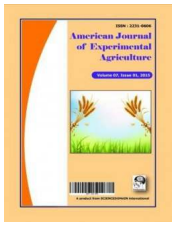

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Technical Efficiency of Chilli Pepper Production in Kaduna State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author BM designed the study, wrote the protocol, wrote the first draft of the manuscript and performed the statistical analysis. Author BA reviewed the experimental design and all drafts of the manuscript. Author ZA identified the plants and managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

This paper deals with issues of improving technical efficiency and productivity of chilli pepper production in Kaduna state. It uses the stochastic frontier analysis approach for the estimation of production functions. The paper made use of a cross-sectional data between August and November 2014 crop season to obtain information from 200 chilli pepper farmers in the 3 local government areas of Kaduna State. The aims of this paper were to describe socio-economic characteristics of chilli pepper farmers and determine the technical efficiency of chilli pepper farmers in Kaduna state. Purposive and random sampling techniques were employed for data collection. The paper revealed that 37.5% of the respondents fall within the age of 30-39 years. The 53% had formal education. The household size ranged from 6-10 persons, majority of the farmers (72%) of chilli pepper farmers do not participate in any chilli pepper related cooperative association, and the result shows that 98.5% of chilli pepper farmers financed their production from their personal savings. The paper revealed that (58.5%) of chilli pepper farmers have extension visit;

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Results indicated that except for labour and agro-chemical, all other factors were significant ($P < 0.01$, $P > 0.1$). The mean technical efficiency is 90%. The findings of this paper revealed that none of the sample chilli pepper farmers reached the frontier threshold. Thus, within the context of efficient agricultural production, output can still be increase by 10% using available inputs and technology. It was therefore recommended that timely and adequate supply of fertilizer should be made available to farmers at affordable price in order to enhance chilli pepper production.

Keywords: Technical efficiency; chilli pepper; stochastic frontier production and Kaduna State.

1. INTRODUCTION

Agriculture has the potential to improve the Nigeria economy, if well harnessed. This will depend, to a large extent, on the encouragement given to the agricultural sector and it plays an important role in the economic development of Nigeria. It provides food for the growing population, employment for over 65% of the population, raw materials for industries and foreign exchange earnings for the government [1]. Thus, resources must be used much more efficiently, which entails eliminating waste, thereby leading to increase in productivity and incomes [2].

Total world production of peppers was estimated to be 14-15 million metric tonnes a year [3]. Pepper is one of the most varied and widely used foods in the world. Pepper production has increased in recent years worldwide. That could be at least in part because of the high nutritional value of pepper [4].

Chilli pepper (*Capsicum frutescens*) is a high value crop that is grown for cash by farmers all over the world [5]. Nigeria is known to be one of the major producers of pepper in the world accounting for about 50% of the African production [6].

Nigeria has good soils and weather that can readily support the growth and production of pepper. Pepper grown in Nigeria is in high demand because of its pungency and good flavour. It can readily be dried, ground and packaged for export. Investing in pepper production is one of the ways of sourcing for foreign exchange [4]. Exportation of pepper in Nigeria has once been reported to be a lucrative business [6]. The major area for its production is the Northern region between latitudes 10°N and 12°30 [1]N. Pepper is utilized mostly for culinary purposes and seasonings. It also has medicinal uses, internally as a stimulant and carminative and externally as a counter- irritant [8].

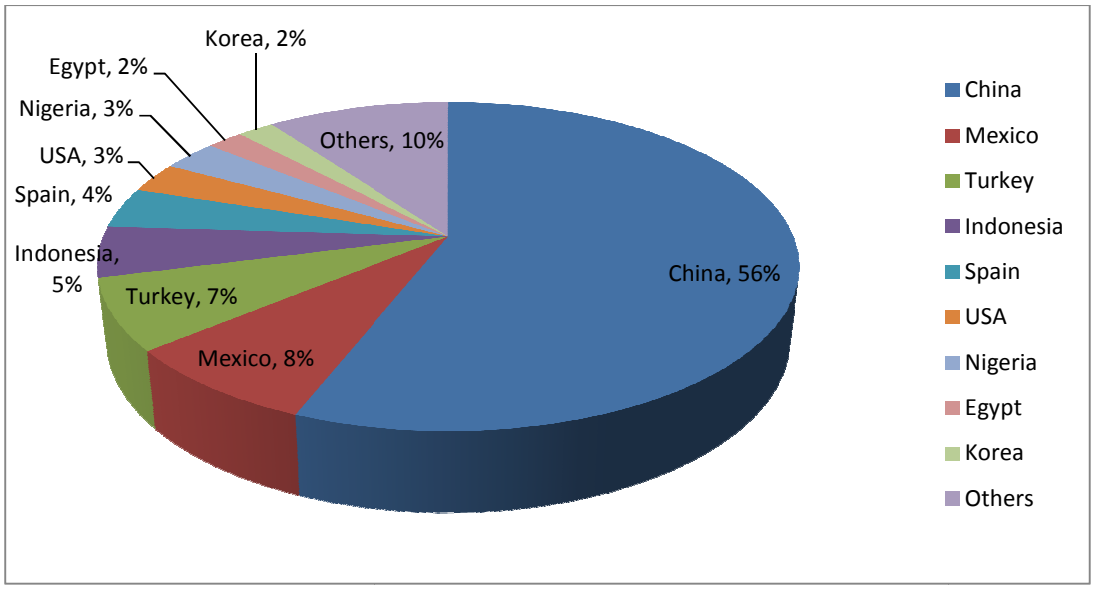

Fig. 1. World chilli pepper production [7]

The demand for pepper is rapidly increasing and there is a great need for increased production [9]. The efficiency with which farmers uses resources and technologies available to them are imperative in Nigeria agricultural production. Non consideration of this has resulted in low farm income which has weakened the financial position of smallholder farmers who produce most of the crops in Nigeria, a condition that has led to poor funding of their economic activities. The implication is that there is scope for further increase in output from existing hectares of crop if resources are accurately exploited [10].

Similarly, the measurement of the productive efficiency in agricultural production is an important issue because it gives pertinent information for making sound management decision in resource allocation. Except for a few descriptive studies, econometric analysis has yet to be conducted to examine the production function for chilli cultivation and its potential for future improvement.

Based on the foregoing, the paper attempts to answer the question on how to determine the level of technical efficiency of the chilli pepper producing farmers.

2. MATERIALS AND METHODS

2.1 Study Area

Kaduna state lies between latitudes 09° 02' and 12° 32' North of the equator and between longitudes 06° 15' and 08° 50' East of the prime meridian. The state shares boundaries with Katsina and Kano state to the north, Plateau to the north east, Nasarawa and Abuja to the south and Niger and Zamfara state to the west [11]. The state has a total land area of about 4.5 million hectares, with an estimated total arable land of about 2.02 million ha comprising 1.94 million ha upland and 0.08 million ha lowland. There are two distinct seasons in the state namely wet and dry seasons. Wet season generally spans from April to October, while dry season falls between October to March. The average rainfall is about 1,482 mm, while temperature ranges from 35℃-36℃ during the humid period to as low as 10℃-23℃ during the hamattan periods of November – February [11].

Kaduna state vegetation is divided into Northern Guinea Savanna and Southern Guinea Savanna. The soil is developed from undifferentiated complex igneous and metamorphic rocks. The fine top soil couple with reasonable organic matter in it enhances the fertility status, especially the southern part of the state. The physical properties of the soil are moderately good and allow continuous cropping for variety of crops [11].

2.2 Sampling Procedure

A multi stage sampling technique was used to select the respondents for this paper. In the first stage, Ikara, Kubau and Soba local government areas were purposively selected out of the 23 local government areas in the state on the basis of being the most prominent producing areas of chilli pepper in the state [11]. Secondly two villages were purposively selected from each of the three local government areas because of the large number of chilli pepper farmers in the areas. Thirdly simple random sampling non replacement method was employed to select 10% out of the population of chilli pepper farmers in each of the villages. Thus, a total of 200 chilli pepper farmers served as the sample size for this paper [11].

2.3 Data Collection and Analysis

Primary data was used for this paper. The interview method of data collection with the aid of structured questionnaire was used to obtain information from the selected farmers in the study area. Data collection was centered on socio-economic characteristic of the farmers such as age, gender, household size, educational status, farming experience, amount of credit, access to extension service, cooperative membership, farm size, quantities and prices of various production inputs used by the farmers.

2.4 Model Specification

Empirical model specification for the determinants of technical efficiency is as follows;

$$\ln Y = \beta o + \beta_1 \ln X_1 i + \beta_2 \ln X_2 i + \beta_3 \ln X_3 i + \beta_4 \ln X_4 i + \beta_5 \ln X_5 i + (Vi - Ui)$$

Where:

ln = the natural logarithm
Y = output of chilli pepper (kg)
βo = constant term
β_1- β_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 (litre)
Vi = random errors outside the farmers control.
U_i = technical inefficiency effects.

The determinant of technical inefficiency is defined by:

$$U_i = \delta_0 + \delta_1 1nZ_1 + \delta_2 lnZ_2 + \delta_3 lnZ_3 + \delta_4 lnZ_4 + \delta_5 lnZ_5 + \delta_6 lnZ_6 + \delta_7 lnZ_7$$

Where:

U_i = inefficiency effects
δ_0 = constant
δ_1-δ_7 = 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)
Z_4 = farmers experience (number of years in chilli pepper production)
Z_5 = pepper related cooperative membership (years of participation)
Z_6 = amount of credit (amount of credit obtained)
Z_7 = extension visit (number of visit)

3. RESULTS AND DISCUSSION

The paper revealed that 37.5% of the chilli pepper farmers were within the age range of 30-39 years with mean of 46 years. This implies that, the farmers are still strong and active and they can participate actively in farming activities is also in line with the findings of [12] younger farmers are more flexible to new ideas and risk; hence they are expected to adopt innovations more readily than older farmers. Education the result shows that 47% of chilli pepper farmers had no formal education, while 30% of the respondents are within 1-6 years of education which means they had only primary education, and 15.5% had secondary education while 7.5% had tertiary education. This indicates that the farmers' educational level is low. This finding is at variance with [13].

The one-third of the farmers (33.5%) had household size that ranged from 6-10 persons. The average household size was 11 persons implying that there is appreciable number of family labour supply to accomplish various farm operations. Farming experience is another important socio-economic factor that can bring about increase in productivity. The result shows that 24% of chilli pepper farmers had an experience of 6-10 years, 18.5% of the respondents are within 11-15 years of farming experience while 17.5% of the respondents are within 1-5 years of farming experience which means that chilli pepper farmers in the study area had vast experience in their production.

The result in cooperative membership shows the numbers of years spent in cooperative association. About 72% of chilli pepper farmers do not participate in any chilli pepper related cooperative association and the reasons for this include: being small scale and unawareness of any association while 28% participated with average of 1.7 years. The effect of this result is that most of the chilli pepper farmers in the study area do not enjoy the assumed benefits accrued to co-operative societies through pooling of resources together for a better expansion, efficiency and effective management of resources and for profit maximization [14] and [15]. Stated that membership of cooperative societies has advantages of accessibility to micro-credit, input subsidy and also as avenue in cross breeding ideas and information.

The result in Table 1 shows that 98.5% of chilli pepper farmers financed their production from personal savings while 1.5% sourced credit, through Bank of agriculture. The low access to credit could be attributed to the fact that government seldom grants financial credit to farmer [14]. Asserts that credit is a very strong factor that is needed to acquire or develop any enterprise; its availability could determine the extent of production capacity. It also agrees with findings of [16] who noted that access to micro-credit could have prospect in improving the productivity of farmers and contributing to uplifting the livelihoods of disadvantaged rural farming communities. The result revealed that 41.5% of chilli pepper farmers in the study area have no extension visit while 58.5% have extension visit with average of 1 visit, this could be attributed to increased of extension agent-farmers' ratio by the KADP in the study area.

3.1 Maximum Likelihood Estimates Results of the Frontier Production Function of Chilli Pepper Production

The variances of the technical efficiency presented in Table 2 indicate that, the sigma-square and the gamma were both positive and

significantly different from zero at 1% and 5% level of probability respectively. This indicates a good fit and the correctness of the specified distribution assumption of the composite error term. Hence the use of the stochastic frontier function estimated by the Maximum Likelihood Estimates procedure is suitable for the data.

However, the estimated coefficients of all the parameters of production function (farm size, seed and fertilizer) were positive and significant at 10%, 1% and 1% level of probability respectively, except labour and agrochemical which were negative and not statistically significant. The average technical efficiency for the farmers is 0.90 implying that, on the average the respondents are able to obtain 90% of potential output from a given mixture of production inputs. Thus, in a short run, there is minimal scope (10%) of increasing the efficiency, by adopting the technology and techniques used by the best chilli pepper farmer. The result shows that the coefficient of farm size (β_1) was positive and significant at 10% level of probability. This implies that an increase in farm size would result to an increase in the quantity of chilli pepper produced in the study area by coefficient of variation (0.213).

The estimated coefficient for seed (β_2) was 0.636 which is positive and statistically significant at 1% level probability. This conforms to the *a priori* expectation that increase in seed would bring about increase in output. The estimated 0.636 elasticity of seed implies that increasing the use of seed by 1% will increase chilli pepper output by less than 1% which means, all things being equal the output is inelastic to changes in the quantity of seed used. The significance of seed quantity is however, due to the fact that seed 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 is in line with the findings of [17] who observed that the estimated coefficient of seed inputs was positive as expected and significant at 1% level implies that the more seed is applied the better the output.

The production elasticity of output with respect to quantity of fertilizer (β_3) was 0.053 which is positive and statistically significant at 1% level. This implies that a 1% increase in fertilizer will increase chilli pepper output by 0.05%. Fertilizer is a major soil augmenting input because it improves the quality of soil by raising yields per hectare. This study is in agreement with the findings of [18,19]. A timely and efficient management and utilization of fertilizer input will improves the quality and quantity of yields per hectare.

The estimated coefficients of Labour (β_4) and agrochemical (β_5) were negatively related with the output and not statistically significant from zero. These implies additional use of labour and agrochemical would reduce the output by the coefficient (-0.085) and (-0.069) respectively. This is against the *a priori* expectation and the negative effect of these inputs (labour and agrochemical) could be attributed to overutilization of the resource in chilli pepper production.

The estimated result of the inefficiency model is contained in Table 2. A negative sign on a parameter means that the variable reduces technical inefficiency, while a positive sign increases technical inefficiency. The results shows that age of the farmers, level of education, farming experience, credit obtained and extension contact have a negative sign, and therefore reduce technical inefficiency (or increase technical efficiency) while household size and cooperative association have positive signs, implying that they increase technical inefficiency (or reducing technical efficiency).

The coefficient of farmer's age was inversely related to technical inefficiency and not statistically significant. This had a positive influence on technical efficiency in chilli pepper farming in the study area. This study is in conformity with the *a priori* expectations that age of the respondent's increases as the technical inefficiency decreases. This finding is in difference with [20] who in their study of small scale farmers in Nigeria found age to be positively related to inefficiency.

The estimated coefficient of education has a negative sign and not statistically significant. This indicates that level of education attained increase technical efficiency. This could probably be explained by the fact farmers probably employ their educational advantages as opportunity to develop their production capability and inferably would be ready to adopt innovations and technologies for improved productivity and is in line with the public assertion that education advancement bring about better technical efficiency in farming as a result of easy understanding of farming technologies and adoption of new innovations.

Table 1. Socio-economic characteristics of chilli pepper farmers

Variable	Frequency (N=200)	Percentage
Age (Years)		
20-29	5	2.5
30-39	75	37.5
40-49	37	18.5
50-59	58	29.0
60 above	25	12.5
Mean	46	
Educational status		
No formal education	94	47.0
1-6	60	30.0
7-12	31	15.5
13 Above	15	7.5
Household size		
1-5	42	21.0
6-10	67	33.5
11-15	50	25.0
16-20	21	10.5
21-25	12	6.0
26-30	4	2.0
>31	4	2.0
Mean	11	
Farming experience		
1-5	34	17.0
6-10	48	24.0
11-15	37	18.5
16-20	19	9.5
21-25	22	11.0
26-30	14	7.0
>31	26	13.0
Mean	17	
Membership of cooperative society		
Non members	144	72.0
1-5	24	12.0
6-10	30	15.0
>11	2	1.0
Mean	1.7	
Source of capital		
Informal	197	98.5
Formal	3	1.5
Mean	1750	
Extension visit		
No visit	83	41.5
1-2	91	45.5
3-4	25	12.5
>5	1	0.5
Mean	1	

N=Number of respondents

The coefficient of household size in the inefficiency model is positive but not significantly different from zero. This may be due to the fact that farmers with large household size has more people to feed with less income left to acquire inputs for production. These findings agree with the findings of [21] there is a positive and significant relationship between household size and farmers' efficiency in production. However, the absolute number of people in a certain family cannot be used to justify the potential for productive farm work. This is because it can be affected by some important factors namely; age, sex and health status. This shows that a reasonable number of the respondents have a large household size. Higher household size provides enough persons for family labour and less money will be needed to pay for hired labour. The coefficient of farming experience in the inefficiency model is negative and significant at 10% level of probability. This implies that farming experience reduces technical inefficiency and contributes positively to technical efficiency in chilli pepper farming in the study area.

The estimated coefficient of cooperative association has a negative sign related to technical inefficiency and significantly different from zero at 5% level of significance. This implies that it reduce technical inefficiency (or increasing technical efficiency), despite the low participation of the farmers in cooperative membership in the study area. Extension contact also has a negative sign related to inefficiency and significantly not different from zero. This implies that it increase technical efficiency (or reducing technical inefficiency). This is in line with several studies that found extension to be positively related with technical efficiency [22].

The estimated coefficient of credit accessibility has negative estimate related to inefficiency and not statistically significant. [14] Asserts that credit is a variable that is needed to acquire or develop any enterprise; its availability could determine the extent of production capacity. It also agrees with findings of [16] who noted that access to micro-credit could have prospect in improving the productivity of farmers and contributing to uplifting the livelihoods of disadvantaged rural farming communities.

3.2 Frequency Distribution of Technical Efficiency Estimates of Chilli Pepper Farmers

The frequency distribution of the technical efficiency estimates for chilli pepper farmers in

Table 2. Result of maximum likelihood estimates frontier technical efficiency of chilli pepper production

Variables	Parameters	Coefficients	Std. error	T-value
Production function				
Constant	β_0	4.24***	0.586	7.24
Farm size	β_1	0.213*	0.120	1.78
Seed	β_2	0.636***	0.106	6.61
Fertilizer	β_3	0.053***	0.0101	5.13
Labour	β_4	-0.085	0.014	-0.61
Agrochemical	β_5	-0.069	0.054	-1.29
Inefficiency model				
Constant	Z_0	0.32	0.46	0.708
Age	Z_1	-0.0007	0.012	-0.060
Education	Z_2	-0.001	0.012	-0.11
Household size	Z_3	0.0022	0.016	0.13
Farming experience	Z_4	-0.020*	0.010	-1.87
Cooperative membership	Z_5	-0.164**	0.074	-2.216
Credit borrowed	Z_6	-0.004	0.0036	-1.41
Extension visit	Z_7	-0.014	0.054	-0.24
Diagnostic statistics				
Sigma-square	(σ^2)	0.2162***	0.0229	9.455
Gamma	(γ)	0.040**	0.018	2.17
Log likelihood function=	*L/f*	-128.037		
LR test of the one-side error	10.086			
Total number of observation	200			
Mean efficiency	0.901			

*Note: *** significant at 1% level of probability, ** significant at 5% level of probability and * significant at 10% level of probability*

the study area as obtained from the stochastic frontier model presented in Table 3. It was observed from the study that 12% of the farmers had technical efficiency (TE) of less than 0.81 level efficiency while 88% of the farmers operate at 0.81 and above level efficiency. The farmer with the best and least practice had a technical efficiency of 0.98 and 0.74 respectively. This implies that on the average, output fall by 2% from the maximum possible level due to inefficiency. Also 90% of the farmers were estimated to have technical efficiency exceeding 0.8, indicating there are some 10% technical inefficient farmers in the study area.

Table 3. Frequency distribution of technical efficiency from the stochastic frontier model

Technical efficiency level	Frequency	Percentage
0.61-0.80	24	12
0.81-1.00	176	88
Total	200	100
Mean	0.90	
Min	0.74	
Max	0.98	

The paper also found that for the average farmer in the study area to achieve technical efficiency of his most efficient counterpart, he could realize about 10.2% (1-0.90/0.98*100) cost savings while on the other hand, the least technically efficient farmers will have about 26.5% (1-0.74/0.98*100) cost savings to become the most efficient farmer.

4. CONCLUSION

The farm specific technical efficiency distribution reveals that none of the farmers achieved the maximum efficiency level. Thus, within the context of efficient agricultural production, output can still be increased by 10% using available inputs and technology.

5. RECOMMENDATIONS

Cooperative association is one of the variables that were significant, it is therefore, recommended that chilli pepper farmers should join cooperative societies to enable them procure fertilizer and other agricultural inputs at subsidized rate.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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