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COST AND RETURN STRUCTURE OF *ACHA* (*Digitaria specie*) PRODUCTION IN SOUTHERN BAUCHI, BAUCHI STATE NIGERIA

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Abstract: The study examined the costs and return of *acha* production in selected local government areas of Bauchi State, Nigeria. A total of 384 *acha* farmers were randomly selected for the study. Data were collected through the use of questionnaire over the period 2022 cropping season. Data were analyzed using descriptive statistics, gross margin analysis and Z-test. Three factors were significant in determining acha production. While land rent and labour were significant at (P < 0.01), seed and herbicide were significant (P < 0.1). Labour accounted for 55.6% of the total costs of production. Of the total labour cost harvesting, tilling and weeding accounted for 15.9%, 14.5% and 12.5%, respectively. The result showed a mean farm size of 0.6 hectare with a mean output of 240kg. Costs and return structure show cost of production ₦29, 627.00, revenue of ₦45, 600.00 and a gross margin of ₦15, 937.00. Operating ratio and gross ratio were 0.6 and 1.6, respectively; while, return per Naira invested was 54k. It was concluded that acha production was a profitable enterprise in the study area with labour being a critical factor in its production. It is recommended, among others, that *Acha* farmers be encouraged to increase the size of their holdings from the existing 0.6ha, improved *acha* varieties should be developed to improve yield and that operations should be mechanized to reduce cost of labour.

Keywords: *Acha*, Costs, Production, Return, Southern Bauchi, Structure

Introduction

Acha (*Digitaria exilis*), also known with other names as fonio, iburu, findi, fundi, pom, and kabug in different West African countries, is the oldest cereal, since its cultivation is thought to date back to 7000 years ago (Cruz, 2004). There are two main varieties: *Digitaria exilis* (white *acha*) and *Digitaria iburua* (black *acha*). Recent studies (Jideani, 2012; Jideani and Jideani, 2011) on *acha* production have shown an increasing consumption of *acha* amidst growing utilizations as food, special diet for the medically challenged individuals.

Although *acha* demand and consumption is on the increase due to increasing awareness of its nutritional value, its production is low compared to other cereals. This may not be unconnected to the challenges of low yield per land area compared with other cereals grown in the study area, 200-700kg/ha, with an average yield of about 0.7t/ha and it ranged from 0.4t/ha in Nigeria to 1.0t/ha in Ivory Coast (FAO, 2019).; difficulty being experienced in obtaining labour for harvest at the time of maturity of the crop; most especially when the time of maturity coincides with that of rice; absence of improved technology for increased productivity.

Acha, also known as fonio, is a nutritious and resilient cereal crop, the value of the nutritional content (amino acids, protein, starch, crude fibre and ash) present in *acha* grain is higher than that reported for other cereals such as rice, maize and sorghum (Adegbola *et al., 2023),* that holds significant potential for enhancing food security and economic prosperity in Nigeria. Bauchi State, located in the northeastern region of the country, is one of the key areas where *acha* production plays a vital role in the livelihoods of many smallholder farmers. Understanding the costs and returns associated with *acha* production in Bauchi State is essential for informed policy decisions, optimizing agricultural practices, and improving the overall profitability of *acha* farming enterprises.

This research presents a comprehensive analysis of the costs and returns of *acha* production in Bauchi State, Nigeria. The research had the objectives of determining the factors that influence allcocation of resources, gross margin of acha production and the profitability of the enterprise. By examining the various inputs, expenses, and revenues involved in *acha* cultivation, as well as determining the factors that influence allocative efficiency, it is aimed at shedding light on the economic viability of *acha* farming operations in the region. Through a systematic assessment of production costs, market prices, yield levels, and profit margins, this study seeks to provide valuable insights for farmers, policymakers, researchers, and other stakeholders interested in promoting sustainable *acha* production and enhancing the economic well-being of rural communities in Bauchi State.

The findings of this research are expected to contribute to the existing body of knowledge on *acha* production economics, offer practical recommendations for improving productivity and profitability, and stimulate further research and investment in the *acha* value chain. Ultimately, by gaining a deeper understanding of the costs and returns associated with *acha* cultivation in Bauchi State, we can work towards building a more resilient and prosperous agricultural sector that benefits both farmers and consumers alike.

Methodology

The study area

Bauchi State is made up of 20 local government areas which have been divided into three agricultural zones, namely, Northern Zone (Zaki, Gamawa, Jama'are, Itas-Gadau, Shira, Giade, Katagum, Misau and Dambam LGA's), Central Zone (Ningi, Warji, Darazo and Ganjuwa LGAs) and Western Zone (Alkaleri, Kirfi, Bauchi, Dass, Tafawa Balewa, Bogoro and Toro LGAs), Agricultural Development Programme (ADP). The State occupies an area of 49, 119km^2;about 5.3% of the total land mass of the country and ranked 5th among 36 States. The State cuts across two distinct ecological zones; Sudan Savannah and Sahel Savannah, with the south west part of the State overlapping into guinea savannah. It is located between $9^0 3^/$ and $12^0 3^,$ north of the equator and between latitude $8^0 50^,$ and 11^0 east of Greenwich meridian. Rainfall amount varies between the northern and southern parts of the state with 700mm and 1300mm, respectively. The major climatic factor affecting cropping pattern and practices in the area is the length of rainfall and growing season that spans between an estimated 110 days to 220 days between the north and the south-western part of the State (Abulrahman *et al.*, 2015). This study was carried out in three of the Local Government Areas in the western zone namely; Tafawa Balewa, Bogoro and Toro LGA's being the main *acha* producing areas of the State. The three local government areas occupy a total land area of 10, 341km^2 with a total projected population of 654, 607 people, at a growth rate of 3.6% (NPC, 2006). Separately, however the land area and population of Tafawa Balewa, Bogoro and Toro LGA's are 2,515^{2}km and 219, 988 people; 894^{2}km and 84,215 people and 6, 932^{2}km and 304, 203 people, respectively (NPC, 2006). Prominent among the tribes inhabiting these LGAs are the Jarawa, Sayawa (Zaar), Ribina, Fulani, Hausawa and Angasawa. However, the Sayawa, Jarawa and Ribina are specifically associated with the cultivation of *Acha* and it has formed part of their material culture. Even though other prominent tribes are engaged in the cultivation of the crop, the Sayawa, Jarawa and Ribina seem to be the traditional producers of this valuable crop (Abdurrahman *et al*, 2015).

Sampling Procedure and Sample Size

A multi-stage sampling procedure was employed in selecting *acha* farmers. First stage was the random selection of 20% of wards in the three LGA's resulting in 2, 3 and 3 wards in Tafawa Balewa, Bogoro and Toro LGAs respectively. Second stage was the random selection of 5 communities from each of the selected wards; thus, a total of 40 communities were selected. Third stage, a simple census of *acha* farmers was conducted using trained enumerators, on the selected communities. Then a total of 384 farmers were randomly selected as sample for the study. Since the actual population of *acha* farmers in the study area was not known, sample size determination for infinite population was applied to determine the sample size required for the study as follows (Smith, 2013)

$NSS = [Z^2 \times SD(1-SD)]/ME^2$ ……..... (1)

Where:

NSS= Necessary sample size

Z= Z value at determined level of significance

SD=Standard deviation

ME= Margin of error or confidence interval

$NSS = [1.96^2 \times 0.5(1-0.50)]/0.05^2$

$= 3.8416 \times 0.25/0.0025$

$= 0.9604/0.0025$

$= 384.16$

~384 respondents needed

Sample was assigned to the selected communities using the formula for assigning sample to strata when the population of *acha* farmers in the selected communities were known from the simple census conducted (Berman, Undated):

$n_a = (N_a/N)*n$……………………….. (2)

Where:

n_a = the sample size for that community

N_a = the known population size of *acha* farmers for that community

N = the total population of *acha* and rice farmers for the selected communities

n = the determined necessary sample size.

Analytical Techniques

Data were analyzed through the use of descriptive statistics (frequencies, percentage, and mean) to identify socioeconomic characteristics of *acha* farmers; Gross Margin analysis, to determine costs and return of *acha* production; and Z-test to test significance of the difference between costs and return of *acha* production.

Gross margin analysis

$GM = GI-TC\ (\sum Q_y P_y - \sum X_i P x_i)$…………… (3)

Where;

GM=Gross margin (N)

GI=Gross Income (N)

TC=Total Costs (N)

Q_y= Output of *acha* (Kg)

P_y= Price per unit of *acha* (N)

$Q_y P_y$= Gross Income or revenue (N) for *acha* production

X_i= Quantity of input used in *acha* production.

Px_i= Price per unit of input used (N)

$\sum$= Summation symbol

$\sum X_i P x_i$ = The total value of variable cost incurred in producing *acha* (N)

Operating Ratio (OR)

$$OR = \frac{Total\ Variable\ Cost(TVC)}{Total\ Revenue(TR)} \quad (4)$$

An operating ratio of less than 1 therefore indicate that the farmer is efficient in managing costs while an operating ratio of 1 or greater than 1 indicates inefficiency in costs management.

Gross Ratio (GR)

$$GR = \frac{Total\ Revenue\ (TR)}{Total\ Cost\ (TC)} \quad (5)$$

Higher ratio, of greater than 1, indicates profitability of the enterprise while lower ratio, of less than 1 shows that the enterprise is not profitable.

Return per naira invested (RNI)

$$RNI = \frac{Gross\ Margin\ (GM)}{Total\ Variable\ Costs\ (TVC)}\ X\ \frac{100}{1} \quad (6)$$

Return per naira invested gives a measure of the profitability of a farm firm by expressing its gross margin as a percentage of the total variable cost. The percentage is then used to indicate the magnitude of the return per each naira invested in the business.

Z-test

$$Z = \frac{\bar{X}_R - \bar{X}_C}{SED} \ldots\ldots\ldots\ldots \quad (7)$$

Where;
t = test of difference between costs and return of *acha* produced
X_R = mean revenue of *acha* produced (N)
X_C = mean costs of *acha* produced(N)
SED = Standard Error of the Difference

Results and Discussion

Farm size

Farm size refers to the total land area in hectares that a farmer cultivates (Ogungbile *et al.*, 2002). Alamu and Rahman (2002) reported that farmers with more land resource are more likely to take advantage of new technology. The result as obtained with respect to the sizes of farms put under *acha* production as studied is as presented in Table 1.

The result shows that 37.5% of the respondents had their farm size measuring between 0.46 and 0.66 hectare, 29.4% had their farm size between 0.67 and 0.77 hectare. Generally, 89.8% of the farmers had farms less than a hectare. The mean size of farm under *acha* cultivation in the area was 0.6 hectare. This is in agreement with the finding of Abdurrahman *et al.* (2015) who reported a mean *acha* farm size of 0.56ha, represented by 68.57% of the *acha* farmers studied. Given the mean farm size for *acha* farmers in the study area, therefore, the decision to adopt new technology, if any, will be negatively affected.

Table 1: Distribution of *Acha* Farmers by Farm Size Cultivated

Farm Size (ha)	Frequency	Percentage
0.25-0.45	88	22.9
0.46-0.66	144	37.5
0.67-0.87	113	29.4
0.88-1.08	24	6.3
1.09-1.29	15	3.9
Total	**384**	**100**
Minimum	0.25	
Maximum	1.2	
Mean	0.6ha	
Std. Deviation	0.3	

Source: Field Survey, 2022

Labour Costs in Acha Production

The labour costs in *acha* production are as presented in Table 2. The result shows that harvesting accounts for the highest labour cost in *acha* production, representing 28.9% of the total labour cost. This is followed by Land preparation, which account for 25.8% and weeding 22.3%. Insecticide application and fertilizer application cost least as they account for 2.0% and 2.25% respectively. Philip and Itodo (2012) however reported that harvesting followed by weeding and land preparation respectively ranked first, second and third in that order. Harvesting cost is high, likely because it is done manually and cannot be delayed when the crop is ready for harvest, as any delay would result in loss of the grains through shattering from wind and/or rainfall. Moreover, *acha* harvesting occurs when labour demand is at the peak from other farming operations.

Table 2: Distribution of *Acha* Farmers by Labour Cost

Labour Cost	Average Amount (₦)	Average Man-day	Percentage
Land Clearing	2,010	3.4	12.1
Land Preparation	4,280	7.1	25.8
Planting	500	0.8	3.0
Herbicide Application	605	1.0	3.7
Weeding	3,700	6.2	22.3
Fertilizer Application	360	0.6	2.2
Insecticide Application	330	0.6	2.0
Harvesting	4,780	8.0	28.9
Total	**16,565**	27.7	**100**

Source: Field Survey, 2022

Descriptive Statistic of Variables

The result in Table 3 showed maximum and minimum output of 720kg and 30kg of *acha* with a mean output of 240kg. Farmers cultivated a maximum of 1.2ha and a minimum of 0.25ha and the report indicated a mean *acha* farm size of 0.6kg. The maximum quantity of seed planted by *acha* farmers was 53kg and the minimum is 5kg. The mean seed quantity planted is 21kg. The maximum amount spent on labour as indicated by the result is ₦34,700.00 while the minimum is ₦4,100.00. The mean cost of labour is ₦16,565.00. The result shows that while fertilizer, herbicide, insecticide, and storage had zero as minimum (because there are respondents who did not use the inputs), transportation incurred a minimum cost of ₦600.00. The maximum and mean values were 50kg and 24kg (fertilizer), 3litres and 0.6litres (herbicide), 200grammes and 58grammes (insecticide), ₦1,400.00 and ₦4,320.00 (storage) then ₦8,800.00 and ₦3,290.00 (transportation). The mean yield of *acha* as compared to other cereals such as millet/sorghum, rice and /maize which have been reported to have mean yields of 1000kg/ha and 2000kg/ha respectively informs the need for more attention to be given to *acha* production so as to improve its productivity,

Table 3: Descriptive Statistic of Variables

Variable	**Unit**	**Minimum**	**Maximum**	**Mean**	**Man Day**	**SD**
Yield	Kilogram	30	720	240		142.6
Land Size	Hectares	0.25	1.2	0.6		0.3
Seed	Kilogram	5	53	21		9.5
Labour						
Land Clearing	Naira	500	4,000	2,010	3.4	803
Land Preparation Planting	Naira	1,500	8,000	4,280	7.1	1,691
Herbicide Application	Naira	100	1,000	500	0.8	190
Weeding	Naira	0	1,000	605	1.0	602
Fertilizer Application	Naira	1,000	9,000	3,700	6.2	1,677
Insecticide Applicat.	Naira	0	700	360	0.6	284
Harvesting	Naira	0	1,000	330	0.6	200
Total Labour	Naira	1,000	10,000	4,780	8.0	1,972
Fertilizer		**4,100**	**34,700**	**16,565**	**27.7**	
Herbicide	Kilogram	0	50	24		14
Insecticide	Liter	0	3	0.6		0.7
Transportation	Gram	0	100	58		46
Storage Material	Naira	600	8,800	3,280		1,853
	Naira	0	1,400	432		291

Source: Field Survey, 2022

through the production of improved varieties and improved practices (Abdurrahman *et al.,* 2015). It is possible that improved evaluation, selection and other breeding methods can result in the selection of higher yielding accessions of *acha* (Kwon-Ndung and Dachi, 2007). The labour component which was high could also be improved through mechanization of the activities as in other crops. Philip and Itodo (2012) were of the opinion that the mechanization of the various *acha* production operations, *acha* production will be made less costly in terms of labour cost and would be more attractive and sustainable. The variability of fertilizer, herbicide, pesticide transportation and storage material as indicated by the standard deviation of 14, 0.7, 46, 1,853 and 291 respectively are an indication of the changes in the inputs at the disposal of farmer during the production season.

Determinants of Allocative Efficiency

The estimates of the stochastic frontier cost function are presented in Table 4. The result reveals that all the variables-land rent, average cost of seed, average cost of fertilizer, average cost of labour, average cost of herbicide and average cost of insecticides have positive effect on the total cost of production; meaning, as these costs increase, total cost of production also increased. While land rent and labour were significant at ($P < 0.01$), seed and herbicide were significant ($P < 0.1$). Fertilizer and insecticides cost are found not to have any significant effect on the total cost of *acha* productions. This may be so because of the low quantity of fertilizer used in *acha* farming and the fact that insecticides used in controlling insects on *acha* farm did not cost much. This is similar to Odundari and Ojo (2006) who reported that all the estimated coefficients (average wage rate per man days of labour, price per kg of planting materials, average price of 10kg of agro-chemicals, average price of farm tools and cassava yield in kg) gave positive coefficients.

Table 4: Determinants of Allocative Efficiency

Variable	Coefficient	Std Err.	Z	P
Constant	-3066055	32605	-9.39	0.000***
lnRent	7169.181	930.4335	7.71	0.000***
lnSeed	5666.309	2558.794	2.21	0.027*
lnFert.	1112.296	2601.149	0.43	0.669
lnLabour	20162.58	3870.161	5.21	0.000***
lnHerb.	3620.485	1443.423	2.51	0.012*
lnPest.	296.8595	1507.706	0.20	0.844

Source: Field Survey, 2022

Gross Margin analysis of acha production

Costs refer to the expenses incurred in organizing and carrying out the production process. They include outlays of funds for inputs and services used in production (Doll and Orazem, 1984). Thus it is the sum total of the value in monetary term of all the inputs used in a particular production process (Adegeye and Dittoh, 1985). Abdurrahman *et al.* (2015), Gidado (2012) and Duniya (2013) employed the use of costs and return to determine the gross margin in *acha* production. All the observations are converted to per hectare, which is the standard unit of measurement from the mean of 0.6ha observed in the study. The result for costs and return analysis are as presented in Table 5.

Table 5: Gross margin analysis of *Acha* production

Item	Price(₦)	Unit	(₦/ha)	M/ Days	%
TOTAL REVENUE					
Output Consumed	190	148	28,131		36.7
Output Sold	190	255	48,519		63.3
Value of Output (kg)	**190**	**403**	**76,650**		**100**
VARIABLE COST					
Land, Rent (hectare)		**1**	630		1.3
Seed (kg)	201	35	7,050		14.3
Fertilizer (kg)		40	6, 380		12.9
Herbicide (L)		1	1, 430		2.9
Insecticide (gm)		97	80		0.2
Transportation			5, 480		11.1
Storage Material			820		1.7
Labour					
Land Clearing			3, 350	5.6	6.8
Tilling			7, 130	11.9	14.5
Planting			830	1.4	1.7
Herbicide Application			1, 010	1.7	2.0
Weeding			6, 170	10.3	12.5
Fertilizer Application			600	1	1.2
Insecticide Application			550	0.9	1.1
Harvesting			7, 830	13.1	15.9
Total Labour			**27,470**	**45.8**	**55.7**
TOTALVARIABLE COST			**49, 340**		**100**
GM(TR-TC)			**27, 310**		
OR (TVC/TR)			**0.6**		
GR(TR/TC)			**1.6**		
Return/₦ invested (GM/TC)*100			**55.35**		
t calculated			**7.55**		
t tabulated			**1.97**		

Source: Field Survey, 2022

Table 5 shows that cost of labour, which includes cost of labour for land clearing, planting, herbicide application, weeding, fertilizer application, insecticide application and harvesting, accounted for the highest cost of *acha* production, which represented 55.7% of the total cost of production; of these, cost of harvesting, tilling and weeding accounted for 15.9% 14.5% and 12.5%, respectively. This is similar to Duniya (2014) who reported that labour accounted for 55.89% of the total cost of *acha* production, but higher than Abdurrahman *et al.* (2015) who reported that labour accounted for 44.2% of the total costs for *acha* production. The result also agrees with the report of Froment and Renard (2001) that labour cost was a major component of cost in *Acha* production. Fertilizer and transportation cost followed labour with 12.9% and 11.1% of the total cost, respectively. The cost and return structure for *acha* farmers revealed that, of the ₦76, 650.00 (including what was consumed in the household) generated as revenue per hectare of *acha* ₦49, 340.00 is total cost of production. This means that when the cost of production was deducted from the gross revenue generated a gross margin of ₦27, 310.00 was left as the profit made from a hectare of *acha* farm. This was however higher than what was reported by Gidado (2012) that the costs and return per hectare associated with *acha* production in Bogoro LGA showed a gross margin and net farm income of ₦12, 227.52/ha and ₦11, 174.90/ha, respectively, but lower than the gross margin of ₦48,920 reported by Suleiman *et al.* (2015). The result is however similar to that obtained by Duniya *et al.* (2013), ₦27, 920. The return per Naira invested shows that on every Naira invested there was a return of 55k which represents 55%.

To determine whether there was a significant difference between costs of acha production and the revenue generated from its sales, z-test was used. The result shows a strong (0.84) positive relationship between costs and revenue, indicating that as one increases the other also increase. It also reveals that the difference between revenue and costs was significant ($P<0.5$) as t-calculated (7.55) was greater than t-tabulated (1.97). The null hypothesis is therefore rejected and the alternative accepted that there was significant difference between revenue and costs of *acha* production in the study area. *Acha* production, therefore, is a profitable business in the study area.

Conclusion and Recommendation

Conclusion:

The majority of farmers (89.8%) have small-scale farms, with an average farm size of 0.6 hectares, which is consistent with previous findings (Abdurrahman et al., 2015). Land, rent and labour are the factors that significantly influence acha production in the study area. Given the gross margin value, operating ratio of 0.6 and a gross ratio of 1.6. it is concluded that *acha* farming is a profitable business in the study area, though with some rooms for improvements on its profitability. Labour is the most critical factor in acha production as it is the most significant expense in *acha* production, accounting for 55.7% of the total cost of production.

Recommendations:

i. There is a need to support small-scale farmers in accessing resources, such as credit, inputs, and extension services, to improve their productivity and competitiveness.
ii. Government and development organizations should prioritize initiatives that promote agricultural technology adoption and scaling up of smallholder farms to improve their productivity and income.
iii. Farmers and producers should consider investing in labour-saving technologies or techniques to reduce labour costs and improve efficiency.
iv. Policy makers and extension agents could provide support and training to farmers on best practices and technologies that could help reduce labour costs and improve overall productivity in *acha* production.
v. Further research is needed to investigate the specific challenges faced by small-scale farmers in the study area and to identify strategies to address these challenges and improve their livelihoods; as well as to identify specific areas within the labour cost category where reductions could be made without compromising productivity.

Overall, the results highlight the importance of addressing the challenges faced by small-scale farmers in the study area to improve their productivity, income, and overall well-being. Also, understanding the cost structure of *acha* production is essential for identifying areas where efficiency gains can be made, and this study provides valuable insights into the importance of labour costs in *acha* production.

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