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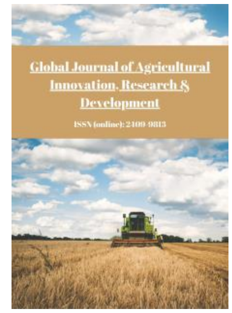

Efficiency Differential of Adopters and Non-adopters of Improved Technologies among Plantain Farmers in South-South, Nigeria

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ABSTRACT

The study investigated efficiency differential of adopters and non-adopters of improved technologies among plantain farmers in South-South, Nigeria. The objectives of the study were to analyze production factors of adopters and non- adopters', measure productive efficiencies of adopters and non-adopters, and evaluate the factors affecting the adoptive behaviour of farmers in the study area. Multi stage sampling technique was used to collect data from 280 plantain farmers. Descriptive statistics, stochastic frontier production/cost function models and logistic regression model were used for analysis. The results showed that adopter obtained higher yield than the non-adopters ($p<0.01$). Significant difference existed between adopters and non-adopters in terms of farm size, labour, inorganic fertilizers, pesticides, income, education, credit status and extension contacts. The mean technical efficiency of the famers was 0.66 and 0.52 for adopters and non-adopters respectively which differs significantly ($p<0.01$). The mean allocative efficiency was 0.57 and 0.44 for adopters and non-adopters respectively, the mean economic efficiency was 0.52 and 0.42 for adopters and non-adopters respectively. Farming experience, family size, adoption index, education, extension contacts, and membership of association were significant factors affecting adoptive choice of the farmers.The study recommended increased use of technologies, more extension contacts, and increased farmers' membership of association.

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1. Introduction

Nigeria is one of the largest producers of plantain globally, ranking 3rd in Africa and 6th in the world, with a production of 3,164,878 metric tonnes in 2017. Plantain cultivation is primarily concentrated in the southern states, with the highest production levels found in the South-South states of Akwa Ibom, Cross River, Delta, Rivers, Bayelsa, and Edo [1]. That year, Nigeria produced 3.1 million metric tonnes of plantain across 493,776 hectares of farmland. While it ranked 6th in total output, it stood at 34th in terms of yield per hectare, producing just 64 metric tonnes per hectare [1]. In comparison, Cameroon and Ghana demonstrate higher efficiency in plantain production. In 2017, Cameroon produced 4.5 million metric tonnes using 358,855 hectares, ranking 2nd in total output and 11th in yield per hectare, with 126 metric tonnes per hectare [1]. Similarly, Ghana produced 4.05 million metric tonnes across 368,505 hectares, ranking 3rd in total output and 20th in yield per hectare [1].

Despite contributing 7.5% of global plantain production [2], Nigeria remains an inefficient producer. This inefficiency stems from reliance on unsustainable production methods, including expanding farmland instead of improving productivity and continued use of traditional farming practices.

The gross value of plantain and banana in terms of their annual product is far above that of several other crops such as maize, rice, cassava and sweet potato in Sub-Saharan Africa [3], thus, making plantain production a significant economic activity for income generation for both large scale and subsistent farmers in Nigeria. Plantain has a production life cycle that is less cost intensive than any other crop making plantain cheaper to produce [3]. Thus, it is the cheapest source of starch and has the least cost of production among food crops in terms of hectare/ kilogram and per 1000 calories which ordinarily should be exploited to address hunger and poverty in Nigeria [4]. The major challenge is therefore that of low adoption level of improved technologies which has reduced productive efficiencies of the farmers.

The demand for plantain in Nigeria is high with supply staggering to meet demand which is often reflected in the unhealthy rise in the price of plantain in rural and urban areas thus making the per capita consumption of plantain in Nigeria the lowest in West and Central Africa region [5]. This inability to meet home demand has undermined the state of this crop as a foreign exchange earner [5]. This implies that Nigeria is not one of the plantain exporting countries in the world, this invariably connotes a significant market potential for increased plantain production in the country.

Moreover, the demand-supply gap is attributed to the fact that plantain is mainly cultivated by scattered small holder farmers who produce the bulk of food in the country. Small holder farmers who are the backbone of the Nigerian agriculture are poor, have limited capital, have fragmented farm holdings, limited access to input, poor extension services and inadequate usage of improved agricultural technologies. These characteristics have severely hampered the performance of the agricultural sector via low level of efficiency of production. This however, is the reason why the concept of farm efficiency has consistently remained topical in developing countries like Nigeria, where resources are seriously limited and opportunities for developing and adopting better technologies are unsteady [6].

Efficiency entails the ability of a firm to obtain maximum output from the given inputs. However, it is usually assumed that the farm firm desires to optimize a profit maximization objective function subject to resource constraint, which underscores the attainment of an optimally high level of output with a given amount of effort or input. In the attainment of the best level of output, productivity of resource is imperative. Thus, efficient utilization of resources is indispensable in achieving broad-based economic and agricultural growth in developing country like Nigeria.

Nyangena and Juma [7], posited that the productivity of farmers in Nigeria could be increased either by adopting improved production technologies or through improved efficiency in resource utilization or both. The author further posited that the low rate of adoption of improved technologies by farmers makes improved efficiency in resource utilization the best option for increased farmers' productivity in the short-run.

Norgrove and Hauser [8, 9] explained that technologies such as organic fertilizers, herbicides, hot water treatment of suckers before planting, de-suckering of plant, prompt planting, propping, trimming, sucker multiplication techniques, early weeding, weeding regularly for up to six months, phyto-sanitary treatment, planting depth of 40cm by 40cm, planting space of 2m by 2m for mono-cropping and 4m by 4m for mixed cropping, use of insecticides, use of shades and wind breaks, proper fertilization of the soil among others are improved technologies which can increase substantially the yield of plantain.

In congruence with Norgrove and Hauser [7, 8] posited that for most Sub-Saharan African countries, the adoption of sustainable improved agricultural technologies that increase production efficiency and improve environmental outcomes remains the most practical option for attaining economic growth, food security and poverty alleviation. Therefore, from the foregoing it is no longer sustainable to meet the food needs of the increasing population by expanding the area under cultivation but rather by improving the productive efficiencies of farmers through the use of improved production technologies on which this study is hinged on. Few studies have been done on the efficiency of plantain farmers notably that of [10, 11]. Both studies looked at the efficiency of plantain farmers. Idumah et al. [11] focused solely on the technical efficiency of plantain growers using the stochastic frontier production function model, whereas Okoruwa et al. [10] used the same methodology to analyze the technical, allocative, and economic efficiencies of the farmers.

However, this study differs from Okoruwa et al. who examined allocative, technical and economic efficiency of plantain farmers in Ogun State, because this study went further to categorized plantain farmers based on the number of technologies used, evaluate efficiencies differentials between adopters and non-adopters of improved plantain technologies and also evaluate factors affecting farmers' decision to adopt improved technologies. While Olumba et al. [9] examined factors affecting plantain farmers use of improved technologies using continuous variables for adoption and ordinary least squares methodology, this study employed discrete variables for adoption and employed binary logistic regression methodology for farmers decision to adopt improved technologies. In addition to that, none of those previous studies were carried out in South-South, Nigeria, which is the major producer of plantain in Nigeria.

It is against this backdrop that this study seeks to evaluate efficiency differentials of adopters and non-adopters of improved technologies among plantain farmers in South-South, Nigeria. Specifically, the study seeks to: compare the output and input levels and socio-economic characteristics of adopters and non-adopters of improved technologies among plantain farmers; measure technical, allocative and economic efficiency of adopters and non-adopters of improved technologies; and examined the adoption level of the technologies by farmers; and evaluate the factors affecting the adoption of improved plantain production technologies in the study area

2. Materials and Methods

2.1. Study Area

The study was conducted in the South-South geopolitical zone of Nigeria which consists of six States. These are Akwa Ibom, Bayelsa, Cross river, Delta, Edo and River States. This zone consists of 66.6 percent of the Niger Delta region where oil and gas are commercially exploited, and thus drives the economy of Nigeria [12]. South-South, Nigeria is strategically located at the point where the 'Y' tail of the River Niger joins the Atlantic Ocean through the Gulf of Guinea. It is located at latitude 4^0N and longitude 6^0E, with an area of 84,587km^2 and has a coastline spread of over 540 km^2. The area is bordered to the South by the Atlantic Ocean and to the East by Cameroun [12]. The zone is blessed with rich soil that supports farming thus crop farming activities are predominant. Major crops cultivated are yam, cassava, plantains and bananas, oil palms, coco yam, sweet potato, groundnut and maize. Apart from yam and cassava, plantain is the major staple for the people, therefore plantain is grown as a major crop across all the six States that made up this region.

2.2. Sampling Techniques

The population for the study consists of plantain farmers in South-South, Nigeria. Multi-stage sampling technique was used for this study. The first stage involved the random selection of three South-South States out of six States using lottery method. The selected state include: Bayelsa, Delta and River State. The second stage involved selection of cultivable areas of the selected States as some of the areas are dominated by water bodies that are more amenable to fishing rather than crop farming. The sampling in the third and subsequent stages was done on State-case-basis as plausible in each of the selected States as described below.

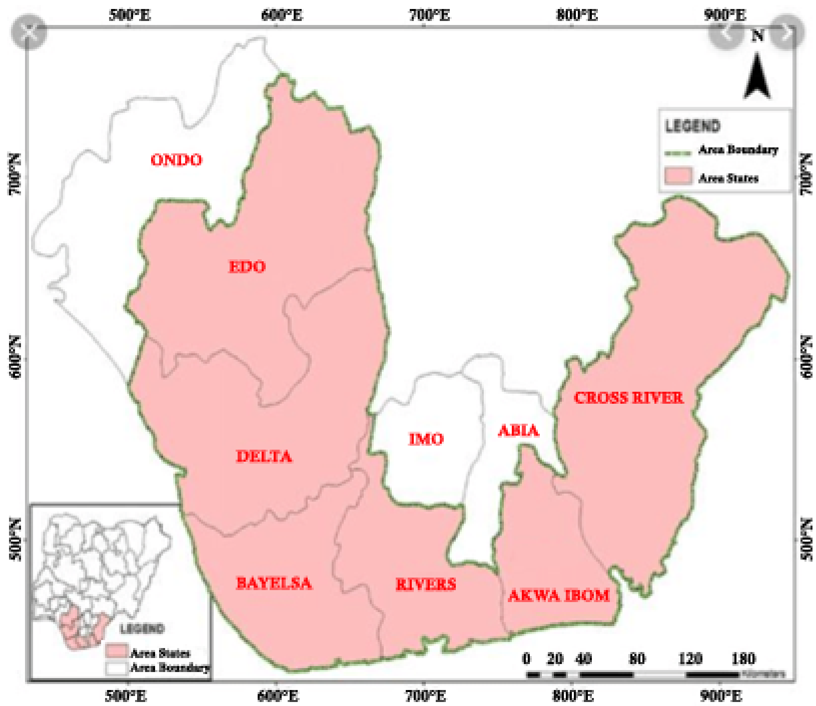

Figure 1: Map of South-South, Nigeria.

Bayelsa State is made up of eight Local Government Areas (LGAs) which are demarcated into 3 agro-ecological zones. Two agro-ecological zones (Yenagoa and Sagbama) were purposively selected due to the preponderance of plantain farming in these zones while the other zone is dominated by fishing activities. The two selected zones consist of five LGAs (Ekeremor, Sagbama, Kolukoma-Opokuma, Yenagoa, and Southern Ijaw). This was followed by a random selection of three LGAs out of the five and another random selection of three communities from each of three LGAs making a total of nine communities. Finally, ten plantain farmers were selected randomly from each of the nine communities to give a total of 90 respondents for Bayelsa State.

Rivers State is made up of 23 LGAs demarcated into three agro-ecological zones namely Rivers West, Rivers East and Rivers South-East. Two non- riverine LGAs were purposively selected from each of the agro-ecological zones due to the preponderance of farming activities in those LGAs. These LGAs included Ahoada West and Abua/Odua in Rivers West agro-ecological zone, Ikwerre and Etche in Rivers East agro-ecological zone and Tai and Gokana in Rivers South-East Agro-ecological zone. This was followed by a random selection of two communities from each of the previously selected six LGAs to give a total of 12 communities, and finally a random selection of eight farmers from each of the 12 communities giving a total of 96 plantain farmers in River State.

Delta State is made up of 25 LGAs which is further demarcated into three agro-ecological zones which consists of Delta North, Delta South and Delta Central agro-ecological zone. Delta Central consist of nine LGAs which includes Ethiope East, Ethiope West, Okpe, Sapele, Udu, Ugheli South, Ugheli North, and Uvwie. Delta North consist of eight LGAs which includes Aniocha North, Aniocha South, Ika North –East, Ika South, Ndokwa East, Ndokwa West, Oshimili North, Oshimili South and Ukwuani. Delta South consists of eight LGAs which includes Bomadi, Burutu, Isoko North, Isoko South, Patani, Warri North, Warri South and Warri South-West (10). In Delta State, there was a random selection of two LGAs from the three agro-ecological zones making a total of six LGAs, followed by a random selection of two communities from each of the LGAs making a total of 12 communities. The final stage entailed a random selection of eight plantain farmers from each of the 12 communities making a total of 96 respondents for Delta State.

Summarily, a grand total of 282 respondents was sampled for the study, sample frames were collected from Bayelsa State Agricultural Development Programme (BSADP), River State Agricultural Development Programme (RSADP) and Delta State Agricultural Development Programme (DSADP). Data for this study was collected from primary sources using questionnaires. Objective one was analysed using descriptive statistics and t test, objective two was analysed using stochastic production and cost function model, objective three was analysed using frequency, percentages and logistic regression model.

Table 1: Summary of sampling technique.

State	Agro-Ecological Zone	LGAs	Communities	Farmers	Selected Farmers
Rivers	Rivers West	Ahoada West Abua-Odua	2 2	8 8	16 16
	Rivers East	Ikwerre Etche	2 2	8 8	16 16
	River South East	Tai Gokana	2 2	8 8	16 16
	Total	6	12	8	96
Bayelsa	Bayelsa West Bayelsa East Bayelsa Central	Sagbama Yenagoa K' Opukuma	3 3 3	10 10 10	30 30 30
	Total	3	9	10	90
Delta	Delta Central	Ugheli North Ugheli South	2 2	8 8	16 16
	Delta North	Ika South Ukwuani	2 2	8 8	16 16
	Delta South	Bomadi Patani	2 2	8 8	16 16
	Total	6	12	8	96
	Grand total	15	33		282

2.3. Method of Data Analysis

The study adopted both descriptive and inferential statistics for data analysis. Socioeconomic characteristics were analyzed with percentages, means and frequency. A four point Likert type scale was used to categories adopters into Very Strong adopters 4, Strong adopters 3, weak adopters 2 and very weak adopters 1. This was done by the basis of the number of technologies adopted divided by the total number of technologies available for adoption. Farmers with mean scores less than 2.5 were further categorized as non-adopters and farmers with mean scores above 2.5 were categorised as adopters as shown on Table **2**.

Table 2: Rating of level of use of improved technologies by the sampled farmers.

Level of Adoption	Scale	Number of Available Technologies	Range of Technologies Adopted	Frequency	Percentage (%)	Remark	Cumulative Frequency
Very Strong adopters	≥ 3.5	20	≥ 18.0	26	9.29	Adopters	
Strong adopters	2.5- 3.49	20	13 - 17.0	74	26.43		100
Weak adopters	1.5 - 2.49	20	8 -12.0	98	35.00	Non adopters	
Very weak adopter	≤ 1.49	20	≤ 7.0	82	29.28		180
Total		20		280	100		280

Source: Field survey, 2022.

The study further adopted the stochastic frontier production function model using the software frontier 4.2 to evaluate the technical, allocative and economic efficiencies of the adopters and non-adopters of improved technologies as well as the factors affecting inefficiency of the adopters and non- adopters. This model was chosen over other models because of its ability to handle both the efficiency component and the factors affecting inefficiency. The stochastic frontiers production function was defined by Coelli [13] as;

Yi = F (Xi,) exp (Vi - Ui), 1, 2……n. (1)

Where Yi = The ith farm's output

Xi = The ith farm's input quantity vector

= Vector of the ith farm's unidentified parameters.

Vi stands for unpredictable mistakes linked to unpredictable elements outside of the control of farmers, such as the weather and infections.

Ui= inefficiency effects, or non-negatives connected to production-related technical inefficiency (one-sided error with U O).

Composite mistake term: Vi - Ui. (2)

The model concurrently measures respondents' individual technical efficiency.

In relation to the stochastic production function in equation (1), farmer (1)'s technical efficiency is provided as follows:

TEi =Y iY (i*) (3)

= F(Xi) exp (Vi - ui)/F(Xi) exp (Vi) (4)

The production function model explicitly specified with the Cobb-Douglas; following (1).

$l_nY = \beta_o + \beta_1 l_n x_1 + \beta_2 l_n x_2 + B_3 l_n x_3 + \beta_4 l_n x_4 + \beta_5 l_n x_5 + - u1$ (5)

l_n = logarithm to base

Y = output of plantain (Kg)

x_1 = farm size (hectare), x_2= labour (man day), x_3 =quantity of planting materials (kg), x_4 = fertilizer(kg), x_5 = agro-chemicals (litres)

β_o= constant term

β_1, β_2………… β_5 = Regression coefficients

V_i = random errors which are assumed to be independent and identically distributed having N (0, δ^2)

U_1 = Non-negative random variables associated with technical inefficiency.

It is assumed that the technical efficiency effects are independently distributed and arise by truncation at (zero) of the normal distribution with mean U_1 and various δ^2, where U_1 is specified thus;

$U_1 = \delta_0 + \delta, z_1 + \delta_2 z_{2i} + \delta_3 z_{3i} + \delta_4 2_{4i} + \delta_5 z_{5i} + \delta_6 z_{6i} + \delta_7 z_{7i} +$ (6)

U_1 = technical inefficiency of the i^{th} farmer

Z_1 = improved technologies adoption indices, Z_2 = level of education (No of years spent in school), Z_3 = farming experience (years), Z_4 = household size (number), Z_5= extension contact (number), Z_6 = credit status (Dummy variable, 1 for access, zero otherwise), Z_7 = membership of cooperative (1 for membership, zero otherwise), Z_8 = sex (binary variable, male = 1, female = 0), Z_9 = age of farmer (years) $\delta 0$-$\delta 8$ = parameters

Following Olumba et al. [14], the adoption indices (Z_1) will be calculated for each farmer by dividing the number of technologies adopted by a particular farmer by the total number of technologies under study and worked into a percentage. In calculating the adoption score a farmer score one for the adoption of each technology which implies a farmer who adopted five technologies scores 5 points.

Mathematically,

$$z1 = \frac{No\ of\ technologies\ adopted}{\text{total number } of\ technologies\ under\ study}\text{x}100 \quad (7)$$

The cost function model was also specified thus:

$$l_nC^* = \beta_o + \beta_1 l_n z_1 + \beta_2 l_n z_2 + B_3 l_n z_3 + \beta_4 l_n z_4 + \beta_5 l_n z_5 + \beta_6 Y^* + - U_1 \quad (8)$$

l_n = natural log

C^* = per farm cost of producing plantain i th farmer (₦)

z_1 = farm size (hectare), z_2 = cost of labour (₦ / man day), z_3 = cost of planting materials (₦ / kg), z_4 = cost of fertilizer (₦ /kg), z_5 = cost of agro-chemicals (₦ /litres)

Y^* = quantity of output

β_o= constant term

β_0-β_2............ β_7 = Regression coefficients

V_i = random errors which are assumed to be independent and identically distributed having N (0, δ^2)

U_1 = Non-negative random variables associated with cost inefficiency.

$$U_1 = \delta_0 + \delta, z_1 + \delta_2 z_{2i} + \delta_3 z_{3i} + \delta_4 2_{4i} + \delta_5 z_{5i} + \delta_6 z_{6i} + \delta_7 z_{7i} + \cdots \quad (9)$$

U_1 = cost inefficiency of the ith farmer

Z_1 = cost of adopting technologies, Z_2 =level of education (No of years spent in school),

Z_3 = farming experience (years), Z_4 = household size (number), Z_5 = extension contact (number)

Z_6 = credit status (Dummy variable, 1 for access, zero otherwise), Z_7 = membership of cooperative (1 for membership, zero otherwise), Z_8 = sex (binary variable, male = 1, female = 0)

Z_9 = age of farmer (years)

$\delta 0$-$\delta 8$ = parameters

This model will be incorporated into the cost frontier model in determining the cost inefficiency of plantain farmers. This is done with the belief that the variables have direct influence on the level of cost efficiency in line with [15]. Economic efficiency was estimated from the inverse of cost efficiency. EE = 1| Cost efficiency (CE) i.e Economic Efficiency is the inverse of Cost Efficiency [13].

Following [16], Allocative efficiency AE is given as;

AE =(EE)|(TE) =(X'eP)|Xt.P) (10)

Logistic regression model was used to evaluate the factors affecting the decision to adopt improved plantain production technologies. This model is appropriate because the dependent variable adoption is discrete. 1 for adopters and 0 for non-adopters. Following (17) the logit model is defined as follows:

$$P_i=p(Y=1|X_i)=Y=\beta_o+\beta_i X_i\ ,\ i=1, 2,------,n \quad (11)$$

Further expressed as;

$$L_i=\ln\left(\frac{pi}{1-pi}\right)=Y_i=\beta_o+\beta_i X_i+U_i \quad (12)$$

Where; ;

p_i=probability of adopting

$(1-p_i)$= probability of not adopting

Y = (adopter =1; non-adopter = 0)

X_1 = age of farmers (years), X_2 = farm size (hectares) X_3 = awareness level of farmers (awareness indices), X_4 = cost of technologies (₦), X_5=extension visits (Number Monthly),X_6= farm income (₦), X_7= farming experience (years), X_8 = household size (Number), X_9 = level of education (years)

e_i = Error term,

b_0 = Intercept, b_1- b_9 = regression coefficients of explanatory variables

3. Results and Discussion

Table **2** shows the Likert rating of the level of adoption of the sampled farmers using four points scale. The table shows that 9.29 % of the farmers adopted 18 and above technologies out of the 20 improved technologies recommended by this study, and are rated as very strong adopters, 26.43 % adopted between 13 and 17 technologies and are rated as strong adopters, 35% adopted between 8 and 12 technologies and are rated as weak adopters, while 29.28% adopted 7 and less technologies and are rated as very weak adopters. Very strong adopters and strong adopters were further collapsed to form the adopters' category while weak adopters and very weak adopters were collapsed to form non adopters' category as presented in this study. Based on the forgoing, 100 farmers were classified as adopters and 180 farmers as non-adopters. This provided a useful basis for empirical analysis of the underlying factors that might contribute to the farmers' decision to adopt and how this has played a role on their productive efficiencies.

3.1. Socio Economic Characteristics and Summary Statistics of Production Factors of Adopters and non - Adopters

The socioeconomic characteristics and summary statistics of inputs and output of the plantain farmers were presented in Table **3**. Adopters of improved plantain production technologies had greater output when compared to non-adopters. The yield per hectare of the adopters which was markedly different was further substantiated by the t-value which was significant at 1% probability level. This implies that plantain farmers who adopted improved production technology have an edge in terms of output, over their counterpart in the non -adopters' category. This result is in consonance with the findings of [8] that a higher yield of plantain was realized through the adoption of innovations. The result on Table **1** also shows that although the non -adopters had a larger farm size which was significant at 1% probability level when compared to the adopters' category, however, this did not translate to greater yield. This implies that farm size may be a necessary factor but not a sufficient requirement for increased yield. This was expected because increasing fixed factors without a reasonable blend of variable factors may not achieve the immediate goal of increased output for a farm firm. The result further shows that there was no significant difference between adopters and non-adopters for quantity of sucker and family labour. The implication of this is that, adopters and non-adopters used the same level of suckers and family labour, but their yield levels significantly differ. This probably could be explained by the varieties of sucker cultivated alongside innovations and other production inputs used. Moreover, there was significant difference between adopters and non-adopters in terms of hired labour, organic fertilizers, herbicides, pesticides and technology adoption index. While hired labour, pesticides, organic fertilizer, herbicides and technology adoption index were statistically significant at one percent probability level ($p < 0.01$), pesticide was significant at 5% level ($p < 0.05$). This implies that the difference in output between adopters and non- adopters could be attributed to their differences in the use of other yield increasing inputs and technologies. This result is in congruence with the report of [8] that plantain farmers in Central and West Africa have a high potential to increase their yield by increasing the use of improved technologies and innovations such as fertilization, hot water treatments, mulching and many others. In addition, annual income, years in school, extension contacts and membership of association distinctively varies between adopters and non-adopters and were significant at five percent level. The significant differences in income could be as a result of greater output, this further corroborates the differences in use of pesticides, organic fertilizers, herbicides and other yield increasing technologies. Farmers with higher incomes are likely to increase their expenditures on yield increasing inputs within the limits of their fixed factors. In the same vein, farmers with more formal education are less conservative and are willing to try new ideas and innovations; this could explain the significant gap in schooling between the two categories of farmers. More contacts with extension agents by adopters may also have influenced their decision to try and continue to use new innovations. This was further strengthened by formal education. Membership of an association also gave adopters an edge over the non-adopters, this is because farmers' membership of an association makes them to meet often, share experiences, and exchange ideas. This will also give them the courage to try new innovations and probably embrace new yield improving technologies.

Table 3: Summary Statistics of the inputs, outputs and socio economic characteristics of the farmers.

Variables	Adopters		Non-Adopters		
	Mean	Standard Deviation	Mean	Standard Deviation	T- value
Plantain output (Kg)	6949.95	537.50	4535.63	257.40	3.134***
Farm size (ha)	2.09	0.85	2.55	0.48	3.232***
Sucker (Kg)	1967.46	1320	2010.78	846.57	0.876
Family Labour (man-days)	42.43	52.18	60.36	48.53	1.543
Hired Labour (man-days)	65.45	70.33	35.36	26.18	9.799***
Organic fertilizer (Kg)	226.44	180.33	230.39	65.30	0.923
Inorganic fertilizer (Kg)	56.93	10.96	18.76	18.90	5.827***
Herbicides (Litres)	20.53	12.44	3.593	1.23	3.572***
Pesticides (Litres)	19.45	9.87	3.717	0.87	1.987**
Technology adoption index	0.71	0.29	0.38	0.18	2.975***
Annual Income ($)	8963.315	65425	4,521.11	1020.14	8.793***
Age (number)	47	6.73	52	13	1.578
Household size (Number)	9	2.88	10	1.67	1.241
Membership of cooperative	0.93		0.55		1.986**
Sex	Male 65%		Male 58%		
Extension visits per year	12		4		2.223**
Education (Years)	15	8.34	7	4.83	4.235***
Farming experience (Years)	11	4.0	13	7.24	1.567
Total number of observations (N)	100		180		

***, ** Significant at 1% and 5% probability levels respectively.
Source: Field survey, 2022. Note: 400 Naira/ USSD.

In terms of age, household size and farming experience, no significant difference existed between the two categories of farmers. The two categories of farmers were at their very active age of production with mean ages of 47 and 52 years for adopters and non-adopters respectively. This implies that the future is bright for this staple because youths are physically strong and willing to take risk. This result is in tandem with [18] that plantain farmers in Ovia North East Local Government Area of Edo State had an average age of 53.3 years.

The result also shows a typical agrarian mean household size of 9 and 10 persons for adopters and non-adopters respectively, this result is in agreement with [18] that farmers in Edo state, Nigeria have an average household size of 7 persons. This is an advantage for both categories of farmers because in Nigeria, large family sizes are required to supply sufficient family labour to farms owing to the fact that cost of labour is high and youth recent preference for white collar jobs. The mean farming experience of 11 and 13 years for adopters and non-adopters signifies that majority of the farmers have experience in farming, this is an advantage for both categories of farmers because experienced farmers take calculated risks. This is in consonance with [18] that 78.6% of plantain farmers in Edo State had farming experience of over 15 years.

Finally, majority of the farmers in both categories were male (adopters 65%, non- adopters 58%) this was expected because males still dominate in the farming of major food crops like yam, cassava ad rice in Southern Nigeria while female folks are dominant in other crops like cowpea, maize, sweet potatoes etc. This however is never to undermine women roles during weeding, harvesting and marketing of plantain.

3.2. Maximum Likelihood Estimates of Production Function, Elasticities and Return to Scale

The maximum likelihood estimates of the stochastic frontier production function using Cobb Douglas model is presented in Table **4**. The parameters were obtained using the programme frontier 4.2. The estimate for sigma squared σ^2 for adopters and non-adopters were 0.784 and 0.612 respectively. The sigma squares were significant at 1% probability levels indicating that there were significantly different from zero. This assures us of the goodness of fit as well as the correctness of the composite error terms. The value of the gamma γ for adopters and non-adopters were 0.527 and 0.739 respectively, this signifies that 53% and 74% of the total variations of plantain output for adopters and non -adopters respectively were due to differences in technical efficiency. To be more concise, inefficiencies of farmers rather than other random factors are significant in determining the level of variation of output of plantain in the study area. The implication of this is that, the variation in output levels across farmers is majorly as a result of factors that are within the control of the plantain farmers and not due to stochastic factors such as war, drought, flood, diseases ad weather. Furthermore, the magnitude and signs of the coefficient of the Cobb-Douglas model is indispensable in discussing the results. Plantain sucker was positive and significant at 1% level for both adopters and non-adopters of improved plantain production technologies, this implies that a unit increase in sucker, holding other variables constant will result to 0.359 and 0.226 percent increase in plantain output for adopters and non- adopters respectively. Farm size was positive and significant at 1% and 5% probability level for adopters and non-adopters respectively. This implies that a unit increase in farm size, all things being equal will result to 0.139% and 0.146% increase in plantain output for adopters and non - adopters respectively. The result of farm size and sucker is in congruence with [10] that there was a positive and significant relationship between planting materials and farm size for elasticity of plantain production in Ogun State. Family labour was positive and significant for non- adopters at 5 % level while it was positive and not significant for adopters. This result is partly in agreement with [16], that a negative and non-significant relationship was observed between total labour and output. It is worthy of note that [16] did not categorize labour into family labour and hired labour as done in this study. This result is plausible because, non-adopters rely so much on family labour in the production of plantain in the study area unlike their adopters' counterpart who had a good blend of both family and hired labour.

The result on Table **2** further shows that the coefficient of fertilizers was positive and significant at 1% level for adopters and positive and not statistically significant ($p<0.05$) for non-adopters. This could probably be as a result of very low use of fertilizers for non- adopters because just like the result revealed earlier, the use of fertilizers and other agro chemicals like herbicides and pesticides have the ability to increase the yield of plantain. Technology adoption index of the farmer was found to be positive and significant at 1% for adopters and positive and not significant ($p<0.05$) for non- adopters. This implies that a unit increase in the use of other yield increasing technologies will result to a 0.113 percent increase in plantain output for adopters. The insignificance in technology adoption index by the non-adopter category is clear and expected, because of their characteristic poor use of yield enhancing technology in their production of plantain.

Table 4: Maximum likelihood estimates of parameters of the Cobb-Douglas stochastic frontier production function.

Variables	Parameters	Adopters Coefficient	t-Ratio	Non -Adopters Coefficient	t-Ratio
Constant	B_0	3.217	7.855***	5.637	4.140***
Sucker	B_1	0.359	3.222***	0.226	2.838***
Farm size	B_2	0.139	3.745***	0.461	2.3116**
Family Labour	B_3	0.062	1.334	0.131	2.277**
Hired Labour	B_4	0.021	0.937	0.061	1.372
Fertilizer	B_5	0.131	4.377***	0.079	0.896
Technology adoption index	*B6*	0.193	3.517***	0.056	1.3305
Diagnostic Statistic					
Log-likelihood function		81.336		126.653	
Sigma squared	σ^2	0.784	6.308***	0.612	4.0179***
Gamma	Γ	0.527	3.717***	0.739	9.679***
L-R test		23.467		39.132	
No of observation		100		180	

***and ** Significant at 1% and 5% probability levels respectively.

The coefficient of the variables of the Cobb-Douglas model represents various elasticities to output for increase in the variable of the model, all the variables have less than unity elasticities, this implies that a 1 % increase in any of the variable will result to a less than proportionate increase in output if other variables are held constant. The return to scale was 0.91 and 1.014 for adopters and non-adopters respectively, this entails a decreasing return to scale for adopters and an increasing return to scale for non-adopters. In other words, adopters are producing in stage II of the production curve where total product (TP) is increasing at a decreasing rate. On the other hand, non- adopters are producing in stage I of the production curve where total product (TP) is increasing at an increasing rate. It is however, safer to produce in stage II which is considered as the stage where resource allocation and production is efficient.

The maximum likelihood estimates of the parameters of stochastic frontier cost model are presented in Table **4**. The sigma squared was 0.599 and 0.628 for adopters and non-adopters respectively. The sigma squared were statistically significant ($p<0.01$) indicating that they are significantly different from zero. The gamma for adopters and non- adopters were 0.869 and 0.786 respectively which suggest that 87% and 79% of the variations of the total cost of output is attributed to cost inefficiency of the plantain farmers rather than random factors. Cost of sucker was positive and significant at 1% for both adopters and non- adopters, this implies that a unit increase in the cost of sucker will increase production cost by 0.098% and 0.136% for adopters and non -adopters respectively if all others variables are held fixed.

Land rent was positive and significant ($p<0.05$) for adopters and positive and not significant ($p<0.05$) for non-adopters, this suggests that land rent constitute a good percentage of the total cost of production which was not the case for their counterpart. The non -adopters may have had the privilege of using ancestral land, or land rented with very little cost implications, this difference in cost of land may be justified by the level of fragmentation of the lands used by non-adopters. Since adopters pay more for land it is only economical for them to use more yield increasing technologies so that they can increase their output level and make profit at the end of the farming season.

Furthermore, the cost of family labour was significant ($p<0.05$) for adopters and non- adopters, this connotes that a unit increase in the cost of family labour will increase cost of production by 0.196% and 0.639% for adopters and non-adopters respectively. This is expected because family labour still forms a major source of labour available for agriculture. On the other hand, hired labour was positive and statistically significant at 1 percent level for adopters and not significant ($p<0.05$) for non- adopters. This was expected because adopters' category used more of hired labour in their farming activities (as part of the package for the adopted technology) when compared to the non-adopters.

Cost of fertilizer and cost of other technologies used were positive and significant for adopters and not significant for non- adopters. This indicates that the use of fertilizers and other yield increasing technologies is striking among adopters. The cost of fertilizer is high, other technologies such as the use of herbicides, pesticides, hot water treatment of sucker etc. also comes with accompanying cost implications, which also increase the total cost of production of plantain. The disparity in income between the two categories of farmers in Table **3** has gone a long way to explain why the use of yield increasing technologies is not affordable for the non-adopter farmers unless there is a financial intervention.

The scale effect among plantain farmers in the study area was computed as the inverse coefficient of the cost elasticities with respect to plantain. Plantain output in the analysis shows that there is scale effect among the sampled farmers. This is corroborated with the value of scale effect of 3.02 and 16.31 which are inverses of the coefficients of plantain output 0.331 and 0.0613 for adopters and non-adopters respectively. The values are greater than one which implies that a unit increase in the total production cost will increase plantain production by 3% and 16% respectively. These suggest that there are positive economics of scales in plantain production. An average plantain farmer in the study area will experience a reduction in the total production cost in the course of production.

Table 5: Maximum likelihood estimates of parameters of the Cobb Douglass stochastic frontier cost function.

Variable	Parameters	Adopters Coefficient	t-Ratio	Non -Adopters Coefficient	t-Ratio
Constant	B_0	6.119	5.421***	3.216	5.231***
Cost of Sucker	B_1	0.098	3.946***	0.106	2.619***
Land rent	B_2	0.062	2.413**	0.012	1.022
Cost of Family Labour	B_3	0.196	1.984**	0.639	2.111**
Cost of Hired Labour	B_4	0.017	2.423**	0.007	1.372
Cost of Fertilizer	B_5	0.151	3.281***	0.149	0.066
Cost of technologies used	B_6	0.007	2.362**	0.010	0.014
Plantain output	B_7	0.331	2.866***	0.0613	3.679***
Diagnostic Statistic					
Log-likelihood function		92..113		109.133	
Sigma squared	σ^2	0.599	11.727***	0.628	6.136***
Gamma	Γ	0.869	3.717***	0.786	5.212***
L-R test		31.134		43.341	
No of observations		100		180	

***, ** implies Statistically Significant at 1%, 5% probability levels respectively.

3.3. Analysis of Productive Efficiencies of the Sampled Farmers

The efficiency levels of adopters and non-adopters are presented in Table **6** and **7**. The results indicate that the technical efficiency (TE), allocative efficiency (AE) and economic efficiency (EE) were less than unity. This suggests that the sampled plantain farmers were operating below the maximum frontier level. The result shows that majority (45%) and 65% of the farmers have TE range of 0.61-0.80 and 0.41-0.60 for adopters and non-adopters' categories respectively. This implies that majority of the farmers must improve their output by 20-40% and 40-60% for adopters and non-adopters respectively given the available set of inputs in order to operate on the maximum frontier output. The mean technical efficiency was 0.66 for adopter and 0.52 for non -adopters. This implies that an average adopter must increase output by at least 34% given their sets of inputs in order to operate on the production frontier. Similarly, non-adopters have to increase output for at least 48% using the given sets of inputs and technology. This result is in consonance with [10], that technical efficiency of plantain farmers in Ogun State was 0.83, that technical efficiency was 0.86 for plantain farmers under agroforestry system in Edo State. The best and the worst technically efficient farmer in the adopter category had a technical efficiency of 0.96 and 0.26 respectively, which suggests that the farmers have to increase output by 4% and 74% for the best and worst farmer respectively to produce maximally on the production frontier. On the other hand, the best and the worst technically efficient farmer in the non- adopter category had a technical efficiency of 0.90 and 0.10 respectively, which implies that the farmers have to increase output by 10% for the best and 90% for the worst farmer to operate on the production frontier using the same level of inputs and technology.

Table 6: Frequency distribution of technical, allocative and economic efficiencies of adopters.

Range	Technical Efficiency *Frequency Percentage*	Allocative Efficiency *Frequency Percentage*	Economic Efficiency *Frequency Percentage*
0.01-0.20	0 0	12 12	13 13
0.21- 0.40	8 8	10 10	15 15
0.41- 0.60	28 28	28 28	28 28
0.61-0.80	45 45	33 33	39 39
0.81- 1.00	19 19	17 17	5 5
Total	100 100	100 100	100 100
Mean	0.66	0.57	0.52
Minimum	0.26	0.12	0.13
Maximum	0.96	0.90	0.91
Mean of Worst 10	0.36	0.29	0.15
Mean of Best 10	0.88	0.86	0.76

The result on Table **6** and **7** also shows the allocative efficiency levels among the sampled farmers. The mean allocative efficiency was 0.57 and 0.44 for adopters and non-adopters respectively. This implies that an average sampled farmer has to increase cost saving by 37% (1-0.57/0.90) and 50% (1- 0.44/ 0.88) for adopters and non-adopters respectively in order for them to achieve the allocative efficiency level of their efficient counterparts elsewhere. This result is corroborated by the result of [10] that farmers in Ogun State have a mean allocative efficiency of 0.68. Furthermore, 50% of the adopters had allocative efficiency level of 60% and greater, while 22% of non-adopter attained the same allocative efficiency level. This suggests that farmers in the adopters' category are on a more allocative efficiency level than their counterparts in the non-adopters' category.

Further result of the analysis shows the economic efficiency of adopters and non-adopters which was estimated as the inverse of cost efficiencies of the sampled farmers. The mean economic efficiencies for adopters and non-adopters were 0.52 and 0.42 respectively. The maximum economic efficiency level was 0.91 for adopters and 0.81 for non-adopters. The minimum economic efficiency level was 0.13 and 0.10 for adopters and non-adopters' category respectively. This result is in congruence with Okoruwa et al. [10], that farmers in Ogun State have a mean economic efficiency of 0.721.

From the results above, allocative efficiency appears to be much of a problem to the two categories of farmers when compared to technical efficiency. This suggests that the low productive efficiencies of the sampled farmers were as result of low allocative efficiency levels rather than technical efficiency. This is further strengthened by Okoruwa et al. [10] that allocative efficiency contributes more to the short fall from maximum possible production frontier. This implies that farmers should put more efforts to get the best combinations of inputs that will give maximum output at the least possible cost. Cost saving is pivotal for the farmers to maximize both output and profit.

Table 7: Frequency distribution of technical, allocative and economic efficiencies of non- adopters

Range	**Technical Efficiency** *Frequency Percentage*	**Allocative Efficiency** *Frequency Percentage*	**Economic Efficiency** *Frequency Percentage*
0.01-0.20	5 2.80	20 11.11	33 18.33
0.21- 0.40	45 25.0	65 36.11	52 28.90
0.41- 0.60	65 36.1	55 30.60	55 30.60
0.61-0.80	55 30.6	31 17.20	35 19.44
0.81- 1.00	10 5.5	9 5.0	5 2.77
Total	180 100	180 100	180 100
Mean	0.52	0.44	0.42
Minimum	0.10	0.09	0.10
Maximum	0.90	0.88	0.81
Mean of Worst 10	0.19	0.29	0.16
Mean of Best 10	0.89	0.86	0.81

3.4. Factors Affecting the Adoption of Improved Plantain Production Technologies

The result presented on Table **8** shows the frequency distribution of plantain farmers' use of improved production technologies in the study area. The result shows that the most used technologies were de-suckering (71.42%), trimming (71.07 %) early and regular wedding for up to six months (67.14%), use of organic fertilizers (66.43%) and propping (62.86%). This implies that plantain farmers in the study area have a long way to go in terms of use of improved technologies, one would have expected 100% use of these technologies because these technologies are common, very easy to use and readily available. This result is in consonance Okoruwa et al. [10] who reported similar results of less than 100% adoption for very simple technologies such as propping, trimming and mulching in Anambra State.

The results further show the five least used technologies which includes, the use of flood resistant mixture (13.57%), sucker multiplication techniques (21.07%), use of shades during sucker preparation (27.85) use of wind break (30.00%) and Phyto sanitary/hot water treatment of sucker before planting (31.78%). This result signifies that plantain farmers in the study area are not doing very well in terms of use of yield increasing technologies. This result is in congruence with the result of Olumba and Rahji [14] whose survey in Anambra State reported a very low adoption level for technologies like sucker multiplication, hot water treatment and use of chemicals.

The result shows that sex was positive and not statistically significant ($p<0.05$). This implies that being a male or a female does not significantly affect the decision to adopt improved plantain production technologies in the study area. Age of farmers was negative and not significant at 5% level. This implies that as age increases, the decision to adopt new improved technologies decreases, implying that younger farmers are likely to adopt new technologies more than older farmers. This is plausible because younger farmers are more active and are relatively more likely to take risks compared to their older counterparts who may be more conservative. Moreover, younger farmers are resilient in case of adverse eventualities or failure such may not be the case for older farmers. This result is in congruence with the findings of [19] that age negatively affected the technology adoption behaviours of Litchi farmers in China.

Table 8: Frequency distribution of plantain farmers use of improved technologies (N= 280).

S/N	Improved Plantain Production Technologies	Frequency*	Percentage*	Rank
1	Early and regularly weeding for up to six months	188	67.14	3rd
2	Mulching	147	52.50	6th
3	Space of 2m by 2m for sole cropping	123	43.92	10th
4	Space of 4m by 4m for mixed cropping	131	46.78	9th
5	Planting depth of 4cm by 4cm	136	48.57	8th
6	Propping	176	62.86	5th
7	Trimming	199	71.07	2nd
8	Use of hybrid varieties	113	40.35	14th
9	Use of inorganic fertilizers	115	41.07	13th
10	Use of Herbicides	121	43.21	11th
11	Use of pesticides	118	42.14	12th
12	Phyto sanitary/hot water treatment of sucker	89	31.78	15th
13	Use of shades during sucker preparation	78	27.85	17th
14	Use of flood protection mixture	38	13.57	20th
15	Sucker multiplication technique),	59	21.07	19th
16	Use of screen house	67	23.93	18th
17	Use of wind break	84	30.00	16th
18	Use of organic fertilizers	186	66.43	4th
19	De suckering	200	71.42	1st
20	Use of lime	145	51.78	7th

*Multiple responses.

The result for extension contact was positive and significant at 5% level. This indicates that farmers who had more extension contact were likely to adopt new improved technologies more than their counterpart with fewer or no contacts. This result is further corroborated by the odd of 1.455, which indicates that the odd for adoption by farmers with better extension visit is higher when compared to the odd (0.6872) for not adopting. This result is expected, extension visits expose the farmers to new ideas and innovations, encourage them to try them, information on how to get improved and subsidized inputs are also shared by extension agents. The extension agents also inform farmers on when and how to access formal credit facilities to enable them to get more cost-effective inputs for their farms. This result is in congruence with the result of [20] that extension contact significantly affected the adoption of improved technologies in rice production in Imo State, Nigeria.

The result for formal education was positive and significant at 1% level. This indicates that educated famers are more likely to use and continuously use improve technologies when compared to their uneducated counterparts with a smaller odd of 0.479 (1/ 2.084). The result is plausible because educated farmers are inquisitive, willing to learn and deliberate about improving their lots. These go a long way to make them try new technologies. Moreover, education has a way of making people teachable and less pessimistic about things. This result agrees with the findings of [18] that a positive and significant coefficient was found for education, he posited that the more farmers are educated the more likely they will adopt new technologies. This is also in congruence with [19] that willingness to adopt increases with years of schooling.

Membership of association was positive and significant at 1% level; this was further substantiated by an odd of 1.946. This indicates that farmers who are members of association have a higher probability of adopting improve technologies when compared to their counterparts with a smaller odd 0.514(1/ 1.946) who do not belong to any association. This result is plausible because membership of association increases the chances of farmers to meet and interact, share ideas, innovations and experiences. Furthermore, membership of association enables farmers' access to formal credit facilities faster when compared to individual farmers. Most farmers' associations are thrift and credit driven, this enables farmers to have access to very low interest loans which also increases their ability to purchase better inputs and also increase their use of new technologies.

The result for income was positive and significant at 1%. This implies that adoption of new technology increase with income level. This is seemingly acceptable because farmers who have more income will be more comfortable to try new technologies. Firstly, because they can afford the cost implications of trying new technologies. Secondly, they can afford to insure their farms. Higher income farmers are also willing to spend money to acquire quality education and trainings for their workers, by so doing they are willing to adopt improved technologies to increase their output. This finding agrees with [21] that income has a positive effect on technology adoption among rice farmers in Nigeria.

Credit status was positive ad significant at 1%, this implies that farmers who have access to both formal and informal credit are willing to adopt new technology. This is plausible because credit increases the purchase power of farmers to acquire better inputs and ideas. Secondly, farmers who have assessed credit will be more deliberate in their quest for better yield, this also may prompt the use of new improved technologies. This result is in congruence with the results of [22, 23] that access to credit was positive and significant at 10% on intensity of technology adoption among smallholder rice farmers in rural Nigeria.

Farming experience was negative and not significant. This implies that experience is not much of a concern for farmers to adopt new technologies. The result connotes that as farmers' experiences increases their tendencies to adopt new technologies reduces. More experienced farmers are likely to be aged farmers, aged farmers from the earlier discussion are very conservative ad not willing to take risk, this is because any adverse eventuality may result to more problems within the family and sometimes affect the health of the farmer. This is not the case for young farmers who are willing to take risk, and in the case of failure start all over again or at worst instances exit from agriculture to other seemingly more profitable ventures.

Table 9: Factors affecting the adoption of improved plantain production technologies.

Variables	Odds Ratio	Std. error	Z	Marginal Effect
Se2	1.011	0.031	0.23	0.009
Age	1.132	0.123	-2.48**	-0.413
Marital status	0.922	0.809	1.06	0.056
Extension visits	1.455	0.052	2.99***	0.067
Education	2.084	0.313	3.241***	0.567
Membership of Association	1.946	0.781	2.49**	0.136
Experience	0.842	0.081	-1.23	-0.670
Income	2.342	5.821	4.12***	0.351
Household size	0.826	0.019	1.07	0.509
Credit status	2.012	0.066	3.08***	0.001
Number of farmers	280			
Wald Chi 2 (10)	36.50			
Prob>Chi 2	0.003**			
Pseudo R^2	0.231			
Constant	1.97**			

*** and ** significant at 1% and 5% probability levels.

4. Conclusion and Policy Implication

This study concluded that there are distinctive differences in the productive factors associated with adopters and non-adopters of improved technologies, this also played a major role in the different levels of productive efficiencies between adopters and non-adopters of improved plantain production technologies in the study area.

Farmers who adopted improved technologies were more technically, allocative and economically efficient than their counterparts who do not adopt. Although the sampled farmers were not fully technically efficient, allocative efficiency is more of a challenge to the farmers than technical efficiency. The farmers' decision to adopt improved plantain production technologies was influenced by annual income, membership of association, extension visits, cost of technologies and access to credit.

The following recommendations were made from the findings of this study;

- Plantain farmers should be encouraged to adopt improved plantain production technology. This could be done by increasing farmers' contacts to adequate extension services, and access to information. This will boost their production efficiencies and thus improve their livelihood.
- The government and other stakeholders should increase plantain farmers' targeted interventions, such as loan schemes, trainings and access to inputs subsidies as is the case with other staples like rice, cassava and maize.
- The study recommends that plantain farmers should consider cost saving strategies alongside yield increasing strategies in their production activities.
- Membership of association should be encouraged, this will boost the farmers' information level, qualify them for formal and informal credit thus increasing their purchasing power to adopt improved plantain production technologies.

Conflict of Interest

There is no competitive interest regarding this manuscript.

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Availability of Data and Materials

Original data for the manuscript can be obtained from the corresponding author upon reasonable request

References

[1] Food and Agriculture Organization of the United Nations. FAOSTAT database [Internet]. Rome: FAO; 2018 (cited 2019 Dec 12). Available from: http://www.fao.org/faostat/en/#data/QC

[2] Olumba CC, Onunka C. Banana and plantain in West Africa: production and marketing. Afr J Food Agric Nutr Dev. 2020; 20(2): 15474-89. https://doi.org/10.18697/ajfand.90.18365

[3] Evans School Policy Analysis and Research. Banana and plantain value chain, West Africa. EPAR Brief No. 239. Seattle: EPAR; 2013.

[4] Tijani I, Omonona B, Ashaolu O, Bamiro O. Economic analysis of plantain production in Irewole Local Government Area, Osun State, Nigeria. Adv Nat Appl Sci. 2009; 3(2): 183-8.

[5] Ayanwale A, Fatunbi A, Ojo M. Innovation opportunities in plantain production in Nigeria. In: Guide Book 1. Forum for Agricultural Research in Africa (FARA); 2016; Accra, Ghana.

[6] Girei A, Dire B, Yuguda R, Salihu M. Analysis of productivity and technical efficiency of cassava production in Ardo-Kola and Gassol Local Government Areas of Taraba State, Nigeria. Agric Fish. 2014; 3(1): 1-5. https://doi.org/10.11648/j.aff.20140301.11

[7] Nyangena W, Juma OM. Impact of improved farm technologies on yields: the case of improved maize varieties and inorganic fertilizer in Kenya. Environ Dev Discuss Pap Ser. 2014; (14-02): 1-20.

[8] Norgrove L, Hauser S. Improving plantain (Musa spp. AAB) yields on smallholder farms in West and Central Africa. Food Secur. 2014; 6: 501-14. https://doi.org/10.1007/s12571-014-0365-1

[9] Olumba CC. Productivity of improved plantain technologies in Anambra State, Nigeria. Afr J Agric Resour. 2014; 9: 2196-204. https://doi.org/10.5897/AJAR2014.8891

[10] Okoruwa V, Sowunmi F, Ogundele F, Omigie C. Resource-use efficiency: an application of stochastic frontier production function to plantain farmers in Ogun State, Nigeria. J Econ Sustain Dev. 2014; 5(21): 114-27.

[11] Idumah F, Owombo P, Ighodaro U, Mangodo C. Economic analysis of plantain production under agroforestry system in Edo State, Nigeria. Econ Anal. 2016; 21(1): 138-44.

[12] National Bureau of Statistics. Annual statistical report for 2011/2012. Abuja: NBS; 2012. p. 231-9.

[13] Coelli TJ. Recent developments in frontier modelling and efficiency measurement. Aust J Agric Econ. 1995; 39(3): 219-45. https://doi.org/10.1111/j.1467-8489.1995.tb00552.x

[14] Olumba C, Rahji M. An analysis of the determinants of the adoption of improved plantain technologies in Anambra State, Nigeria. J Agric Sustain. 2014; 5(2): 232-45.

[15] Muhammad B, Mad NS, Alias R, Dan IAL. Efficiency analysis of cotton production: a case study of Gassol and Lau Local Government Areas of Taraba State, Nigeria. E3S Web Conf. 2018; 52: 00030. https://doi.org/10.1051/e3sconf/20185200030

[16] Farrell MJ. The measurement of productive efficiency. J R Stat Soc Ser A. 1957; 120(3): 253-81. https://doi.org/10.2307/2343100

[17] Gujarati DN, Porter DC. Basic econometrics. 5th ed. Singapore: McGraw-Hill/Irwin; 2009.

[18] Akintade TF, Okunlola JO, Akinbani AS. Factors influencing the adoption of plantain improved technologies among smallholder farmers in Edo State, Nigeria. Int J Biotechnol Healthc. 2016; 6(6): 96-100.

[19] Hui L, Diejun H, Qiuzhuo M, Wene Q, Hua L. Factors influencing the technology adoption behaviours of litchi farmers in China. Sustainability. 2020; 12: 271. https://doi.org/10.3390/su12010271

[20] Onyeneke RU. Determinants of adoption of improved technologies in rice production in Imo State, Nigeria. Afr J Agric Res. 2017; 12(11): 888-96.

[21] Awotide BA, Karimov AA, Diagne A. Agricultural technology adoption, commercialization and smallholder rice farmers' welfare in rural Nigeria. Agric Food Econ. 2016; 4(3): 1-24. https://doi.org/10.1186/s40100-016-0047-8

[22] Awotide DO, Kehinde AL, Akorede TO. Metafrontier analysis of access to credit and technical efficiency among smallholder cocoa farmers in Southwest Nigeria. Int Bus Res. 2015; 8(1): 132. https://doi.org/10.5539/ibr.v8n1p132

[23] Shadrach O. Effect of access to credit on agricultural productivity: evidence from cassava farmers in the Afigya-Kwabre District of Ghana. Int J Innov Res Soc Sci Strateg Manag Tech. 2017; 4(3): 55-67.