Jimjel. Zalkuwi *et al*, International Journal of Advances in Agricultural Science and Technology,

Vol.2 Issue.10, October- 2015, pg. 01-12 **ISSN: 2348-1358**

Possibility of Improvement in Sorghum Production: A Comparative Study of Technical Efficiency in India and Nigeria

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ABSTRACT: ***This study analyzed and compared the technical efficiency of sorghum production in India and Nigeria. Data were collected through a survey of 480 selected sorghum farmers; 240 from each country using simple random sampling and purposive sampling techniques simultaneously. The result of the stochastic frontier production function analysis shows that the variance parameters, that is the sigma squared (δ^2) and the gamma (γ) were statistically significant at 1 % level each for both states of sorghum production. The coefficient of farm size, labour, fertilizer and chemicals were positive and significant for India while farm size, labour and seed were positive and significant in Nigeria. Profit level can be increased in India by increasing the amount of farm size, labour, fertilizer and chemicals and decreasing the use of seed while Profit in sorghum production can be increased in Nigeria by increasing the amount of farm size, labour and seed and decreasing the use of fertilizer and chemical. Mean technical efficiency were 0.6774 and 0.775 for India and Nigeria respectively. Farmers operate at 32 %, and 22 %, for India and Nigeria respectively below frontier level due to variation in technical, efficiency respectively. The inefficiency model shows that the coefficient of Age and Literacy Level was negative a priori sign and in consonance with the a priori expectation. It was concluded that the farmers in the Nigeria state are more efficient than the farmers in Indian state.***

Keywords: Possibility, sorghum, technical efficiency, India, Nigeria

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Introduction

Sorghum (*Sorghum bicolor* (L) Moench) is the fifth, fourth and third major cereal in terms of production and acreage in the World, India and Nigeria respectively (ICRISAT, World sorghum). Sorghum is a versatile plant because it can tolerate drought, soil toxicities, a wide range of temperatures and high altitudes, Sorghum is now widely found in drier area of Asia, Australia, Africa and America. The total production ranges from 50-55 million tonnes from approximately 50 million ha of land, United State is the highest producers and are follow by, Nigeria, Mexico, India, Sudan and soon

Sorghum has some unique properties that make it suitable to use for food. Some sorghum varieties are antioxidants rich and all sorghum varieties are gluten-free product, which is a desirable alternative for people who are allergy to wheat. Sorghum is a resistant crop to drought so it can withstand drought and its neutral taste enables sorghum to absorb other flavours. This has been shown in sorghum (white) that has been exported from United States to Japan to be used for snack purpose. For example, U.S. sorghum (white) has been exported to Japan to be processed into flour and then processed into snack food products. It is expected that more sorghum (white) based products will debut soon both in Japan and in North America.

Sorghum is also an important animal feed used in countries like United States, Mexico, Nigeria, India and Sudan. Good sorghum quality is available with a nutritional feeding value that is equivalent to that of maize (corn). Sorghum can be processed to improve its nutritional value by using the techniques such as grinding, steam flaking popping, steaming, extruding and crushing.

The products are used in pet foods and also to feed swine, egg-laying hens, dairy cattle, goat and sheep. About 12 percent of domestic sorghum production also goes to produce ethanol and its various products. With the demand for renewable energy fuel sources is increasing, the need for products like sorghum-DDGS (sorghum distiller's dried grains with soluble) will increase as well due to sorghum's favourable nutrition profile.

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Several studies indicated that the existing low levels of technical efficiency hinder efforts to achieve progress in production (Seyoum *et al*., 1997, Zalkuwi *et al* 2013). Even with the significant growth in sorghum production, there is inefficiency in the production system of sorghum production. An improvement in the efficiency of production system will have direct positive effect on, agricultural growth, rural livelihood and nutritional security in a country like India and Nigeria, where sorghum is one of the major crops.

Under these circumstances it is important to know whether the producers have the same or different levels of efficiency (technical). The study therefore, tries to measure the efficiency (technical) under different farms in India and Nigeria.

Methodology

Selection of sample size

Two divisions were selected from the state (Pune and Amravati), a district from each division were selected randomly, after which two villages were selected from each district (ie four villages) comprises of (Shirapur, Kalman, Kinkhed and Kanzara) were randomly selected. So the stratified random sampling using equal allocation was used to select equal number of farmers (60) from 4 villages to give 240 farmers (List of sorghum producer was prepared in each village and the total of 240 sorghum producers were selected randomly). In Nigeria, Adamawa State was selected purposively based on the basis of highest production level. The state has twenty-one Local Government Areas which are categorized into four agricultural zones; North West, South West, North East Zone and Central . Each Local Government Area have been purposively selected from each zone (four LGA), comprise Viz; Ganye, Mubi south, Girei and Guyuk,. The four districts were selected purposively from each Local Government area, after those four villages from the selected district (one village from each district). The stratified random sampling with proportional allocation was used to select farmers from the four villages to give 240 farmers.

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ANALYTICAL TOOL

The frontier stochastic production model was used to determine the efficiency of the sorghum farmers; TEj=Actual output/Potential output*

* Potential output was taken from 10% progressive farmers of sample

The Empirical Frontier Stochastic Production Model

The frontier stochastic production function used in this study was specified as follows:

$$\text{Log}Y_i = B_o + B_1\log X_1 + B_2\log X_2 + B_3\log X_3 + \ldots\ldots\ldots\ldots B_6\log X_6 + V_i - U_i \quad (1)$$

Where

Y = Output of sorghum in kg

X_1 = Farm size in hectares

X_2 = Quantity of sorghum seed planted in kg

X_3 = Amount of family labour used in man-days

X_4= Quantity of chemicals used in litres

X_5 = Quantity of fertilizer used in k

V_i = Random noise (white noise) which are N (0, δ^2, V)

U_i = Inefficiency effects which are non-negative, normally distribution N (0,δ^2, U)

The technical efficiency of sorghum production for i^{th} farmers, defined by the ratio observed output as to the corresponding frontier production associated with no technical inefficiency effect, is expressed by;

$$TE = \text{Exp}(-U_i) \text{ so that } O \leq Te \leq 1 \quad (2)$$

Variance parameters are δ^2 =

$$\delta^2_V + \delta^2_U \text{ and } \gamma = \delta^2_U / \delta^2 \quad (3)$$

So that $O \leq \gamma \leq 1$

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The inefficiency model is defined by,

$$U_i = \delta_o + \delta_1 Z_1 + \delta_2 Z_2 \quad (4)$$

Where,

U_i = inefficiency effect

Z_1 = Age of farmer (in years)

Z_2 = Literacy level (in years)

Result and discussion

Estimation of efficiency in Sorghum Production

This section examines the relative performance of the process used in transferring given input into output. The technical efficiency of the respondents in sorghum production was estimated using stochastic frontier functions.

Table 1: Maximum Likelihood Estimate of the Cobb-Douglas Stochastic Frontier Production Function Model for Indian and Nigerian Sorghum Farmers

		India		**Nigeria**	
Variable	**Parameter**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Production factors					
Constant	β_0	5.1671***	12.4552	2.8465***	9.7321
Farm size (X1)	β_1	0.8457***	4.9781	0.2152***	3.3895
Labour (X2)	β_2	0.3308***	3.6577	0.1952**	2.1981
Seed (X3)	β_3	0.0554	0.3328	0.2061**	2.3258

Fertilizer (X4)	β_4	0.1682*	1.950	-0.0091	-0.5849
Chemicals (X5)	β_5	0.1243**	2.3305	0.0490	1.4212
Inefficiency effects					
Age	d_1	-0.1001**	-2.0707	-0.1947**	-2.1432
Literacy level	d_2	-0.5484***	-3.3482	-0.1692***	-2.7431
Diagnostic statistics					
Sigma squared (d^2)		0.2200***	3.1100	0.6688***	5.2574
Gamma (ϒ)		0.5179***	4.8537	0.4530***	0.1368

*** Estimates are significant at1% level,

** Estimates are significant at 5% level.

*Estimates are significant at 10% level

The maximum likelihood estimates of the stochastic frontier production function and inefficiency model results are presented in Table 1. The estimate for parameters of the stochastic frontier production function indicates that the elasticity of output with farm size was positive and approximately 0.8457 in India and it was 0.2152 in Nigeria. They were all statistically significant at 1 % level. This implies that a one percent increase in area under sorghum production will raise output of sorghum by 0.8457% in India and 0.2152%. This shows that land is a very important factor in sorghum production both in India and Nigeria. This finding is at tandem with the findings of; Odoh and Folake (2006) Gwani 2012

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;Zalkuwi(2012), Zalkuwi 2014, Ibrahim et al(2013) that land has positive sign and statistically significant.

Coefficient of labour were (0.3308) and (0.1952) in India and Nigeria respectively, are significant and positively related to sorghum output. This means that an increase in man days of labour by 1% would increase sorghum output by 0.33%and 0.28% respectively. This can indicate that availability of labour increases the likelihood of the farmer to go into crop diversification. This is because crop diversification guarantees substantial labour cost savings which otherwise will be incurred when there is no crop diversification. Different crops have different labour intensity; hence, diversification is common among crops with low labour intensity than those with high labour intensity

The production elasticity of seed in India was 0.0554 and it was not statistically significant this implies that a one percent increase in one kg of seed under sorghum production will decrease the output of sorghum production0.0554%. While it was an important factor in Nigeria with Seed input having an elasticity coefficient of 0.2061 and positively related to total output of sorghum in the study area. This shows that a 1% increase in quantity of seeds used in production would increase output of sorghum by 0.2061%. By implication, raising the productivity of seed is expected to translate into a more than proportionate increase in the output of sorghum per hectare. This agrees with Olayide and Heady (1982) who stated that agricultural productivity can be increased through increase in the quantity of a particular input, or increase in the productivity of input, or a combination of both. So seed is a very important factor of production. The significant and positive sign of seed variable also indicated that a moderate increase in population of sorghum on the field will increase the yield provided that, the farm is not over populated beyond the recommended sorghum ration or mixture ratio capacity that will lead to competition for nutrients which will lower the yield. This finding is in consonance with the work of Shehu *et al.* (2007a) and Ogundari (2008), who found that seed is an important factor in production

The production elasticity for fertilizer in India was significant at 10 % level. Fertilizer improves the productivity of existing land by increasing crop yields per hectare. A 1%

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increase in the use of fertilizers would increase output of sorghum crop by 0.1682%, from the findings therefore is an indication that fertilizer is a critical variable input in sorghum production in the study area which increase the output of sorghum farmers. This agrees with comparable findings by Daniel *et al*. (2013) who reported positive relationship between fertilizer and output of farmers, while The production elasticity of fertilizer in Nigeria was -0.0091, it was not statistically significant, the insignificance of fertilizer use may be due to the good and fertile nature of the soil of the area which makes farmers to cultivate without much need for fertilizer. This has also encouraged more farmers in the study are to shift much of their attention to sorghum cultivation, since access to fertilizer has become prerogative of the few elite and politically connected farmers.

Chemicals have an elasticity coefficient of 0.1243 and statistically significant at 5%. This means that a 1% increase in the quantity of chemical use in sorghum production would increase output by 0.1243%. The use of chemical reduces expenditure on weeding and at the same time reduces fatigue and drudgery associated with production process. This implies that the use of chemical increases productivity and also enables farmers to cultivate large hectares of land which in turn bring about increase in output, while The production elasticity for chemical in Nigeria was 0.0490 and was not significant This might be because of the technicality involved in using chemicals in multi-cropping system, so it requires skills.

The above result reveals that the important factors of sorghum production in India are land, labour, fertilizer and chemical while the important factor of sorghum production in Nigeria are land, labour and seeds

The estimated gamma parameter (γ) are0.5179 and 0.4530 for India and Nigeria respectively and also significant at 1% level, indicating that 52% and 45% of the variation in the total output of production among the sampled farmers is due to differences in their technical efficiencies in India and Nigeria respectively. The estimated sigma square (δ^2) for India in Table 1 was (0.2200) and significantly different from zero at 1% level. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term also the

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Sigma squared (σ^2) on the other hand was 0.6688 and statistically significant at 1% level indicating correctness of fit of the model as assumed for the composite error term.

Table 2 Technical Efficiency Rating of the Sorghum Farmers

	India		**Nigeria**	
Efficiency	**Frequency**	**Percentage**	**Frequency**	**Percentage**
<0.40	12	5.0	2	0.8
0.40 – 0.49	24	10.0	12	5.0
0.50 – 0.59	39	16.3	24	10.0
0.60 – 0.69	55	22.9	22	9.2
0.70 – 0.79	55	22.9	64	26.7
0.80 – 0.89	48	20.0	78	32.5
0.90 – 1.00	7	2.9	38	15.8
Total	240	100	240	100
Minimum efficiency	0.2864		0.353	
Maximum efficiency	0.9350		0.964	
Mean efficiency	0.6774		0.775	

Source: Computed from Stochastic Frontier Result

The technical efficiency in Table 2 was derived from MLE result of the stochastic production function. The result shows that the TE of the respondents was less than 1 (100 %) hence the variation in TE exits among respondents. It means that, all the respondents produced below maximum efficiency. The minimum efficiency in India was 0.2864, while their maximum

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efficiency was 0.9350; and their mean efficiency were 0.6774. The distribution of the farm efficiency for sorghum production shows that, majority (69 %) of them operated above 59 % of their maximum efficiency and 31 % operated below 59% while the distribution of technical efficiency of the farmers in Nigeria reveals that about 6% had technical efficiency of less than 50 percent, while about 19% had technical efficiency of 50-69 percent, 75% of the respondents had technical efficiency of 70% and above. The magnitude of the mean technical efficiency of the farmers is a reflection of the fact that most of the sampled farmers carry out sorghum production under technical conditions, involving the use of inefficient tools, local seed varieties and so on.

Hypothesis 2: There is no significant difference between the technical efficiency of the farmers in the two countries ($X_1 = X_2$).

X_1 = India Sorghum Farmers

X_2 = Nigeria sorghum Farmers

Level of significance $\alpha = 0.05$ %

$^{\alpha}/_{2}$

= 0.025

Z computed is 7.2020 Z tabulated =1.96 thus at 5 % level of significance Z computed is greater than Z tab (7.20 > 1.96). From the result, the null hypothesis was rejected and the alternative hypothesis was accepted. Meaning that at 5 % level of significance there was a significant difference between the economic efficiencies for India sorghum and Nigeria sorghum farmers. It is clear that, Nigeria sorghum producers were more technically efficient than India sorghum producers

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CONCLUSION

It may be concluded from the study that under the given socio-economic and farm conditions (including technology), the production of sorghum can be increased by 33 and 23 percent for India and Nigeria respectively, since farmers in the study area operate below the frontier level . Profit on the farm can also be enhanced by increasing farm size, increasing the human resources, increasing the quantity of seed and the use of chemical on the farm. It can be concluded from the findings that sorghum farmers in Nigeria are more technically efficient than those of Indian.

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