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TECHNICAL EFFICIENCY OF BAMBARA NUT PRODUCTION IN NIGER STATE, NIGERIA

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ABSTRACT
There is a gap between actual and potential output of Bambara nut due to inefficient use of existing resources, thereby hindering profit maximization. Therefore, this study aims at determining the technical efficiency of Bambara nut production in Niger State, Nigeria. Multistage sampling technique was used to randomly select 150 representatives of Bambara nut producers in the study area. Primary data were obtained using structured interview schedule. Stochastic frontier production function was used to analyze the data collected. Results showed that four out of the five variables included in the efficiency model, namely: farm size, seed, labour and herbicide were statistically and positively significant at 1%, 10%, 10% and 10% respectively. Fertilizer was not significant. Similarly, the factors affecting Bambara nut production in the study area as shown by the inefficiency model were age, education and farming experience. In addition, the mean efficiency of the respondents was 0.71. The study concluded that Bambara nut production in the study area was efficient. However, there are prospects of increasing production efficiency by 29% using existing inputs and technologies. It was therefore concluded that Bambara nut farmers in the study area should be encouraged to join existing cooperatives or form new ones so as to benefit from various incentives such as economies of scale, access to formal credit facilities, linkage with product buyers, among others. In addition, they should engage in rotational communal labour.

Keywords: Technical efficiency, stochastic frontier model, Bambara nut, Niger State, Nigeria.

INTRODUCTION
Bambara nut (Vigna subterranea) is a hardy crop and has ability to fix nitrogen to the soil and also grow under certain environmental conditions that cannot favour other crops such as poor soils and drought. It has been recognized as an important nutritious food source when food is scarce (Paliwal *et al.,* 2020). Bambara nut strive well under conditions which are too arid for groundnut (Arachis hypogea), maize (*Zea mays*) and even sorghum (*Sorghum bicolar*). Thus, drought resistance makes it a useful legume to include in climate change adaptation strategies. Therefore, it has the potential to contribute to the improvement of food and nutritional security, while proffers solutions for environmental sustainability and equitability in food availability and affordability. It is sometimes termed a "complete food" due to its balanced macronutrient composition such as carbohydrate, protein, fats, fibre as well as essential amino acids like methionine, leucine, isoleucine, lysine, phenylalanine, threonine, valine and tryptophan (Azman *et al.*, 2019).

According to Muhammad *et al.* (2020), at present, the global agricultural system is focused on a limited number of crop species, thereby presenting a threat to food security and supply, especially with predicted global climate change conditions. The importance of neglected or underutilized crop species in meeting the world's demand for food has been duly recognized by research communities, governments and policy makers worldwide. As a result, the development of underutilized crops, with their vast genetic resources and beneficial traits,

may be a useful step towards solving food security challenges by offering a multifaceted agricultural system that includes additional important food resources. The authors added that Bambara nut is among the beneficial underutilized crop species that may have a positive impact on global food security.

Nigeria has an annual population growth rate of 2.6% (World Bank, 2020). Therefore, there is need to increase food production in order to feed the growing population. However, total land holding per household is becoming smaller and smaller which implies that the opportunity to increase smallholders' productivity through farm size expansion is almost nil. As a result, measuring efficiency is highly important to improve production and productivity with a given level of resources.

Adzawla *et al.* (2015) and Sanusi *et al.* (2018) determined the efficiency of Bambara nut production in northern Ghana and Yala Local Government Area of Cross River State, Nigeria respectively. Both studies showed that Bambara nut production in the study areas were efficient. On the other hand, Korir *et al.* (2011) found out that Bambara nut production in Western Kenya was inefficient. The presence of inefficiency not only limits the gains from the use of existing resources, it also hinders the benefits that could arise from the use of improved technological inputs. In other words, the gap between actual and potential outputs could be closed by utilizing minimum inputs to achieve a possible maximum output. Studies in this regard especially for Bambara nut production in Niger State are very limited.

To this end, this study aims at determining the technical efficiency and factors affecting Bambara nut production in Niger State, Nigeria. The result of this study is expected to guide the policy makers in planning areas of intervention for Bambara nut farmers. This is because increasing food production is facilitated by improving production efficiency on one hand and eliminating production constraints on the other. Therefore, tackling sources or variables that contribute to inefficiency of production as well as removing obstacles that hinder optimal production will go a long way in boosting farm level productivity and ensure food security in order to meet up with the Sustainable Development Goal (SDG) of zero hunger by 2030.

MATERIALS AND METHODS

The Study Area

This study was conducted in Niger State. Niger State is one of the 36 States of the Federal Republic of Nigeria. It is made up of 25 Local Government Areas (LGAs). It is situated between latitudes $8^0$22'N and $11^0$30'N and longitudes $3^0$30'E and $7^0$20'E. The State has a total land area of 74,244km^2 which represents about 10% of the total land area in Nigeria out of which 85 percent is arable (Niger State Bureau of Statistics, 2012). The soils are fertile and the hydrology permits the cultivation of most of Nigeria's staple crops and still allows sufficient opportunities for grazing and fresh water fishing. Most of the communities in Niger State are predominantly agrarian and viable for cultivation of varieties of crops such as sugar cane, vegetables, groundnut, soya beans, rice, melon, cassava, sorghum, millet, shea butter, yam, cotton, cowpea and of course Bambara nut. The inhabitants of the State also domesticate livestock like cattle, sheep, goats and chicken among others.

Niger State is divided into three zones by the Niger State Agricultural Development Project (NSADP). The zonal distribution is in line with the agro-ecological characteristics and cultural similarities of the areas. The zones are: I (Niger South), II (Niger Central), and III (Niger North) with headquarters at Bida, Kuta and Kontagora respectively (Okolo and Osifo, 2017).

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Sampling Procedure

Multistage sampling technique was employed to select the respondents for the study. The first stage involved purposive selection of Zone I (Niger South) on the basis of being the most prominent Bambara nut producing Zone in the state. The second stage was the random selection of Katcha, Lavun, and Edati Local Government Areas out of eight Local Governments. The third stage involved the proportional selection of five villages in Lavun, four villages in Katcha and three villages in Edati LGAs giving a total of 12 villages based on the population of Bambara nut farmers in each LGA. In the fourth stage, a random selection of 20% of the farmers in each of the villages was done giving a total of 150 representative farmers for the study as shown in Table 1.

Table 1: Sampling frame and sample size of Bambara nut farmers in the study area

LGA	Villages	No of farmers	20% of farmers	Farmers sampled
Katcha	Essa	47	9.4	9
	Kataeragi	68	13.6	14
	Bakeko	59	11.8	12
	Dzwafu	64	12.8	13
Lavun	Egbako	50	10	10
	Batati	69	13.8	14
	Dassun	57	11.4	11
	Busu	78	15.6	16
	Doko	83	16.6	17
Edati	Etsu Tasha	55	11	11
	Enagi	67	13.4	13
	Gazhe	52	10.4	10
Total		**749**	**149.8**	**150**

Source: Field Survey (2019)

Method of Data Collection

Data for this study were collected from primary source. Primary data were obtained using structured interview schedule on Bambara nut farmers by trained enumerators under the supervision of the researcher.

Method of Data Analysis

Stochastic frontier production function was used to determine the technical efficiency of Bambara nut farmers in the study area. It is expressed in its implicit form as used by Tenaye (2020) as:

$Y_i = f(X_i, \beta)e_i$ …(1)

$e_{i=} v_i + u_i$ …(2)

where;

Y_i = quantity of output of the i^{th} farm (kg)

X_i = vector of inputs used by the i^{th} farm

β = vector of parameters to be estimated

e_i = farm specific composite error term

v_i= random error outside farmer's control

u_i =technical inefficiency effects

Explicitly, the Cobb-Douglas stochastic frontier production function is specified as follows:

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$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + (v_i + u_i) \quad \ldots(3)$$

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 (mandays)
X_5 = herbicide (litres)

The determinants of technical inefficiency which represents the factors that determine Bambara nut production in the study area is defined by:

$$U_i = \delta_0 + \delta_1 \ln Z_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 + \delta_5 \ln Z_5 \quad \ldots(4)$$

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 Bambara nut production)
Z_5= extension visit (number of visits per production cycle).

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

Thirty-two percent of the respondents indicated that they had primary education as shown in Table 2. The respondents that had secondary education were 28.70% while 10% attended tertiary institutions. This result agrees with that of Valerie and Luvembe (2016) who found out that 25.8%, 32% and 12.2% of Bambara nut farmers in Kenya had primary, secondary and tertiary education respectively. Table 2 further show that majority (76%) of Bambara nut farmers in the study area cultivate on one to two hectares. This implies that majority of Bambara nut producers in the study area are smallholder farmers. In addition, 21.3% have farming experience of 11 to 20 years while 6.6% have been engaged in Bambara nut production for 41 years and above. The mean farming experience of respondents was 18 years. This in line with the findings of Mohammed (2014) who reported that the mean farming experience of Bambara nut farmers in Kano State, Nigeria was 20 years.

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Table 2: Socio-economic characteristics of respondents

Variables	Frequency	Percentage	Mean	SD
Educational level				
No formal education	44	29.3		
Primary	48	32		
Secondary	43	28.7		
Tertiary	15	10		
Total	**150**	**100**		
Farm size (ha)				
Less than 1	23	15.3	1.32	0.88
1.0 – 2.0	114	76		
2.1 – 3.0	8	5.3		
Above 3.0	5	3.3		
Total	**150**	**100**		
Farming experience				
1 – 10	64	42.7	18.11	13.5
11 – 20	32	21.3		
21 – 30	22	14.7		
31 – 40	22	14.7		
41 and above	10	6.6		
Total	**150**	**100**		
Extension contacts				
0	114	76		
1 – 2	18	12		
3 – 4	11	7.3		
5 and above	7	4.7		
Total	**150**	**100**		

Source: Field survey, 2019

Table 3 shows that farm size was statistically significant at 1%. This implies that a 1% increase in farm size will increase yield by 1.201%. This in line with a priori expectation which means that increasing farm size will lead to increase in output. This result agrees with Onuche et al (2020) who studied profitability of Bambara nut production in Kogi State.

Seed was statistically significant at 10% which means that increasing seed quantity by 10% would increase the output of Bambara nut in the study area by 0.379%. 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 abundance. This result is consistent with the finding of Mohammed (2016) on profitability and production efficiency of small-scale Bambara nut farming in Kajuru Local Government Area of Kaduna State.

Labour was discovered to be positively significant at 10%. This means that increasing man-days of labour by 10% will lead to increase in production by 0.351%. As cost of production increases, farmers resort to minimise cost by employing more of family and communal labour which are relatively cheaper. This result is in line with Valerie and Luvembe (2016) and Korir *et al.* (2011) who each reported a positive relationship between labour and output in their studies on Bambara nut conducted in Kenya.

The coefficient of herbicide (0.084) was positive and significant at 10%. This implies that increase in quantity of herbicide by 10% will result in increase in output by 0.084%.

According to Gianessi (2013), in many parts of the world, herbicides are being increasingly used to replace tillage in order to improve environmental conditions. In comparison with tillage, herbicide use reduces erosion, fuel use, greenhouse gas emissions and nutrient run-off and conserves water. This result agrees with Jamala *et al.* (2013) who assessed agro-chemicals utilization by small-scale farmers in Guyuk, Adamawa State, Nigeria.

Furthermore, fertilizer was also not statistically significant. Most often than not, farmers in Nigeria get fertilizer at the middle or towards the end of the rainy season when they no longer need it due to late deliveries (Otitoju and Ochimana, 2016). This makes its impact on output to be insignificant because of poor timing of application.

In addition, Table 3 shows that coefficient of sigma squared otherwise known as total variance (0.171) was statistically significant at 1%. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. Also, the coefficient of gamma otherwise known as variance ratio (0.751) was significantly different from zero at 1% level of significance. This implies that about 75% of the differences between the observed and maximum production frontier outputs were due to differences in technical inefficiency and not related to random variability; thus, the use of stochastic frontier production function is appropriate for this study.

The inefficiency model in Table 3 represents the factors affecting Bambara nut production in the study area. Age, education and farming experience were significant while household size and extension visit were not. Age was positive and statistically significant at 1%. This means that as age of respondents increase, their technical inefficiency also increases (or their technical efficiency decreases). In other words, older farmers are less technically efficient compared to younger farmers because they are less energetic to work on the farm; which is in conformity with a priori expectation that increase in age increases technical inefficiency. This result is in line with Dolaree *et al.* (2017) who found a negative relationship between age and technical inefficiency of soybean farmers in Mubi North Local Government Area of Adamawa State, Nigeria.

The coefficient of education (-0.395) was negative and statically different from zero at 5% level of probability. This implies that the more education acquired by respondents, the less will be their technical inefficiency. In other words, education contributed positively to technical efficiency of Bambara nut farmers in the study area. Education motivates farmers to adopt innovations and technologies for improved productivity. This finding agrees with Mohammed (2015) who studied resource use efficiency of chilli pepper production in Kaduna State, Nigeria.

Furthermore, farming experience was negative and statistically significant at 5%. This means that increase in years of farming experience of respondents decreased technical inefficiency (or increase technical efficiency). Increase in farming experience could enhance the skill of the farmers which in turn increase their production and efficiency because they over the years, they have tried and tested methods and techniques that work and those that do not work. This result agrees with Maurice (2004) who reported that farming experience increases efficiency of cereal crop production in Adamawa state, Nigeria.

On the other hand, household size and extension visit were discovered not be significant factors that contribute to Bambara nut production in the study area. Given that parents today want their children to acquire quality formal education, they spend a lot of money paying for education, health and general wellbeing of the children who in turn do not actively participate in farming. Also, the use of herbicides and modern equipment in production process reduces dependence on family labour; thus, a farm family with few members can cultivate several

hectares of land given appropriate technology and machinery. Similarly, extension contact was not a significant factor that contributed to Bambara nut production in the study area.

Table 3: Maximum Likelihood Estimates (MLE) of the Stochastic Frontier Production Function and Inefficiency Model of Bambara nut farmers

Variables	Coefficient	Standard Error	t-value
Efficiency model			
Constant	7.989***	0.728	10.97
Farm Size	1.201***	0.205	5.847
Seed	0.379*	0.194	1.953
Fertilizer	0.003	0.026	0.013
Labour	0.351*	0.213	1.652
Herbicide	0.084*	0.045	1.881
Inefficiency model			
Constant	-4.111	7.588	-0.542
Age	0.143***	0.046	3.113
Education	-0.395**	0.201	-1.962
Household size	0.394	0.558	0.706
Farming experience	-0.062**	0.025	-2.447
Extension visits	0.186	0.258	0.722
Variance Parameters			
Sigma squared	0.171***	0.046	3.669
Gamma	0.751***	0.787	9.545

Asterisks indicate significance ***= 1%, ** = 5%, *= 10%, respectively
Source: Computed from field data, 2019

The distribution of technical efficiency of the respondents is presented in Table 4. It shows that 31.33% of the respondents have technical efficiency of 0.81 to 0.90; while 29.33% have estimates ranging from 0.81 to 0.90. Only 2% of the respondents have technical efficiency level of 0.30 and below. Further analysis show that the technical efficiency levels for all respondents range from 0.22 to 0.93 with a mean of 0.71 which indicates that a typical Bambara nut farmer in the study area could increase output by 0.29 or 29% using the same input bundle. This result is in line with the Adzawla *et al.* (2015) who reported a mean efficiency score of 83% among Bambara nut producers in northern Ghana.

Table 4: Distribution of technical efficiency

Efficiency score	Frequency	Percentage	Mean	Minimum	Maximum
0.21 – 0.30	3	2	0.71	0.22	0.93
0.31 – 0.40	8	5.33			
0.41 – 0.50	9	6			
0.51 – 0.60	14	9.33			
0.61 – 0.70	20	13.33			
0.71 – 0.80	44	29.33			
0.81 – 0.90	47	31.33			
0.91 – 1.00	5	3.33			
Total	**150**	**100**			

Source: Computed from field data, 2019

CONCLUSION AND RECOMMENDATIONS

Bambara nut production in the study area is a highly efficient venture. However, there are prospects of increasing production efficiency by 29% using existing inputs and technologies. Thus, with more access to extension services, farmers will be better informed on how to efficiently utilize production inputs thereby ensuring higher technical efficiency and increased productivity. As a result, the following recommendations are proffered: one, the agricultural extension system should be revitalised so as to reach a larger number of farmers by employing more personnel, motivating them as well as utilising mass media and social media platforms. Also, Bambara nut farmers in the study area should be encouraged to join existing cooperatives or form new ones so as to benefit from various incentives such as economics of scale, access to formal credit facilities, linkage with product buyers, among others. In addition, farmers should engage in rotational communal labour. This will go a long way in reducing the cost of labour which is the highest cost component of respondents in the study area. Finally, farmers should be encouraged to adopt the use of improved and disease resistant varieties.

REFERENCES

Adzawla, W., Donkoh, S. A., Nyarko, G., O'Reilly, P., Olayide, O. E. & Awai, P. E. (2015). Technical Efficiency of Bambara Groundnut Production in Northern Ghana. *UDS International Journal of Development,* 2(2): 37-49.

Azman, H. R., Barkla, B. J., Mayes, S. & King, G. J. (2019). The Potential of the Underutilized Pulse Bambara Groundnut (Vigna Subterranea (L.) Verdc.) For Nutritional Food Security. *Journal of Food Composition and Analysis*, 77:47-59.

Dolaree, D. A., Moses, J. D. & Zalkuwi, J. (2017). Profitability of Soya Beans Production in Mubi North Local Government Area of Adamawa State, Nigeria. *International Journal of Advances in Agricultural Science and Technology*, 4(6): 1-8.

Jamala, G. Y., Ari, B. M., Tsunda, B. M. & Waindu, C. (2013). Assessment of Agro-Chemicals Utilization by Small-Scale Farmers in Guyuk, Adamawa State, Nigeria. *Journal of Agriculture and Veterinary Science*, 6(2): 51-59.

Korir, M. K., Serem, A. K., Sulo, T. K. & Kipsat, M. J. (2011). A Stochastic Frontier Analysis of Bambara Groundnut Production in Western Kenya. 18th International Farm Management (IFMA) Congress Methven, Canterbury, New Zealand.

Maurice, D. C. (2004). Resource Production in Cereal Crop Production among Fadama Farmers of Adamawa State Nigeria. Unpublished M.Sc. Thesis, University of Maiduguri.

Mohammed, B. (2015). Analysis of Resource Use Efficiency and Profitability in Chilli Pepper (Capsicum frutescens) Production and Its Contribution to Household Farm Income in Kaduna State. Unpublished M.Sc. Thesis. Ahmadu Bello University, Zaria, Nigeria.

Mohammed, H. (2016). Analysis of Profitability and Production Efficiency of Small-Scale Bambara Nut Farming in Kajuru Local Government Area of Kaduna State. Unpublished M.Sc. Thesis. Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

Muhammad, I., Rafii, M. Y., Ramlee, S. I., Nazli, M. H., Harun, A. R., Oladosu, Y., Musa, I., Arolu, F., Chukwu, S. C., Haliru, S. B., Akos, S. I., Halidu, J & Arolu, I. W. (2020). Exploration of Bambara Groundnut (Vigna subterranea (L.) Verdc.), an Underutilized Crop, to Aid Global Food Security: Varietal Improvement, Genetic Diversity and Processing. *Agronomy*, 10(6):766-774.

Niger State Bureau of Statistics (2012). Niger State Agricultural Statistics: Facts and Figures about Niger State. Minna. Pp. 54.

Okolo, C. C. & Osifo, M. (2017). Sources of Information and Finance for Women Shea Butter Producers in North Central States of Nigeria. *Nigerian Journal of Rural Sociology,* 17(2): 28-32.

Onuche, U., Ibitoye, S. J. & Anthony, T. (2020). Profitability and Efficiency of Bambara Groundnut Production in Nigeria: A Case Study. *Review of Agricultural and Applied Economics*, 23(2): 92-101.

Otitoju, M. A. & Ochimana, D. D. (2016). Determinants of farmers' access to fertilizer under fertilizer task force distribution system in Kogi State, Nigeria. *Cogent Economics & Finance*, 4(1): 1-9.

Paliwal, R., Abberton, M., Faloye, B. & Olaniyi, O. (2020). Developing the role of legumes in West Africa under climate change. *Current Opinion in Plant Biology*, 56:242-258.

Sanusi, S. O., Tiku, N. E., Okwoche, P. O., Waziri-Ugwu, P. R. & Abdullahi, Z. Y. (2018). Analysis of Resource Use Efficiency in Bambara-nut Production in Nigeria. *Journal of Agricultural Economics, Environment and Social Sciences*, 4(1): 1-10.

Tenaye, A. (2020). Technical Efficiency of Smallholder Agriculture in Developing Countries: The Case of Ethiopia. *Economics,* 8(34): 1-27.

Valerie, P. and Luvembe, S. W. (2016). Influence of Farmers' Socio-economic Characteristics on Adoption of Bambara Nut Production in Western Kenya. *Asian Journal of Agricultural Extension, Economics & Sociology,* 14(1): 1-10.

World Bank (2020). Population growth (annual %) – Nigeria. Retrieved from: https://data.worldbank.org/indicator/SP.POP.GROW?locations=NG.