a scope to increase the technical efficiency of the farmers by 15% (1.00-0.85) in the short-run through efficient utilization of existing inputs given the current state of technology. Also, the elasticity of output with respect to farm size, fertilizer, yam seed/sett and agro-chemical were positive and statistically significant at both 1% and 5% levels. While, age, education, farming experience, household size and extension visit were the dominant sources of technical inefficiency in sole yam production among the farmers. The efficiency differentials between the technically most efficient farmer and the technically least efficient farmer is 29% indicating a wide gap. Based on the findings of this study, the following recommendations were proffered:

i. There is need to provide financial support through small credit scheme to help farmers ~~to~~ expand production for full utilization of other inputs like land, fertilizer and labour among others that were observed to be underutilized.

ii. There is need for research institutions to develop low cost technologies that will reduce the level of labour input for various farm operations.

iii. Improved varieties of yam seed/setts should be made available to the farmers at affordable prices by relevant stakeholders to expand yam production thereby obtaining optimum yield/profits.

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