

Research paper

**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 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. Acha production is profitable and 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.

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

31 INTRODUCTION

32 *Acha (Digitaria exilis)*, is also known with other names as fonio, iburu, findi, fundi, pom and
 33 kabug in different West African countries. It is the oldest West African cereal, since its cultivation is
 34 thought to date back to 7000 years ago (Cruz, 2004). The Europeans coined the English name
 35 “Hungry rice”. Among the West African countries, the most leading producing countries of acha are
 36 Nigeria, Guinea, Burkina Faso and Mali. Annual production in West Africa is estimated at about
 37 250,000tonnes. The global land area being put to its production is estimated to be 380,000 ha with an
 38 annual production of 250,000 tonnes. The average production of acha per hectare has remained low
 39 ranging from 600-700kg/ha (Cruz, 2004; CIRAD, 2011). In Nigeria, annual yields of 3,098 tonnes,
 40 112,000 tonnes and 126,000 tonnes of acha have been reported (Abdullahi and Luka, 2003) over a
 41 land area of about 150,000 hectares. Acha can be utilized in ways similar to rice. Mc Watters (2000)
 42 described how food products from acha are preferred to those from other cereals. Cookies and
 43 crackers made in an almost endless array of forms are examples. Acha starch has been compared
 44 with maize starch as a binder at various concentrations and was found to be as good as maize starch
 45 in the formulation of paracetamol tablets (Musa *et al.*, 2008 and Iwuagwu *et al.*, 2001). The
 46 breakthrough in acha processing which has been a bottle neck may enhance acha production to meet
 47 local demands in Africa and even for export (Aslafy, 2003). This might be responsible for the
 48 increased interest in acha production in Africa in recent years.

49 Like in most developing countries, Nigeria is characterized by low crop productivity per
 50 hectare, small land holdings: thus, small scale farming and rudimentary farming systems (Fasasi,
 51 2006) which is attributed to poor and inefficient use of resources. Certainly, by raising agricultural
 52 productivity, food availability could be increased. The food produced must be distributed efficiently
 53 at minimum costs in order to guarantee continuous availability of the food; which is a subject of food
 54 marketing, as described by Idachaba (2004), who observed that food insecurity could be caused by
 55 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 (Jideani, 2012; Jideani and Jideani, 2011) on acha production have shown an increasing importance of the crop amidst growing utilization as food; hence 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.

METHODOLOGY

Study Area: The study was conducted in Kaduna State, Nigeria (latitude $09^{\circ} 02'$ and $11^{\circ} 32'$ North of the equator and $06^{\circ} 15'$ and $80^{\circ} 50'$ East of prime meridian. It had a population of 6,066,562 people in 2006 (NPC, 2006) 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.

Sampling Procedure: Multi-stage sampling technique was employed in selecting 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 size of 1,086.

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 distance from house to markets) which are assumed to influence production and market price of acha.

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

Stochastic Frontier Production Function (SFPF): The stochastic frontier production function as used by Thomas (2007), Rahman and Umar (2009), Oluwatayo *et al.* (2008), Onu *et al.* (2000), and Parikh and Shah (1995) among others, derived from the error model of Aigner, Lovell and Schmidt (1977) was employed to achieve objectives 1, 2 and 3 of the study. 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:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + v_i - u_i \dots\dots\dots(2)$$

105 Where,
 106 $\ln$ = natural logarithm to base e,
 107 Y_i = output of acha (kilogrammes)
 108 X_1 = farm size (hectares)
 109 X_2 = labour used in crop production (man hours)
 110 X_3 = quantity of seeds used (kilogrammes)
 111 X_4 = quantity of chemicals used (litres)
 112 X_5 = quantity of fertilizer used (kilogrammes)
 113 V_i = assumed independently distributed random error or random stocks which are outside
 114 the farmer's control
 115 U_i = technical inefficiency effects which captures deviation from the frontier.

117 **Technical Inefficiency Model**

118 The average level of technical efficiency measured by mode of truncated normal distribution has
 119 been assumed (Kumbhakar and Heshmati, 1995; Yao and Liu, 1998) to be a function of socio
 120 economic factors. Some authors included some management practices variable as were assumed to
 121 have influence on efficiency. This study has departed from these by including some transaction cost
 122 variables which are assumed to also have influence on efficiency (Heinrich *et al.*, 2011). External
 123 transaction costs result in allocative inefficiency and their expression is in the variation of prices.
 124 Thus, analysing the variation of prices among farms provides information about market access and
 125 the significance of market transaction costs. Internal transaction costs determine the degree to which
 126 producers are able to exploit production possibilities. Thus, technical inefficiency can be regarded as
 127 a function of socio economic characteristics and internal transaction costs. It is assumed that these
 128 inefficiency effects are independently distributed and U_{ij} arises by truncation (at zero) of the normal
 129 distribution with mean U_{ij} and variance δ_u^2 , where U_{ij} is the technical inefficiency and its
 130 determinants in crop production specified as;

$$131 \quad u_i = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \beta_8 Z_8 + \beta_9 Z_9 + \beta_{10} Z_{10} \text{ ----- (3)}$$

132 Where:

133 U_i = technical inefficiency of the i th farmer

134 Z_1 = Household size of farmer (number of people)

135 Z_2 = Years of formal education of the farmer Amount of credit obtained by the i th
136 farmer (Naira)

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

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

139 Z_5 = Annual non farm income of the farmer in naira

140 Z_6 = Processing cost in naira

141 Z_7 = Harvesting cost in naira

142 Z_8 = Storage cost in naira

143 Z_9 = Transportation cost in naira

144 Z_{10} = Farm distance (km)

145 The parameters of the model were obtained using the computer programme, frontier version 4.1
146 (Coelli, 1994). The *a priori* expectation is that the estimated coefficients of the inefficiency function
147 provide some explanation for the relative efficiency levels among individual farms. Since the
148 dependent variable of the efficiency function represents the mode of the inefficiency, a positive sign
149 of an estimated parameter implies that the associated variable has a negative effect on inefficiency
150 and a negative sign indicates the reverse.

151 **The gross margin (GM) analysis:** This was used to determine the cost and return structure of
152 acha farmers and is given by:

$$153 \quad GM = \sum Q_y P_y - \sum X_i P_{xi} \dots\dots\dots(6)$$

154 Where,

155 GM = gross margin in naira/hectare

156 Q_y = Quantity of output in kilogramme

157 P_y = Price per unit of output in naira

158 $Q_y P_y$ = GI = gross income or revenue in naira/hectare

159 X_i = Quantity of inputs used in producing acha

160 P_{xi} = Price of inputs in naira
 161 $\sum X_i P_{xi}$ = TVC = total variable cost of producing acha in naira
 162 Prices of inputs and output used were based on market prices of 2011.

163 RESULTS AND DISCUSSION

164 Relationship between inputs and output

165 The maximum likelihood error estimates of the stochastic frontier production function model
 166 are presented in Table 1. The estimates of the stochastic frontier production function revealed a
 167 positive relationship between output and farm size which was found to be significant at 1% level,
 168 which could mean that it is possible to expand acha farming activity in the study area. The magnitude
 169 of the coefficient of farm size shows that output is inelastic to land or farm size, meaning that there is
 170 still some scope for increasing output per plot by expanding farmland. The coefficient of labor was
 171 significant and had a positive sign, implying the importance of labour in urban farming in the study
 172 area. In the study area, farming is still at the subsistence level generally. This involves the use of
 173 traditional farming implements such as hoe, machete and manual. The production elasticity of output
 174 with respect to quantity of fertilizer is 0.4183, which is highly statistically significant at 1% level.
 175 The coefficient of planting materials was positive and significantly different from zero. This implies
 176 that planting materials are important in crop production in urban farms in the study area. The result
 177 further revealed the variance parameters; the sigma squared (δ^2) which indicates the goodness of fit
 178 and correctness of the distributional form assumed for the composite error term and the gamma (γ)
 179 which indicates the systematic influences that are un-explained by the production function and the
 180 dominant sources of random errors.

181

182 **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	G	0.4898**	0.2160
Mu	M	0.7883	
Log Likelihood Function		-17.1947	
Likelihood Ratio test		37.1928	

*** $P < 0.01$, ** $P < 0.05$

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	0.0418
Herbicides	0.0284
Return to scale	1.1616

192

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

197 **Inefficiency effects**

198 The contribution of farmers' socio economic characteristics (household size, level of formal
 199 education, farming experience, extension contacts and off farm income) and transaction cost
 200 variables (harvesting cost, storage cost, processing cost, transportation cost and farm distance) to
 201 farm inefficiency is also presented in table 1. The result revealed an insignificant value of γ to be
 202 0.49 which means that 49 percent of the total variation in farm output is due to the selected technical
 203 inefficiency variables captured in the model. Some of the included variables have significant effects
 204 on the technical efficiency of the farmers while others have no significant effects. Also, the signs of
 205 some coefficients agree with the a priori expectations (negativity of coefficients). Thus, 51 percent of
 206 the technical inefficiency of the farmers might have been accounted for by other natural and
 207 environmental factors that are not captured in the model. These factors include land quality, weather,
 208 labour quality, disease and pest infestations, and so on. Of the selected and included variables

209 **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
<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

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	Average Quantity/ ha	Unit (Naira)	Price	Average cost/ha (Naira)	Percentage
A. Returns					
Total output	494.10kg	130.00		60,005.59	100.00
B. Variable Cost					
Seeds	39.20kg	125.00		8,075.14	23.03
Labour	61.64man-days	500.00		18,492.24	52.73
Fertilizer	60.70kg	100.00		6,168.79	17.59
Herbicides	0.42litres	950.00		348.36	00.99
Land	0.95hectares	2,185.80		2,185.50	6.20
Total variable cost				35,270.50	100.00
Gross Margin(A-B)				24,735.09	

Rate of return on investment= 1.45

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.

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. High cost of labour could extend production period, thereby, reducing the yield which in turn affects revenue.

CONCLUSION AND RECOMMENDATIONS

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 the technological change would be the source of acha productivity growth in the future. 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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