

Analysis Of Technical Efficiency And Determinants Of Acha (*Digitaria Exilis*) Production In Kaduna State, Nigeria.

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ABSTRACT

The study aimed at analyzing the technical efficiency of acha production using structured questionnaire administered to 200 randomly selected acha farmers in Kaduna State. The data were subject to analysis using the stochastic frontier production function and the gross margin analysis in order to achieve the set objectives. The scale coefficient (1.16) indicates that the farmers are operating at increasing returns to scale, that is, stage one of the production phase. The technical efficiency score of each respondent revealed that the most efficient farmer operated at 96% efficiency, the least efficient farmer was found to operate at 53% efficiency level, while the most frequently occurring efficiency score was 81%, indicating that farmers still have room to increase the efficiency in their farming activities as about 19% efficiency gap from the optimum (100%) is yet to be attained by all farmers. The technical inefficiency model revealed that the farmers' selected socio economic characteristics (production experience, contact with extension agent, household size, level of education and off farm income) and transaction cost variables (harvesting cost, storage cost, transportation cost, farm distance) contributed immensely to the technical efficiency of acha farmers, as the variable were significant ($P=0.01$). Acha production is profitable in the study area. Important constraints encountered by acha farmers include high cost of labour, inadequate capital and high cost of inputs. The study suggests increase in the use of inputs by farmers as well as investing in research and extension activities by the government so that farmers can make better decisions regarding input and cost allocation in farming.

Keywords: Technical efficiency, acha production, socio-economics, transaction cost.

1. INTRODUCTION

Acha (*Digitaria exilis*), is also known with other names as fonio, iburu, findi, fundi, pom and kabug in different West African countries. It is the oldest West African cereal, since its cultivation is thought to date back to 7000 years ago [1]. The Europeans coined the English name "Hungry rice". Among the West African countries, the leading producing countries of acha are Nigeria, Guinea, Burkina Faso and Mali. Annual production in West Africa is estimated at about 250,000 tonnes. The global land area being put to its production is estimated to be 380,000 ha with an annual production of 250,000 tonnes.

The average yield per hectare has remained low ranging from 600-700kg/ha [1; 2]. In Nigeria, annual yields of 3,098 tonnes, 112,000 tonnes and 126,000 tonnes of acha have been reported [3] over a land area of about 150,000 hectares. Acha can be utilized in ways similar to rice. [4] described how food products from acha are preferred to those from other cereals. Cookies and crackers made in an almost endless array of forms are examples. Acha starch has been compared with maize starch as a binder at various concentrations and was found to be as good as maize starch in the formulation of

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paracetamol tablets [5 and 6). The breakthrough in acha processing which has been a bottle neck may enhance acha production to meet local demands in Africa and even for export. This might be responsible for the increased interest in acha production in Africa in recent years.

Like in most developing countries, Nigeria is characterized by low crop productivity per hectare, small land holdings: thus, small scale farming and rudimentary farming systems [7] which is attributed to poor and inefficient use of resources. Certainly, by raising agricultural productivity, food availability could be increased. The food produced must be distributed efficiently at minimum costs in order to guarantee continuous availability of the food; which is a subject of food marketing, as described by [4], who observed that food insecurity could be caused by supply- side factors and demand- side factors. One of the supply- side causes of food insecurity identified by him is food marketing problem, which he argued that the dwindling agricultural production in Nigeria is a confirmation of the unattractiveness of agriculture as a result of low returns and compensation being paid to farmers which tend to discourage increased production. The choice of acha as a crop for this study is derived from the fact that acha consumption/demand is on the increase due to the increasing awareness of its nutritional value.

Recent studies by [8 and 9] on acha production have shown an increasing importance of the crop amidst growing utilization as food; hence there is the need to increase the supply level of the grain by conducting more research. This knowledge will enable researchers and analysts to meaningfully derive a workable framework for the adjustment of production and employment of resources to economic growth or trends. The objectives of the study are: to examine the relationship between inputs and output in acha production in the study area; determine the resource use efficiency of acha farmers in the study area; and determine the influence of socio economic and transaction cost variables on the technical efficiency of acha farmers in the study area.

2. MATERIAL AND METHODS

2.1 Study area

The study was conducted in Kaduna State, Nigeria (latitude 090 02' and 110 32' North of the equator and 060 15' and 800 50' East of prime meridian. It had a population of 6,066,562 people in 2006 [10] with a current projected population of the State at 3.2 percent national population growth rate as 7,037,153 people. The vegetation is divided into Northern Guinea Savanna in the North and Southern Guinea Savanna in the South. The soils are a mixture of fine sand and clay which have been described as sandy loam in nature. The wet season usually last for about six months (May-October) with great variation as one move northwards. The rainfall is very much heavier in the Southern part of the State which has an average of 1,524mm than in the extreme Northern part which has an average of 1,016mm.

2.2 Sampling procedure

Multi-stage sampling technique was employed in selecting 80 the farmers for this study. First, out of the 23 Local Government Areas in Kaduna State, Jaba, Kachia and Kagarko were purposively selected for this study on the basis of being the prominent producing Local Government Areas in the State. Secondly, eleven villages were purposively selected from these Local Government Areas on the basis of the farmers' intensity of production and accessibility. Thirdly, simple random sampling was employed in selecting farmers from each of the villages for enumeration so as to avoid being biased. Twenty percent of the sample frame from each of the villages was used as the sample size. A total of 200 acha farmers were randomly sampled from a population of 1,086.

2.3 Data collection

Primary data was collected based on 2011 cropping season using structured questionnaire. Variables on which the data was collected include information as: Socio-economic variables such as age, educational level, household size, farming experience, farm size, main occupation, access to and amount of credit, contacts with extension workers;. Production variables which include inputs and output Costs of transaction variables (such as harvesting, transportation, storage, threshing costs and farm distance) which are assumed to influence production of acha.

2.4 Analytical tools: Stochastic frontier production function model and the gross margin analysis were used.

2.4.1 Stochastic frontier production function (SFPF)

The stochastic frontier production function as used by [11, 12, 13, 14, 15] among others, derived from the error model of [16] was employed to achieve the objectives of the study. The stochastic production function with a multiplicative disturbance term is of the form:

$$Y = f(X\beta)e^u \quad (1)$$

Where Y is the farm output in kg, X is a vector of input quantities, β is a vector of parameters and e is a stochastic disturbance term consisting of two independent elements U and V, given by:

$$e = v - u \quad (2)$$

The empirical model stochastic frontier production function used in this study is specified in a double log form of Cobb-Douglas production function as follows:

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

Where,

$\ln$ = natural logarithm to base e,

Y_i = output of acha (kilogrammes)

X_1 = farm size (hectares)

X_2 = labour used in crop production (man hours)

X_3 = quantity of seeds used (kilogrammes)

X_4 = quantity of chemicals used (litres)

X_5 = quantity of fertilizer used (kilogrammes)

V_i = assumed independently distributed random error or random stocks which are outside the farmer's control

U_i = technical inefficiency effects which captures deviation from the frontier.

2.4.2 Technical inefficiency model

The average level of technical efficiency measured by mode of truncated normal distribution has been assumed [17,18] to be a function of socio-economic factors. Some authors included some management practices variable as were assumed to have influence on efficiency. This study has departed from these by including some transaction cost variables which are assumed to also have influence on efficiency [19]. External transaction costs result in allocative inefficiency and their expression is in the variation of prices. Thus, analysing the variation of prices among farms provides information about market access and the significance of market transaction costs. Internal transaction costs determine the degree to which producers are able to exploit production possibilities. Thus, technical inefficiency can be regarded as a function of socio economic characteristics and internal transaction costs. It is assumed that these inefficiency effects are independently distributed and U_{ij} arises by truncation (at zero) of the normal distribution with mean U_{ij} and variance δu , where U_{ij} is the technical inefficiency and its determinants in crop production specified as;

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + W \quad (4)$$

Where:

U_i = technical inefficiency of the i th farmer

Z_1 = Household size of farmer (number of people)

Z_2 = Years of formal education of the farmer Amount of credit obtained by the i th farmer in naira (₦)

Z_3 = Years of farming experience of the farmer in crop production

Z_4 = Contacts with extension agents during the cropping season (number of times)

Z_5 = Annual non farm income of the farmer in naira (₦)

Z_6 = Processing cost in naira (₦)

Z_7 = Harvesting cost in naira (₦)

Z_8 = Storage cost in naira (₦)

Z_9 = Transportation cost in naira (₦)

Z_{10} = Farm distance (km)

W = the random variable which is defined by the truncation of the normal distribution with zero mean and variance, such that the point of truncation is $-z_{it}\delta$, that is, $W \geq z_{it}\delta$.

The parameters of the model were obtained using the computer programme, frontier version 4.1 [20]. The *a priori* expectation is that the estimated coefficients of the inefficiency function provide some explanation for the relative efficiency levels among individual farms. Since the dependent variable of the efficiency function represents the mode of

the inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on inefficiency and a negative sign indicates the reverse.

2.4.3 The gross margin (GM) analysis

This was used to determine the cost and return structure of acha farmers and is given by:

GM = \sum Q_y P_y - \sum X_i P_{xi} (5)

Where,
GM = gross margin in naira (N)
Qy = Quantity of output in kilogramme
Py = Price per unit of output in naira (N)
QyPy = GI = gross income or revenue in naira (N)
Xi = Quantity of inputs used in producing acha
Pxi = Price of inputs in naira (N)
ΣXiPxi = TVC = total variable cost of producing acha in naira (N)
Prices of inputs and output used were based on market prices of 2011.

3. RESULTS AND DISCUSSION

3.1 Relationship between inputs and output

The maximum likelihood error estimates of the stochastic frontier production function model are presented in Table 1. The estimates of the stochastic frontier production function revealed a positive relationship between output and farm size which was found to be significant at 1% level, which could mean that it is possible to expand acha farming activity in the study area. The magnitude of the coefficient of farm size shows that output is inelastic (0.6365) to land or farm size, meaning that there is still some scope for increasing output per plot by expanding farmland. The coefficient of labor was significant and had a positive sign (0.2294), implying the importance of labour in urban farming in the study area. In the study area, farming is still at the subsistence level generally. This involves the use of traditional farming implements such as hoe, machete and manual. The production elasticity of output with respect to quantity of fertilizer is 0.0456, which is highly statistically significant at 1% level. The coefficient of planting materials was positive (0.2255) and significantly different from zero. This implies that planting materials are important in crop production in urban farms in the study area. This study conforms to those obtained by [12, 13, 14]. The result further revealed the variance parameters; the sigma squared (δ²) which indicates the goodness of fit and correctness of the distributional form assumed for the composite error term and the gamma (γ) which indicates the systematic influences that are un-explained by the production function and the dominant sources of random errors.

Table 1: Stochastic frontier production function estimates of acha farmers.

Variables	Parameters	Coefficient (β)	Standard error
Constant	β ₀	4.3804***	0.2339
Land size	β ₁	0.6365***	0.0516
Labour	β ₂	0.2294***	0.0347
Seeds	β ₃	0.2255***	0.0605
Fertilizer	β ₄	0.0456***	0.0127
Herbicides	β ₅	0.0284	0.0726
Inefficiency effects			
Constant	δ ₀	0.8271*	0.2666
Household size	δ ₁	-0.1245**	0.0521
Level of formal education	δ ₂	-0.0326**	0.0151
Farming experience	δ ₃	-0.0009	0.0068
Extension contacts	δ ₄	-0.0989**	0.0418
Off- farm income	δ ₅	0.74E-06**	0.46E-06
Processing cost	δ ₆	-0.50E-04**	0.31E-04
Harvesting cost	δ ₇	0.14E-04	0.28E-04
Storage cost	δ ₈	-0.70E-04	0.0002
Transportation cost	δ ₉	0.0001**	0.58E-04
Farm distance	δ ₁₀	0.4679**	0.1843

Variance Parameters

Sigma Squared	δ^2	0.1022**	0.0354
Gamma	Γ	0.4898**	0.2160
Mu	μ	0.7883	
Log Likelihood Function		-17.1947	
Likelihood Ratio test		37.1928	

*** $P=0.01$, ** $P=0.05$, * $P=0.10$

3.2 Return to scale of acha farmers

The elasticity values (coefficients) shown in table 2 indicate the relative importance of every factor used in acha production. The scale coefficient (1.16) which is greater than one indicates that the farmers are operating at increasing returns to scale, that is, stage one of the production phase. The implication of such a result is that a proportional increase of all the factors of production leads to a more than proportional increase in production.

Table 2: Partial elasticities and returns to scale of acha production inputs

Variables	Coefficients
Land size	0.6365
Labour	0.2294
Seeds	0.2255
Fertilizer	0.0456
Herbicides	0.0284
Return to scale	1.1634

Within the limits of statistical reliability, the signs and values of the coefficients provide a measure of the efficiency of resource-use of the production inputs in acha production in Kaduna State. The result means that the resources (land, labour, seeds, fertilizer and herbicide) were under utilised, hence, there is need to increase the use of the inputs until the rational stage is reached.

3.3 Inefficiency effects

The contribution of farmers' socio economic characteristics (household size, level of formal education, farming experience, extension contacts and off farm income) and transaction cost variables (harvesting cost, storage cost, processing cost, transportation cost and farm distance) to farm inefficiency is also presented in table 1. The result revealed an insignificant value of γ to be 0.49 which means that 49 percent of the total variation in farm output is due to the selected technical inefficiency variables captured in the model. Some of the included variables have significant effect on the technical efficiency of the farmers while others have no significant effects. Also, the signs of some coefficients agree with the a priori expectations (negativity of coefficients). Thus, 51 percent of the technical inefficiency of the farmers might have been accounted for by other natural and environmental factors that are not captured in the model. These factors include land quality, weather, labour quality, disease and pest infestations, and so on. Of the selected and included variables contact with extension agent, household size, level of education, off farm income, processing cost, transportation cost and farm distance had significant influence on farm inefficiency. This conforms to other studies by [19, 20, 21, 25].

3.4 Individual farm technical efficiency scores

The technical efficiency score of each respondent is presented in Table 3. The respondents were found to be more than 70% technically efficient. About 5% of the respondents were found to be less than 50% efficient. The most efficient farmer operated at 96% efficiency while the least efficient farmer was found to operate at 53% efficiency level, while the most frequently occurring efficiency score was 86%. From the results obtained, although farmers were generally relatively efficient, they still have room to increase the efficiency in their farming activities as about 14% efficiency gap from the optimum (100%) is yet to be attained by all farmers. The implication of the result is such that the average crop farmers require 11% (that is $(1-0.81/0.96)*100$) cost saving to attain the status of the most efficient crop farmer while least performing farmers would need 31% (that is $(1-0.53/0.96)*100$) cost saving to become the most efficient farmer.

Table 3: Farm-specific technical efficiency indices among Farms

Class interval of efficiency indices	Frequency	Percentage
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<0.50	0	0
0.51-0.60	3	1.55
0.61-0.70	5	2.58
0.71-0.80	10	5.16
0.81-0.90	64	32.67
0.91-1.00	112	57.73
Total	194	100.00

Mean efficiency = 0.81; Minimum efficiency = 0.53; Maximum efficiency = 0.96

3.5 Profitability analysis

Table 4 shows the average costs and returns of acha farmers per hectare. Acha farming may not be for the purpose of only satisfying the household food need or subsistence. The farmers may be interested in selling their outputs to raise income. Thus, the farmers like any other entrepreneur would be interested in the profitability of the farm enterprise. For this reason, efforts were made to determine the costs associated with acha farming and also revenue that accrues to the farmers' efforts. Only the variable costs of production were considered while the profitability was measured as the gross margin. Of all variable items, labour-related activities put together take the largest share (52.73%) of the short-run cost of production.

Table 4: Costs and returns structure of acha farmers

Item	Unit Price (N)	Average cost/ha (N)	Percentage
A. Returns			
Total output	130.00/kg	60,005.59	100.00
B. Variable Cost			
Seeds	125.00/kg	8,075.14	24.41
Labour	500.00/man-day	18,492.24	55.89
Fertilizer	100.00/kg	6,168.79	18.65
Herbicides	950.00/litre	348.36	01.05
C. Total variable cost		33,085.00	100.00
D. Gross margin = (A-C)		27,920.59	
E. PM = (D/A*100)			47.00
F. ROI = (D-C/C*100)			84.00

PM = Profit margin, GR = Gross ratio, ROI = Return on investment

On the average, it costs N35, 270.50 to cultivate one hectare of acha farmland in the study area. An average of N60, 005.59 accrues to a farmer as revenue and N24, 735.00 is left as the gross margin. Other profitability ratios used were the profit margin and rate of return on investment. The return on investment showed that for every one naira invested by acha farmer, a profit of 84 kobo is made. This ratio reflects the return available to investments. It shows the returns to the capital investment over the life of the investment and reflects the true value of profit or gain that can be realized for every 1N investment made to the enterprise. These ratios not only indicate substantial return to the enterprise, but also a high level efficiency in the use of capital.

3.6 Constraints to acha production

Among the constraints encountered by acha farmers in the study area, high cost of labour, inadequate capital and high cost of inputs were identified as the major problems encountered by the farmers. This reveals why labour accounts for about 53% of the variable cost of production. This agrees with findings by [21, 22, 23, 24]. High cost of labour could extend production period, thereby, reducing the yield which in turn affects revenue.

4. CONCLUSION

Within the limit of productivity analysis, the farm size, seed rate, labour and fertilizer in acha production seem to be the important factors of acha production for farmers in the study area. This means that there are substantial opportunities to increase productivity and income through more efficient utilization of these productive resources. Having higher technical efficiency means that there is little gap left to reach the optimum. The evidence that farmers also respond by intensive application of other inputs supports the argument in literature that farmers respond to increasing prices to some degree by

intensive application of other inputs besides extending the quantity supplied. Own price therefore plays a less important role in supply decision and non price factors have larger role to play.

Based on the findings, the following recommendations are made:

Timely and adequate supply of fertilizer at subsidized rate will enhance the output of crops on farms. Increase in seed rate and in more labour intensification in the farming activities will be appropriate for the improvement of productivity in acha. The government should continue to increase its support for public investment in research and extension services so as to help farmers make better decision in terms of resource utilisation. Improved agricultural technology, access to markets, irrigation facilities and expansion of basic physical capital appear crucial for market expansion.

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