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TECHNICAL EFFICIENCY OF SOYBEAN PRODUCTION IN NIGER STATE, NIGERIA

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ABSTRACT

The efficiency with which farmers use resources and technologies available to them are imperative in boosting production. However, activities of armed bandits, conflict between farmers and pastoralists, rising prices amid decreasing consumer purchasing power and diminishing household incomes are some factors that impede agricultural production. Therefore, the objective of this study was to determine the technical efficiency of soybean production among small holder farmers in Niger State. A three stage sampling technique was used to select 150 respondents for the study. Primary data collected with the aid of structured questionnaires were analyzed using stochastic frontier Cobb-Douglas production function model. Results showed that the mean technical efficiency level of the respondents was 0.89 which implies that a typical soybean farmer in the study area could increase output by 11% using the same input bundle. Also, the efficiency model shows that coefficients of farm size, seed quantity and labour were positively significant which indicates that that increase in these variables will lead to increase in technical efficiency. The inefficiency model reveals that coefficients of credit and extension visit were positively significant while those of age and farming experience were negatively significant. This means that as credit and extension visit increases, technical efficiency decreases; while increase in age and farming experience will increase technical efficiency. The study recommended that extension services should be streamlined so that farmers do not receive conflicting information as this could hinder efficiency in production. Also, credit given to farmers should be monitored to ensure effective utilization.

Keywords: Soybean, technical efficiency, stochastic frontier, Niger State

INTRODUCTION

Soybean is the fourth major cereal crop in the world after wheat, maize and rice (Grassini *et al*., 2021) in view of its role as a source of vegetable protein, industrial raw materials and raw materials of livestock (Farikin *et al.*, 2016). Its average protein content is 40% which makes it richer than any common vegetable or animal food source found in Nigeria. Soybean cake is a valuable livestock feed, particularly for poultry, while the haulms are a suitable feed for goats and sheep. In addition, soybean is used in industries for making wood veneer, paper coatings, printing ink, adhesive and alkyd resins, etc. Moreover, soy-milk, soy-cheese, soy flour and dadawa are made from soybeans (Omoigui *et al.*, 2020).

Consumption of soybean in Nigeria between 2021 and 2022 is estimated to reach 1.275 million tonnes. This represent an increase of 38% compared to the 2020-2021 estimates (Donley, 2021). However, there is a huge supply gap for the reason that soybean is predominantly cultivated in the northern parts of the country were security concerns exist as a result of attacks by Boko Haram and armed bandits, conflict between farmers and pastoralists, rising prices amid decreasing consumer purchasing power and diminishing household incomes, secondary effects of COVID-19 and unwillingness of the government to change its forex policy to help boost import of wheat, soybean, and corn (Boluwade, 2021). In addition, the cultivation of more land in order to boost production is hindered by urbanisation, land tenure system and climate change. Thus, the economically viable option to close the supply gap is for farmers to maximize the use of available socio-economic and production resources.

The concept of efficiency as regards the use of farm resources refers to the relative performance of the processes involved in transforming given inputs into outputs (Ezeh *et al*., 2012). Therefore, the efficiency with which farmers utilize available resources and technologies are imperative in boosting production. Mohammed (2015) opined that efficiency measurement in agricultural production is an important issue since it provides information needed for making sound management decision in resource allocation. Similarly, Idiong (2007) stated that in the short run, improving the level of efficiency is the best option to increase productivity given available resources. To this end, this study aims at determining the technical efficiency of soybean production among smallholder farmers in Niger State, Nigeria. The findings will not only contribute to existing literature, but it will also serve as a guide to policy makers and donor agencies in planning intervention programmes for smallholder soybean farmers.

METHODOLOGY

Study area

The study was carried out in Niger State. The State lies between latitude 9° 35' 0.7980" N and longitude 6° 32' 46.7376" E. It covers a land area of 76,469.903 square kilometers (about 10% of the total land area of Nigeria) out of which about 85% is arable (Anthony, 2017). As a result, most of the residents are involved cultivation of various types of crops such as cereals, legumes, roots and tubers as well as animal production. The state experiences distinct wet and dry seasons with mean annual rain fall of 1,100mm in the northern parts and 1,600mm in the southern parts. The temperature ranges from 23°C to 37°C. Daylight duration is about 8.5 hours with relative humidity of 40% (Sallawu *et al*., 2016).

Sampling technique and sampling size

The population of the study is soybean farmers in Niger State. A three stage sampling technique was used to select respondents for the study. In the first stage, Mariga and Rafi Local Government Areas (LGAs) were purposively selected

due to higher concentration of soybean farmers as documented by Niger State Agricultural Development Project. In the second stage, three villages were purposively selected from each LGA based on large number of soybean farmers. The third stage involved computation of sample size using Raosoft sample size calculator. Thus, the sample size for the study was 150.

Analytical technique

Primary data collected with the aid of structured questionnaires were analyzed using stochastic frontier Cobb-Douglas production function model. This is because it incorporates a disturbance term which is in line with the variability nature of agricultural production. The empirical model is specified as follows:

$$lnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + (v_i - u_i)$$

Where:

ln = natural logarithm

β_0 = constant term

$\beta_1 - \beta_5$= regression coefficients

X_1 = farm size (ha)

X_2 = quantity of seed (kg)

X_3 = quantity of fertilizer (kg)

X_4 = total labour used (man days)

X_5 = agrochemical (litres)

v_i= random error outside farmer's control

u_i = technical inefficiency effects

The determinants of technical inefficiency are defined by:

$$u_i = \delta_0 + \delta_1 lnZ_1 + \delta_2 lnZ_2 + \delta_3 lnZ_3 + \delta_4 lnZ_4 + \delta_5 lnZ_5 + \delta_6 lnZ_6$$

Where:

δ_0 = constant

$\delta_1 - \delta_6$= parameters to be estimated

Z_1 = age of farmer (years)

Z_2 = formal education (years of formal schooling)

Z_3 = household size (number of people per farmer's household)

Z_4 = farmers experience (number of years in soybean production)

Z_5 = amount of credit (amount of credit obtained for soybean production per season)

Z_6 = extension visit (number of visits per production cycle)

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

The mean age of respondents in the study area was 41 years as shown in Table 1. This indicates that they were predominantly middle-aged farmers who are energetic and could withstand the rigors of soybean production. This result is in agreement with Opaluwa *et al*. (2020) who found out that the mean age of cowpea farmers in Bassa, Kogi State was 42.53 years.

Table 1: Socio-economic characteristics of the soybean farmers

Variables	Frequency	Percentage	Mean	SD
Age (years)				
20-29	14	9.3	41	9.9
30-39	63	42.0		
40-49	39	26.0		
50-59	28	18.7		
>59	6	4.0		
Total	**150**	**100**		
Educational level				
No formal education	11	7.3		
Primary education	13	8.7		
Secondary education	58	38.7		
Tertiary education	18	12.0		
Adult education	5	3.3		
Quranic education	45	30.0		
Total	**150**	**100**		
Household Size				
1 – 5	29	19.3	9.0	6
6 – 10	68	45.3		
11 – 15	30	20.0		
16 – 20	15	10.0		
>20	8	5.3		
Total	**150**	**100**		
Farming experience (years)				
1 – 5	63	42	8	6
6 – 10	44	29.3		
11 – 15	20	13.3		
16 – 20	16	10.7		
>20	7	4.7		
Total	**150**	**100**		
Credit amount				
≤ ₦100,000	45	30	131,349	62,739
₦101,000 – ₦200,000	89	59.3		
> ₦200,000	16	10.7		

Total	**150**	**100**
Extension visit		
Yes	123	82
No	27	18
Total	**150**	**100**

Source: Field survey data, 2021

As regards highest educational level attained, only 7.3% of the respondents affirmed that they were illiterate. The remaining 92.7% had one form of education such as adult (3.3%) and Qur'anic (30%). Majority of the sampled soybean farmers (38.7%) reported that their highest educational level was secondary while 12% indicated that it was tertiary. Education plays a vital role in facilitating adoption of new practices and technologies which in turn increases technical efficiency of production since farmers are able to utilize available resources to maximize output. This result agrees with Kumar *et al*. (2022) who reported 96.67% literacy level among soybean farmers in Rajnandgaon District of Chhattisgarh State in India.

Distribution of respondents by household size is shown in Table 1. 45% of the respondents had household size of 6 to 10 persons while 20% had household size of 11 to 15 persons. The average household size of all respondents was 9 persons. This finding agrees with Saliu *et al*. (2017) who reported average household size of 9 persons among small-scale soybean farmers in Kaduna State.

Farming experience is the number of years a farmer is engaged in active production. Majority (42%) of the respondents had farming experience of 1 to 5 years while 4.7% reported a farming experience of more than 20 years. The average farming experience of all respondents was 8 years. This finding is in line with Ukaoha *et al*. (2022) who studied profit efficiency of soybean production in Federal Capital Territory, Nigeria.

Credit amount refers to money borrowed from both formal and informal sources for production purposes. 30% and 10.7% of the respondents borrowed less than ₦100,000 and more than ₦200,000 respectively. The remaining 59.3% of the respondents borrowed between ₦101,000 and ₦200,000 respectively. The mean credit amount of the respondents was ₦131,349. This result agrees with Onuwa *et al*. (2022) who found out that the average credit amount received by cowpea farmers in Kanke Local Government Area of Plateau State was ₦101,500.

Extension visit refers to whether a respondent had physical contact with an extension agent during the last planting season or not. 82% of the respondents confirmed that had at least one physical contact with an extension agent while the remaining 18% replied that they had no extension visit during the last planting season. This result is in line with Tafida *et al*. (2022) who reported that 91.8% of soybean farmers in Tofa Local Government Area of Kano State had access to extension service.

Level of technical efficiency

The technical efficiency level of soybean farmers in the study area is presented in Table 2. It shows that the technical efficiency level for respondents range from 0.46 to 0.98 with a mean of 0.89 which indicates that a typical soybean farmer in the study area could increase output by 0.11 or 11% using the same input bundle. This result is in line with Olayiwola (2013) who reported mean technical efficiency among small, medium and large scale soybean farmers in Ijebu-Ode, Ogun State to be 0.87, 0.91 and 0.94 respectively.

Table 2: Distribution of Respondents by Technical Efficiency score

Efficiency Score	Frequency	Percentage	Mean
0.51 – 0.60	2	1.33	0.89
0.61 – 0.70	7	4.67	
0.71 – 0.80	35	23.33	
0.81 – 0.90	87	58.00	
0.91 – 1.00	19	12.67	
Total	**150**	**100**	

Source: Computed from field data, 2021

Technical efficiency of soybean production

The result of maximum likelihood estimates of stochastic frontier production function is presented in Table 3. It shows that sigma squared value of 0.9577 is statistically significant at the 1% level indicating the goodness of fit and the correctness of the specified distributional assumption of the composite error term. The Gamma value of 0.8635 is also statistically significant at 1% level. This implies that about 86.35% of the variation in output levels of soybean farming is attributable to technical inefficiency in resource use.

Table 3: Maximum Likelihood Estimates (MLE) of the Stochastic Frontier Production Function of soybean farmers

Variables	Parameter	Coefficient	Standard Error	t-value
Efficiency model				
Constant	β_0	0.104	0.106	0.986
Farm Size	β_1	0.784***	0.052	15.08
Seed	β_2	0.517**	0.322	0.160
Fertilizer	β_3	0.067	0.013	1.510
Labour	β_4	0.325**	0.337	0.963
Agrochemical	β_5	-0.069	0.054	-1.290
Inefficiency model				
Constant term	δ_0	3.9281**	1.451	2.707
Age	δ_1	-1.6038*	0.420	-3.816

Education	δ_2	0.1750	0.123	1.421
Household size	δ_3	0.1206*	0.154	1.678
Farming experience	δ_4	-0.265***	0.261	-0.101
Credit amount	δ_5	0.280***	0.459	0.610
Extension visit	δ_6	0.4275***	0.113	3.332
Variance parameters				
Gamma		0.8635***		
Sigma squared		0.9577***		
Log Likelihood function		-15.893		

Source: Computed from field data, 2021
Key: ***; **; * means significant at 1%; significant at 5%; significant at 10% respectively

In addition, results of efficiency model shows that farm size, seed quantity and labour were statistically significant at 1%, 5% and 5% respectively. The coefficient of farm size 0.784 indicates that a positive relationship between farm size and soybean production in the study area. Thus, a 1% increase in farm size will lead to an increase in output of soya bean by 7.84kg. This result is in line with Moses (2017) who reported a positive relationship between farm size and output of soybean farmers in Mubi North Local Government Area of Adamawa State.

The coefficient of seed (0.517) was also positive, thus increasing quantity of seed used by 5% will result in increased output by 0.517%. This result agrees with Tashikalma (2011). Seed quantity is important because it determines to a large extent the output obtained. If correct seed rates and quality seeds are not used, output will be low even if other inputs are in adequate. Also, the coefficient of labour (0.325) was positive, thus a 5% increase in labour would boost soybean production in the study area by 0.325%. This result is in line with Sujaya (2017). As cost of production increases, farmers resort to minimise cost by employing more of family and communal labour which are relatively cheaper. However, this invariably means increase in man days per hectare of labour.

The coefficient of fertilizer (0.067) was not different from zero. This implies that an increase in quantity of fertilizer will not appreciably increase output of soybean in the study area. This is because soybean is a legume which improves soil fertility by converting and fixing nitrogen from the atmosphere into the soil. Thus, it does not require much fertilizer. This result agrees with Oseni *et al*. (2015). Also, the coefficient of agrochemical (-0.069) was not different from zero which implies that increasing its quantity will not result in increased output. This finding is in line with Mustapha & Salihu (2015), Moses (2017) and Oluwatusin *et al*. (2020). The negative sign could be due to over application of agrochemical by the respondents. Sadiq *et al.* (2017) found out that manure, inorganic fertilizer and biocides (herbicides and insecticides) had the highest inefficiency levels in cowpea production in Niger State due to excessive use.

Technical inefficiency of soybean production

The result of inefficiency model shows that the coefficient of age was negatively different from zero at 10% level of significance. Thus, increasing age of farmers will improve technical efficiency level. In other words, older farmers are more technically efficient than younger farmers. This finding agrees with Hasan *et al*. (2015) who studied technical efficiency of rice production in Bangladesh.

In addition, household size was found to be positively significant at 10%. This implies that as household size of respondents increase, their technical efficiency reduces. Large household size does not necessarily imply availability of cheap family labour. Given that parents today want their children to acquire quality formal education, they spend a lot of money paying for education, health and wellbeing of the children who in turn do not actively participate in farming thereby decreasing technical efficiency. This can be inferred based on socio-economic characteristics presented in Table 1 which indicates that the respondents had relatively large household sizes and are mostly educated, hence they will like their children to be educated too. This result is in line with Musaba & Banda (2020) who studied the technical efficiency of small-scale soybean farmers in Mpongwe District of Zambia. The authors stated that large families tend to have high number of dependents thereby reducing supply of family labour which subsequently reduces technical efficiency.

The coefficient of farming experience (-0.265) means that as years of farming experience of respondents increases, their technical efficiency also increases. The more experience farmers have in soybean farming, the more skills they acquire and the more comfortable they become with the production system. This result agrees with Maurice (2004) reported that farming experience increases efficiency in farmers.

In addition, amount of credit received by the respondents was positively significant at 1%. This implies that as credit amount increases, efficiency of soybean production decreases. The reason could be due to diversion of funds meant for farming to non-agricultural activities like purchase of expensive phones, motor cycles, renovation of buildings, marrying new wives and the like.

Furthermore, extension visit was positively significant at 1% which signifies that as number of extension contact increases, production efficiency decreases. The reason could be due to conflicting information received by farmers from different extension agents thereby affecting their output. This result is in line with Mairabo (2020) who studied economics analysis of watermelon production in Niger state.

On the other hand, the coefficient of education (0.1750) was not statistically different from zero. This indicates that education has no impact on technical efficiency or inefficiency of soybean farmers in the study area. The reason could be that productivity is more correlated with farming experience than education. In other words, an experienced farmer with less education has the potential to produce more efficiently than a highly educated individual with little or no farming experience. Fatoba (2007) found out that there is no significant relationship between education and technical efficiency in production of rice, soybean and sugarcane in middle belt region of Nigeria.

CONCLUSION AND RECOMMENDATIONS

The factors that influence technical efficiency of soybean production in the study area are farm size, seed quantity, labour, age, and farming experience. Thus, a typical soybean farmer in the study area can increase productivity by 11% using the same input bundle. It is recommended that extension services provided by the government, donor agencies and Non-Governmental Organizations should be streamlined so that farmers do not receive conflicting information as this could hinder efficiency in production. Also, a proficient

extension service will assist farmers to effectively use agrochemicals and credit received from formal and informal sources.

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