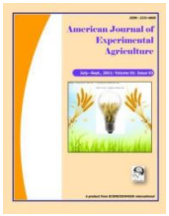

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Profit Efficiency of Cocoyam Production in Kaduna State, Nigeria

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Authors' contributions

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

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ABSTRACT

Aims: Aims of the study were to describe socio-economic characteristics of cocoyam farmers, profitability of cocoyam production and determine the profit efficiency of cocoyam producers in Kaduna state.
Study Design: Primary data were collected from cocoyam producers through the use of structured questionnaires.
Place and Duration of Study: This study was carried out in three local government area in Kaduna state, Nigeria between August and November 2014 cropping season.
Methodology: Multistage purposive and random sampling techniques were employed for data collection.
Results: The study showed that 34% of the respondents fall within the age range of 30 and 39years. The majority of the farmers (50%) had no formal education. The household size ranged from 6-10 persons, whereas (73%) were not members of cooperative society. Results indicated that except for cost of fertilizer, all other factors were significant ($P < 0.01$ and $P < 0.1$). The mean profit efficiency is 66% while the range is 3-99%

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Conclusion: The findings of the study revealed that none of the sampled cocoyam farms reached the frontier threshold. Also, amount of credit received and farming experience was the socio-economic variable responsible for the variation in profit efficiency of the cocoyam producers. It was therefore recommended that timely and adequate supply of seed should be made available to farmers at affordable price in order to increase profit from production of cocoyam.

Keywords: Profit efficiency; cocoyam; stochastic production frontier; Kaduna state.

1. INTRODUCTION

Nigeria's domestic economy is partly determined by agriculture which accounted for 40.9% of the Gross Domestic Product (GDP) in 2010 [1]. Agriculture has been an important sector in the Nigerian economy in the past decades and is still a major sector despite the oil boom. Basically it provides employment opportunities for the teeming population, eradicates poverty and contributes to the growth of the economy. Despite these however, the sector is thus characterized by low yields, low level of inputs and limited areas under cultivation [2]. Nigeria is an agrarian economy with 70% of its people dependent on agriculture [3]. The Government of Nigeria has been trying to achieve food security at both house hold and national level through its mechanized approach.

Root and tuber crops which are among the most important groups of staple foods in many tropical African countries [4] consistute the largest source of calories for the Nigeria population [5]. Cassava (*Manihot esculenta*) is the most important of these crops in terms of total production, followed by yam (*Dioscorea* spp.), cocoyam (*Colocasia* spp. and *Xanthosoma* spp.) and sweet potato (Ipomoea batatas) [5].

Cocoyam (*Colocasia esculenta* and *Xanthosoma mafafa* (L) Okeke) are important carbohydrate staple food particularly in the southern and middle belt areas of Nigeria [6]. Nutritionally cocoyam is superior to cassava and yam in the possession of higher protein, mineral and vitamin contents in addition to having more digestible starch [7,8]. Cocoyam which ranks third in importance and extent of production after yam and cassava is of major economic value in Nigeria [9]. Edible cocoyam cultivated in the country is essentially species of *Colocasia* (taro) [10] and *Xanthosoma* (tannia). The average production figure for Nigeria is 5,068,000 mt which accounts for about 37% of total world output of cocoyam [11]. Small scale farmers, especially women who operate within the subsistence economy grow most of the cocoyam in Nigeria.

It is highly recommended for diabetic patients; the aged, children with allergy and for other persons with intestinal disorders [12]. According to [13], boiled cocoyam corms and cormels are peeled, cut up, dried and stored or milled into flour. The flour can be used for soups, biscuits, bread and puddings for beverages. The peels can also be utilized as feed for ruminants.

Despite the importance of cocoyam, more research attention has been given to cassava and yam [14,15]. [16], Observed that research on cocoyam has trailed behind cassava and yam as root crops in Nigeria and other countries. [17] noted that the totality of published scientific work on cocoyam is insignificant when compared with those of rice, maize, yam and cassava. However, [16] asserted that it was only in the last decade that policy makers and national agricultural research systems began to show systematic interest in the crop because of concern over biodiversity. There is a declining trend in cocoyam production as well as a shortage of its supply in domestic markets as a result of a number of technical, socio-economic and institutional constraints, which need to be addressed. Cocoyam farmers are generally found on a small scale and its production has been undermined.

Arising from the forgoing, there is need to have a look into the production of cocoyam, one of the major roots and tuber crops in Nigeria which is fast becoming an extinction crop. This is due to the general believed that most families no longer consume it because it is not readily available for consumption even during its season, as a result of reduction in its production level. This study therefore measured the technical efficiency of cocoyam producers in Kaduna state.

Production of cocoyam has not been given priority attention in many countries probably because of its inability to earn foreign exchange and its unacceptability by the high income countries for both consumption and

other purposes [18]. Most of what is produced is consumed locally [19]. The production is labour intensive with most operations carried out manually at the traditional level. There is a dearth of information on the economics of cocoyam production in Nigeria.

1.1 Concept of Efficiency Measurement Using Frontier Profit Function

[20] in his pioneering study defined efficiency as the ability to produce a given level of output at lowest cost. Efficiency can be analyzed by its two components: technical and allocative efficiency. Technical efficiency is defined as the degree to which a farmer produces the maximum feasible output from a given bundle of inputs (an output oriented measure), or uses the minimum feasible of inputs to produce a given level of output (an input oriented measure). On the other hand, allocative efficiency relates to the degree to which a farmer utilizes inputs in optimal proportions, given the observed input prices [21]. These components have been measured by the use of frontier production function which can be deterministic or stochastic. Deterministic frontier production function explains that all deviations from the frontier are attributed to inefficiency where as in stochastic frontier production function it is possible to discriminate between random errors and differences in efficiency [21]. [22] argued that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments [23]. Thus, this led to the application of stochastic profit function models to estimate farm specific efficiency directly [23,21,24,25,26].

According to [26] the profit function approach combines the concepts of technical and allocative efficiency in the profit relationship and any error in the production decision is assumed to be translated into lower profits or revenue for the producer. Profit efficiency is defined as the ability of a farm to achieve highest possible profit given the prices and levels of fixed factors of that farm and profit inefficiency is defined as loss of profit from not operating on the frontier [23]. It should be noted that [27] had extended the stochastic production frontier model by suggesting that the inefficiency effects can be expressed as a linear function of explanatory variables, reflecting farm-specific characteristics. The advantage of their model is that it allows estimation of the farm-specific efficiency scores and the factors explaining efficiency differentials among farmers in a single stage estimation procedure. This study therefore, used [27] model by postulating a profit function, which is assumed to behave in a manner consistence with the stochastic frontier concept. The model was applied to cocoyam producers in Kaduna State, Nigeria.

The stochastic frontier profit function is defined as:

$$\pi_i = f(X_i;\delta) + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots \quad \ldots\ldots\ldots(1)$$

Where πnormalized profit of the ith farms is, X_i is a vector of inputs used by farm *i*, and ε_i is a "composed" error term. The error term ε_i is equal to $v_i - u_i$. The term v_i is a two-sided $(-\infty < v_i < \infty)$ normally distributed random error ($v \sim N[0, \sigma_v^2]$) that represents the stochastic effects outside the farmers' control. The term u_i is a one-sided $(u_i \geq 0)$ efficiency component that represents the technical inefficiency of farm. The distribution of the term u_i can be half-normal, exponential, or gamma [28,29] and half-normal distribution ($u \sim N[0, \sigma_u^2]$) is used in this study. The two components v_i *and* u_i are also assumed to be independent of each other.

Profit efficiency (PE) of an individual firm is defined in terms of the ratio of predicted actual profit to the predicted maximum profit for a best-practiced cocoyam farmer, conditioned on the level of price of output and inputs used by the firm. Profit inefficiency is therefore defined as the amount by which the level of profit for the firm is less than the frontier profit. This is shown in equation [2]

$$PE_i = \frac{\pi}{\pi^{max}} = \frac{f(X_i\delta)\exp(V_i - U_i)}{f(X_i\delta)\exp(V_i)} = \exp(-U_i) \quad (2)$$

2. MATERIALS AND METHODS

2.1 Study Area

This study was conducted in Kaduna state of Nigeria. Kaduna state lies in the north western part of the country's geopolitical zone, about 200km away from Abuja the federal capital. The state lies between latitudes 90°N and 12°N of the equator and between longitudes 6°E and 9°E of the prime meridian. Kaduna 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 [30]. The state occupies an area of approximately 68,000 square kilometers or 7% of Nigeria's land mass. The state has 23 Local

Government Areas [31]. The mean annual rainfall shows a marked decrease from South to North (1,524 mm to 635 mm). Two distinct seasons occur in the state; the rainy season and the dry season. The relative humidity is constantly below 40% except in few wet months when it goes up to an average of 60%. The duration of dry season is 5-7 months which normally starts from October. The state is agrarian and well suited for the production of arable crops such as maize, yam, millet, and sorghum because of a favourable climatic condition. Livestock production is also practiced in the state. Rearing of goats, sheep, cattle and different classes of poultry as well as marketing of their products is practiced in the state. The people of the state live mostly in organised towns and cities [32]. A large variety of non-agricultural occupations also exit.

The total population of the state is 6.11 million [31]. Based on annual population growth rate of 3.2%, the projected population of the state was about 7.33 million people in 2012. Within the state there are a number of establishments ranging from companies, research institutes, higher institutions and colleges.

2.2 Sampling Procedure

Multistage sampling techniques were used to select respondents for this study. The first stage involved a purposive selection of the three (Giwa, Kudan and Ikara) local governments based on predominance of cocoyam production among the farmers. Secondly, 9 villages were purposively selected, Three (Giwa, Yakawada, Guga; Gimbawa, Kwasallawa, Malikanchi; and Musawa, Hunkuyi, Kudan) from each local government area based on their intensity of cocoyam production. Finally, a simple random sampling was employed in selecting farmers from each of the villages. Fifty percent (50%) of the sample frame (248) was used as the sample size. In all, 124 farmers were randomly selected for the study.

2.3 Data Collection and Analysis

Primary data were used for this study. These were collected with the aid of structured questionnaires. The information collected includes labour input, fertilizer input, seed, farm size and farmer's socio-economic characteristics such as age, household size, educational status, amount of credit received, number of extension contacts, years spent on the cooperative, and income.

2.4 Model Specification

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

$$\ln\pi_{i=} \beta_0+\beta_1\ln X_{1i}+\beta_2\ln X_{2i} + \beta_3\ln X_{3i} + \beta_4\ln X_{4i} + V_i - U_i$$

Where subscript i refer to the observation of ith farmers,

ln = Logarithm to base e,
π_i = Profit of the ith farmers (₦)
X_1 = average price of seed (₦)
X_2 = average price of fertilizer (₦)
X_3 = average price of labour (₦)
X_4 = average price of farm size (₦)

The inefficiency effects, V_i is a random error term assumed to be independently and identically distributed as N (0, σ_V^2). U_i represents profit inefficiency and is identically and distributed as a truncated normal with truncations at zero of the normal distribution [33]. The U_i is defined as:

$$U_i = \delta_0 + \delta_1\ln Z_{1i} + \delta_2\ln Z_{2i} + \delta_3\ln Z_{3i} + \delta_4\ln Z_{4i} + \delta_5\ln Z_{5i} + \delta_6\ln Z_{6i}$$

Where:

U_i = Technical inefficiency of the ith farmer
Z_1 = Age of the farmer (years)
Z_2 = Years of education of the ith farmer
Z_3 = Household size of the ith farmer (Numbers of people)
Z_4 = Cooperative Association of the ith farmer (Years of participation)
Z_5 = Extension Contact of the ith farmer (Number of contacts)
Z_6 = Access to Credit by the ith farmer

3. RESULTS AND DISCUSSION

The socio-economic characteristics of the respondents are presented in Table 1. The study revealed that 34% of the respondents fall within the age range of 30 and 39 years. The mean age of the farmers was 40 years; this implies that the majority of the farmers were younger, who can contribute positively to agricultural production for the next two decades. This result is consistent with the findings of [34] who observed that youth constitute the majority of the cocoyam farmers, and younger farmers are more flexible to new ideas and risk; hence they are expected to adopt innovations more readily than older farmers. The majority of the farmers (50%) had no formal education. This indicates that the farmers' educational level is low. According to [35],

education has a positive and significant impact on farmers' efficiency in production. The literacy level greatly influences the decision making and adoption of innovation by farmers, which may bring about increase in production of the crop. The educational level of farmers does not only increase his productivity but also increase his ability to understand and evaluate new techniques. The majority of the farmers (30%) had household size with 6-10 members. The average household size was 13 persons implying that there is appreciable source of family labour supply to accomplish various farm operations. According to the report of [36], 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. About (73%) of cocoyam farmers do not participate in any cooperative association. According to them, their non-membership is due to being small scale and unawareness of any association while 27% participated with average of 2.4 times per year. The effect of this result is that most of the cocoyam 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. [37] stated that membership of cooperative societies have advantages of accessibility to micro-credit, input subsidy and also as avenue in cross breeding ideas and information. (85%) of cocoyam farmers in the study area have no access to extension service while (15%) have access to extension service with average of 0.4/ year. This could be attributed to low extension agent-farmers' ratio in the study area.

3.1 Profitability of Cocoyam Production in the Study Area

The result in Table 2 revealed that cocoyam seed used by the farmers in the study area were mainly unimproved seeds taken from the last harvest. The quantity of cocoyam set (seed) was 1068.2 kg/ha with an average market price of ₦271 per kg was used and this constitutes 62.2% of the total cost of production. The quantity of fertilizer was 490.47kg/ha with an average market price of ₦100 per kg was used and this constitutes 28.5% of the total cost of production.

Labour costs consist of cost of land preparation, planting, fertilizer application, weeding, replacement and harvesting. The family labour was computed on the basis of opportunity cost in man-day. The wage rate varied according to farm operation to be performed. An average wage rate of ₦400 per man-day was used, giving the average labour cost per hectare to be ₦9780 while the total cost of fixed inputs (cost of renting land and depreciation of tools) incurred on cocoyam production was ₦6113 and this constitute 3.6% of the total fixed cost.

The result in Table 2 revealed that the total revenue (TR) was ₦290,076.7 while the total cost (TVC + TFC) was ₦171,760. The net farm income was therefore ₦118,316.7. the average rate of return on investment (return per naira invested) was 1.69, indicating that for every ₦1 invested in cocoyam production in Kaduna state, a profit of 69 kobo was made. Thus, it could be concluded that cocoyam production in the study area though on a small scale, was economically viable. This finding is similar to that of [38] who observed that cocoyam production is profitable by returning ₦1.80 to every ₦1.00 spent.

3.2 Profit Efficiency and its Determinants among the Cocoyam Farmers

The maximum likelihood estimates of the parameters of the stochastic profit frontier model are presented in Table 3. The estimated sigma squared (σ^2) was significantly different from zero at the 1 percent level; this indicates a good fit and correctness of the specified distributional assumptions of the composite error terms. This conforms to [39,21]. In addition, the estimated gamma parameter (γ) of 0.30 was significant at 1 percent level of significance (Table 3), indicating that about 30 percent of the variation in actual profit from maximum profit (profit frontier) among cocoyam farms was due mainly to differences in farmers' practices rather than random variability.

Table 1. Socio-economic characteristics of cocoyam farmers

Variable	Frequency (N = 124)	Percentage
Age (years)		
20-29	32	25.8
30-39	42	33.8
40-49	17	13.7
50-59	20	16.0
60 above	13	10.4
Mean	40	
Educational status		
No formal education	62	50.0
Primary education	11	8.9
Secondary education	34	27.4
Tertiary education	17	13.7
Household size		
1-5	28	22.5
6-10	37	29.8
11-15	23	18.5
16-20	19	15.3
21 above	17	13.6
Mean	13	
Membership of cooperative society		
Non members	90	72.6
1-5	21	16.9
6-10	4	3.2
11-15	4	3.2
16 above	5	4.0
Mean	2	
Extension contact		
No contact	105	84.7
1-3	16	12.8
4-6	3	2.4
Mean	0.4	
Access to credits		
Personal savings	116	93.5
Borrowing	8	6.5

N = Number of respondents

Table 2. Average cost and return per hectare of cocoyam production

Variables	Values/ha (₦)	% Contribution
Total Revenue	290076.7	
Total cost (TVC + TFC)		
a. seed (kg)	106,820	62.2
b. fertilizer (kg)	49,047	28.5
c. labour (man-days)	9780.00	5.7
Total variable cost (a + b + c)	165,647	
a. Cost of renting land	4813	2.8
b. Depreciation of tools (hoe and cutlass)	1300	0.8
Total fixed cost= (a + b)	6,113	3.6
Total cost =(165,647 + 6,113)	171,760	
Net Farm Income= (NFI)= (TR - TC)	118,316.7	
Return per Naira Invested (TR/TC)	1.69	100

Only the coefficients of the cost seeds and cost of fertilizer were found to be positive while the cost of labour and cost of farm land were negative. Demonstrating that cost of seed and cost of fertilizer had positive effect on the profit efficiency of cocoyam farming in Kaduna state while the cost of labour and cost of farm land had negative effect on profit efficiency .

This implied that a unit increase in the prices of inputs with positive coefficient will lead to increase in the profit efficiency of cocoyam and vice versa. However, the coefficient for cost of seed with positive coefficient of 0.58 was statistically significant at 1 percent level of significance and this appears to be the most important variable determining profit efficiency. This implies that for a 1 percent increase the use of seed, the profit obtainable from cocoyam production will increase by 52 percent.

The negative sign of labour may be due to high cost of a negative relationship do exist between family labour and hired labour among the resource-poor rural farmers because the consumption of additional hired labour is meant to supplement available family labour such that as the availability of family labour decreases, additional hired labour is consumed at the limit of the lean resources of the farmers. Due to the high cost of hired labour if additional hired labour must be consumed then additional cost must be incurred while the negative cost of fertilizer may perhaps be due to wrong use leading to too much application of fertilizer by the cocoyam farmers, therefore resulting in extra cost sustained by the farmers.

The negative sign of farm land at 10 percent level of significance shows that for a 10 percent increase in the cost of farm land, the profit obtainable from cocoyam production will decrease by 37 percent. This may be due to over utilization of resources as a resulting of additional cost incurred; hence increasing their farm size will decrease profit, other things being equal. This finding is at variance with [40], significant coefficient of farm size at 5 percent level of significance points to the fact that cassava farmers were operating at small scale level, hence increasing their farm size will improve profit.

The parameters estimates for determinants of profit efficiency were reported in the lower part of Table 3. However the analysis of inefficiency models shows that the signs and significance of the estimated coefficient in the inefficiency model have important implication on the profit efficiency of the farmer.

The results further showed that the profit inefficiency of the cocoyam farmers was positively influenced by age, household size, cooperative membership and extension contact while education, farming experience, and credit negatively influence profit inefficiency (Table 3). This result is in agreement with [41,23]. Thus, investments in rural education through effective extension delivery program and provision of credit will boost farmers' efficiency. The result of this study has clearly shown that opportunities exist in cocoyam production.

The result showed that there is a significant and positive relationship between age and profit at 10% level of probability. This implies that cocoyam farmers with more age exhibited significantly less profit than farmers with less age.

The result showed that there is a significant and negative relationship between experience and profit at 10% level of probability. This implies that cocoyam farmers with more years of experience exhibited significantly more profit than farmers with less years of experience. This could probably be explained by the fact farmers probably employ their experience over time as an opportunity to enhance more profit. This finding is consistent with [42].

The result in Table 3 showed that there is a significant and negative relationship between credit and profit at 10% level of probability. This implies that cocoyam farmers with access to credit exhibited significantly more profit than farmers with less credit. 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 [43] 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. This finding also conform to the study of [44] supported this fact by reporting in his study that credit increases the net revenue obtained from fixed inputs, market conditions and individual characteristics, while credit constraint decreases the efficiency of farmers by limiting the adoption of high yielding varieties and the acquisition of information needed for increased productivity.

The result in Table 3 showed that there is a significant and positive relationship between extension contact and profit. This implies that cocoyam farmers with more extension contact exhibited significantly less profit than farmers with less extension contact.

3.3 Frequency Distribution of Profit Efficiency Estimates of Cocoyam Farmers

Table 4 presents the distribution of profit efficiency of cocoyam farmers. The profit efficiency score ranged between 0.13 and 0.98 with an average of 0.66. The average profit efficiency score of 0.66 implied that an average cocoyam farmer in the study area could increase profits by 34% by improving technical and allocative efficiency in cocoyam production. This result conformed to the findings of [45,21] who reported mean profit efficiency levels of 0.77 for Bangladeshi rice farmers and 0.78 for Nigerian cowpea farmers respectively. This result indicates that about 56% of cocoyam farmers seemed to be skewed towards efficiency level of 61% and above, while the farmer with the best and least practice had a profit efficiency of 0.98 and 0.13 respectively. In spite of this, the results implied that a considerable amount of profit can be obtained by improving technical and allocative efficiency in cocoyam production in the area

Table 3. Maximum likelihood estimates results of frontier profit function of cocoyam production

Variables	Parameters	Coefficients	Std. error	T-value
Profit Function				
Constant	β_0	15.497	1.517	10.213***
ln cost of seed	β_1	0.576	0.162	3.563***
ln cost of Fertilizer	β_2	0.194	0.236	0.823
ln cost of Labour	β_3	-0.276	0.108	-2.551***
ln cost of farm land	β_4	-0.375	0.204	-1.831*
Inefficiency variable				
Constant	Z_0	0.082	0.451	0.181
Age	Z_1	0.019	0.010	1.911*
Educational status	Z_2	-0.548	0.291	-1.887*
Household size	Z_3	0.002	0.015	0.131
Farming experience	Z_4	-0.005	0.019	-0.286
Cooperative association	Z_5	0.025	0.039	0.664
Amount of credit borrowed	Z_6	-0.00009	0.00005	-1.789*
Extension contact	Z_7	0.00006	0.00003	1.881*
Diagnostic Statistic				
Sigma-square	(σ^2)	0.681	0.094	7.223***
Gamma	(γ)	0.301	0.097	3.105***
Log likelihood function	*L/f*	-142.820		
LR test	31.633			
Total number of observation	164			
Mean efficiency	0.66			

*Asterisk indicate significance ***1%,**5%, *10%.*

Table 4. Frequency distribution of profit efficiency estimates from the stochastic frontier model

Efficiency level	Frequency	Percentage
< 0.2	11	8.87
0.21-0.40	8	6.46
0.41-0.60	41	33.06
0.61-0.80	28	22.58
0.81-1.00	36	29.03
Total	124	100
Minimum	0.13	
Maximum	0.99	
Mean	0.66	

4. CONCLUSION

The paper estimates the farm level profit efficiency and its determinants using the stochastic parametric method of estimation. The findings of the study revealed that none of the sampled cocoyam farms reached the frontier threshold. Also, amount of credit received and farming experience was the socio-economic variable responsible for the variation in profit efficiency of the cocoyam producers.

5. RECOMMENDATIONS

The coefficient for cost of seed with positive coefficient of 0.58 was statistically significant at 1 percent level of significance and this appears to be the most important variable determining profit efficiency. This implied that a unit increase in the prices of seed will lead to increase in the profit of cocoyam; it was therefore recommended that timely and adequate supply of seed should be made available to farmers at affordable price in order to increase profit from production of cocoyam. Also, the level of profit efficiency of some farmers was very low due to improper management of resources; it is therefore recommended that farmers should be trained and advised on proper and efficient utilization of resources (seed, farm size and labour) in order to improve their profit efficiency.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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