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Full Length Research Article

Technical Efficiency of Small-Scale Production of Date Palm in Jigawa State

*[1]M. U. Muhammad, [1]E.S. Esheya and [2]S. Ibrahim
[1]Department of Agricultural Economics and Extension, National Open University of Nigeria.
[2]School of Preliminary Studies, Sule Lamido University Kafin Hausa
[*Corresponding Author: Email: mmuhammad@noun.edu.ng; ☎: +2348030636332]

ABSTRACT
This study was conducted to analyse the technical efficiency of small-scale date palm farmers in Jigawa state, Nigeria. A sample size of 113 small scale date palm farmers was selected for the study using random sampling technique. The technical efficiency for small- scale date palm production was determined using stochastic frontier production function. While age was identified as the major contributor to the technical inefficiency, the study however revealed the mean technical efficiency is 78% in small scale date palm production which implies a 22% potential for the least technically efficient small-scale date palm farmer to increase date palm production with the current level of resources and technology. It was concluded that small scale date palm production is technically efficient in the study area, although age is the major contributing factor of the technical inefficiency in date palm production.
KEYWORDS: Technical Efficiency, Inefficiency, Small-Scale, Date Palm, Production.

INTRODUCTION

Agricultural sector plays a crucial role in rural economy and livelihood. This is one sector where the poor contributes to the growth directly instead of getting benefit from growth generated elsewhere. In Nigeria, the crop sector forms an important livelihood activity for most of the farmers, supporting agriculture in the form of critical inputs, contributing to the health and nutrition of the household, supplementing incomes, offering employment opportunities, and serving as a store of wealth in times of need. It acts as a supplementary and complementary enterprise.

Date palm is an important crop which can be used for agriculture diversification and income enhancement. The Nigerian date palm has the potential of two production cycles annually with little management. Date palm is believed to have been introduced into Nigeria in the early 17th century which was brought by the Tran-Saharan trade route from North Africa and Muslim pilgrims on pilgrimage to the Holy Cities of Mecca and Medina (Omamor *et al.*, 2000). Since then, Date palm cultivation has remained restricted to compounds, homestead, and orchards in the Northern parts of Nigeria, while in the Southern part of the country it is mainly planted as ornamental for aesthetic purposes (Sanusi *et al.*, 2014).

In 2009, world production of dates was about 7.52 million tons, and the top producing countries were Egypt, Iran, Saudi Arabia, United Arab Emirates, Pakistan, Algeria, Iraq, Sudan and Oman (Heuze *et al.*, 2015) Reports show that Egypt is the highest Date palm producer in Africa, producing about 1,711,200 metric tons (FAO, 2020) while in West African countries Niger was the highest, producing about 22,154 MT, followed by Chad with 20,000MT and Mauritania 18,857MT (FAO, 2013). Nigeria is not listed among dates producers at the international scene which may be attributed to dearth of information on the Nigeria date palm sector. Nigerian annual production of date was over 21,000MT with Kano, Jigawa, Yobe, Borno, Gombe, Bauchi and Adamawa States as the major producers of date palm (Abdulqadir *et al.*, 2011). Jigawa State is famous for date palm farming and its production dates back to over 400 years. Date fruits are commonly consumed in Nigeria, especially in its ecological areas. The national consumption of dates in 2009 was estimated at 89,580 metric tonnes which placed the country among the world top 10 consumers of date palm fruit (Sani *et al.,* 2010).

Frontier production function can be described as "an extension of the familiar regression model based on the microeconomic premise that a production function represents some sort of ideal, the maximum output attainable given a set of inputs" (Greene, 1997). The pioneering work of Koopmans (1951) provided the earliest formal definition of technical efficiency as: "A producer is technically efficient if, and only if, it is impossible to produce more of any output without producing less of some other output or using more of some input." Subsequently, Debreu (1951) and Farrell (1957) developed a slightly different definition of technical efficiency by ruling out the slack units: "one minus the maximum equi-proportionate (radial) reduction in all inputs that is feasible with given technology and output" (Fried *et al:* 2008). In the production function the efficiency prediction is taking a value between zero (0) and one (1).

Despite the mandate vested on Nigerian Institute for Oil Palm Research (NIFOR) to provide new technologies and innovations on how to enhance and improve date palm production and productivity, harvest of the crop in Jigawa small scale plantations is less than the recommended output of 40-60kg date fruit /tree/year. As a result, date palm production in Jigawa state did not improve. number of hectares and total date production in Nigeria was from a single source since 2010. This is where the need for findings on updated production and technical efficiency in date palm farming in Jigawa State has become very imperative. The aim of this study therefore is to determine the technical efficiency and factors contributing to technical inefficiency of small-scale date palm production in Jigawa State, Nigeria.

MATERIALS AND METHODS

Sampling and Data Collection

The study was conducted in Jigawa state made up of 27 local government areas categorised along four Agricultural Development Zones namely: Birnin kudu – Zone I, Gumel – Zone II, Hadejia – zone III and Kazaure – zone IV. Multi-stage sampling technique was used in this study. Stage 1 involves purposive selection of 2 LGAs' in Zone I from which four wards and six villages were selected respectively. This is due to the concentration of date palm production in the selected areas. Simple census was conducted in each village to know the number of date palm producers and the total population summed up to 159 small-scale date palm producers. Using the random selection without replacement method, 70% of the total small-scale date palm farmers' population of each village was randomly picked, yielding a total sample size of 113 small-scale date palm farmers.

Primary data were used as a source of information in this study. The data were collected with the aid of structured questionnaire administered to the date palm producers. The questionnaire was used to collect information on: socio-economic characteristics, inputs used, outputs obtained and constraint and/or challenges in date palm production.

Statistical Analysis

Simple descriptive statistical tools such as mean, standard error, frequency, percentages and the stochastic frontier production function were used to analyse the data collected.

Stochastic Frontier Production Functions (SPFF)

The stochastic frontier production model was used for estimating the technical efficiency of date palm production. The explicit form of the stochastic frontier production model is specified as follows:

$$Yij = \beta 0 + \beta 1 \ln X1i + \beta 2 \ln X2i + \beta 3 \ln X3i + \beta 4 \ln X4i + \beta 5 \ln X5i + Vij - Uij \quad ---- \quad 1$$

Where;

Y_i = Quantity of date palm fruit obtained (kg/tree)

X_1 = Labour (man days)

X_2 = Date palm trees (No.)

.

X_3 = Quantity of Pollen (g)

X_4 = Quantity of organic fertilizer used (kg)

V_i – are assumed to be independent and identically distributed (iid) N (0, σv2) random errors independently distributed of the U_i's which are non-negative random variables associated with technical inefficiency of production.

U_i = are error terms assumed to be independently distributed such that U_i is obtained by
truncations (at zero) of the N (μ, σ2) distribution.

βo = constant term to be estimated

β_1 - β_6 = Vectors of unknown parameters to be estimated

i = 1, 2, 3…, farm

Technical Efficiency (TE)

Technical efficiency (TE) was determined by finding the ratio of the observed output (Yi)
with the frontier output (Yi*) given the available technology, that is:

Yi / Yi*

i. e.

$$TE = \beta 0 + \beta 1 Xi + V - U \beta 0 + \beta 1 Xi + V / \quad --- \quad 2$$

$$TE = exp(-U) = e{-U} \quad ------------------- 3$$

So that; 0 ≤ TE ≤ 1

RESULTS AND DISCUSSIONS

Stochastic Frontier Production Function

The Maximum Likelihood Estimate for the stochastic frontier production function used in explaining the influence of production inputs on the output of date palm, and also in determining the effect of socioeconomic characteristics of farmers on technical inefficiency are presented in Tables 1 and 2.

Sigma-square of 0.168 shows the goodness of fit and correctness of the specified distributional assumption of the included error term, while, the gamma (γ) estimates of 0.758 was significant at 1% This implies that 75.8% of the variations in technical efficiency of date palm production are contributed by the inefficiency variables included in the model (Aigner *et al.* 1976). The generalised likelihood ratio estimated of 21.48 was obtained for small-scale date palm production. This value is less than the critical chi-square value of 22.525 (given by Kodde and Palm 1986) at 1% level of significant. The result also shows that the coefficients for tree stand (0.91) and Quantity of pollen (0.12) were positive and significant at 1% and 5% respectively. This implies that increase in the number of date palm trees and quantity of pollen would bring about increase in date palm output.

Table 1: Estimation of stochastic frontier production function of small-scale date palm production

VARIABLES	COEFFICIENT	STD. ERROR	T-VALUES
Constant	4.03	0.173	23.20***
Labour (man-days)	0.0349	0.0628	0.556
Tree Stand (number)	0.908	0.0592	15.35***
Pollen (bunch)	0.119	0.0510	2.34**
Organic Fertilizer (kg)	-0.027	0.0496	-0.548
Sigma-Square (δ^2)	0.168	0.0688	2.44**
Gamma (γ)	0.758	0.112	6.74***
Log likelihood function	18.8		
LR test	21.5		

Source: Field Survey, 2021; $\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\gamma = \sigma_u^2/\sigma^2$ Significant levels: *** = 1%, ** = 5%

[illegible] = [illegible]. [illegible] + [illegible]. [illegible] + [illegible]. [illegible] + [illegible]. [illegible] − [illegible]. [illegible]

The result revealed that the estimated coefficient of number of date palm trees which was found to be positive, conform to the *a priori* expectation and significant at 1%. The coefficient of number of trees 0.91 indicates that, the output of date palm is inelastic to changes in the number of date palm trees. This also implies that a 1% increase in number of trees cultivated *ceteris paribus*, would lead to an increase in the date palm output by 0.91%. This could be due to the fact that date palm production cannot take place if the date palm trees are not included in the production process. The estimated coefficient for the quantity of pollen is positive and this conform to the *a priori* expectation and significant at 5% level of probability. The magnitude of the coefficient 0.12 indicates that the output of date palm is inelastic to changes in the quantity of pollen used. Hence, a 1% increase in the quantity of pollen used, *ceteris paribus*, would lead to an increase in the date palm output by 0.12%. The estimated coefficient of labour (0.035) is positive and not significant which indicates that labour has a positive relationship with date palm output.

The coefficient of Quantity of fertilizer was negative (-0.027). This means that quantity of organic fertilizer used have negative relationship with the date palm output. It also implies that unit increase in the use of organic fertilizer will reduce production output by 0.027. This does not conform to the a priori expectation. The negative effect of organic fertilizer could be the attribute of over utilization of this resource. This finding contradicts the findings of Mounir and Mohamed, (2006) who reported that organic manure has positive relationship with date palm output but not significant (coefficient 0.004). The estimated elasticity of variables vis; labour man-days, number of date palm trees, and quantity of pollen were all positive and less than 1 (i.e., Ep <1). This indicates that the allocation and use of variables were in stage II of production, meaning that the technical efficiency of variables is declining. The elasticity for quantity of organic fertilizer was negative (i.e., Ep <0), this indicates that the allocation and use of this variables was in stage III of production. It implies that there is excess use of organic fertilizer and the addition of quantity of organic fertilizer will reduce the total output of date palm among small scale farmers (i.e., over utilization of organic fertilizer). Obviously, this could be due to the fact that the farmers use no specific recommendation for the application of organic fertilizer (Esheya, 2022).

The return to scale of 1.03 indicates that the RTS is greater than 1, and this implies the date palm production in the study area was at increasing return to scale. This shows that the farmers are in stage I of production and very close to stage II. Therefore, the farmers should increase the number of trees and pollen and also adopt new technologies as well as reduce the use of organic fertilizer so as to attain the maximum technical efficiency. The result from Table 2 shows that 51% of the respondents were operating very close to the efficiency frontier, followed by those between 0.61 – 0.80 efficiency level. The farmers with the best and least practice have a technical efficiency of 0.97 and 0.31 respectively. The mean technical efficiency of 0.78 implies that, on the average, the farmers were 78 percent technically efficient. However, the observed output is 22% less than the maximum frontier output.

The respondents will be able to obtain 78% of potential output from the combination of the given inputs. In the short run, there is scope of 22% of increasing the efficiency in the date palm production, by adopting the new technologies and techniques used in the modern date palm farming.The result revealed that for the average small scale date palm farmers in the study area to achieve the technical efficiency level of its most efficient counterparts, they only need about (1 – (0.78/0.97) 19.59% increase in production. The least technically efficient small-scale date palm farmer needs to increase production with about (1 – (0.31/0.97) 68.04% to achieve required technical efficiency. The result depicts that the respondents were technically efficient in driving maximum output from input, given the available resources. The Technical Efficiency of small-scale date palm production is shown in Table 2.

Table 2: Frequency distribution of farm specifics TE levels

EFFICIENCY LEVEL	FREQUENCY	PERCENTAGE
0.01 - 0.20	0	0
0.21 - 0.40	1	0.88
0.41 - 0.60	8	7.08
0.61 - 0.80	46	40.71
0.81 - 1.00	58	51.33
Total	113	100
Minimum	0.31	
Maximum	0.97	
Mean	0.78	

Technical Inefficiency Estimates for Small-Scale Date Palm Production

The result in Table 3 depicts that household size, level of education, farmer's years of experience and access to land have negative values and therefore contribute positively to the technical efficiency and reduces inefficiency, this conforms with the *a priori* expectation. The coefficient estimates show the farmers' age and farmers' group membership were positive, indicating that these variables increase the level of technical inefficiency in date palm production among small scale producers in Jigawa state. The negative value observed for coefficient of years of experience (-0.02) shows that years of experience has the advantage of reducing technical inefficiency.

Table 3: Estimation of Technical inefficiency in date palm production

VARIABLES	COEFFICIENT	STD. ERROR	T-VALUES
Constant	-5.52	6.37	-0.866
Farmers' Age (years)	0.0282	0.0158	1.78*
Household Size (No.)	-0.0249	0.0149	-1.67
Educational Status	-0.0272	0.105	-0.260
Experience (years)	-0.0193	0.0113	-1.70*
Group Membership	2.56	2.87	0.893
Mode of access to land	-0.0280	0.0677	-0.413

*Significant levels: * = 10%*

The coefficient of household size was (-1.67), it implies that farmers with relatively large household size could have advantage of reducing hired labour and decreases the technical inefficiency by -0.02. The coefficients of years of education, farmers' years of experience and access to land were both negative and non-significant. This indicates that they have positive influence on technical efficiency of date palm production in the study area, this finding conforms to that of Mounir and Mohamed (2006) and Girei *et al.* (2013). The estimated coefficients of age, farmer group membership have positive signs, meaning that they contributed more to the technical inefficiency (Adamu *et al.*, 2021).

The coefficient of age (0.03) was positive and significant at 10%, this shows that the respondents age contributes more to the inefficiencies of the farm specific and it depicts that farmers who are older are relatively inefficient this conforms with the findings of and that of (Mounir and Mohamed, 2006). The coefficients of group membership were positive and non-significant. The expectation is that technical efficiency would increase with increase in level of formal education, farmers group membership, years of experience and access to land as these could help the farmers in sourcing information on new technologies and adoption of such technologies (Iwala *et al.,* 2006).

CONCLUSION

Based on this study it can be concluded that about 90% of the small-scale date palm farmers are operating close to the frontier level of technical efficiency meaning more than half of the small-scale date palm farmers in the study area are technically efficient. Thus, within the context of agricultural production, output can still be increased using available inputs and technologies. Hence, it is recommended that the youth be encouraged to engage in date palm farming and forming date palm farmer's groups as this will help in acquiring and sharing extension and market information and easy access to funding.

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