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Original Paper

Assessment of The Technical Efficiency and Cost and Returns on Seed Yam Farms in North-Central

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***Abstract*—Achieving maximum output with a minimum level of resources has been a major discourse in recent years mostly in Nigeria's seed yam production. Thus, the study evaluated the technical efficiency of the CAY- and NRCRI - seed yam farm and the costs and returns to seed yam production of CAY- and NRCRI - seed yam farms. The study adopted a quantitative research approach. Similarly, a multistage sampling method was used to 283 seed yam farmers. Descriptive statistics, cobb douglas stochastic frontier production function model and gross margin analysis were used for the study. The findings of the study revealed that technical efficiency scores of CAY- (20%) and NRCRI (17%) – seed yam farmers were generally low respectively, Similarly, CAY-Seed yam farmers' farms had a higher gross margin ($199.64) when compared to NRCRI seed yam farmers' farms ($97.29), The study concludes that seed yam technologies did not generally improve the technical efficiency of the seed yam farms. The study recommends that external factors such as seed yam varieties used should be assessed. For instance, farmers' compliance to technologies introduced and the state of health of seed yam farmers should be considered in determining the technical efficiency of farms.**

Keywords*— gross margin, output, resources, seed yam, technologies, technical efficiency

I. Introduction

Although, the importance of yam in addressing food insecurity cannot to be over emphasized, considerations given to yam production has in recent times soared particularly in Nigeria. Globally, over 600 classes of the genus *Dioscorea* exist in the world however, the most significant edible species are *D. rotundata* (white yam), *D. cayenensis* (yellow yam), *D. dumetorum* (bitter yam), *D. esculenta* (Chinese yam), *D. alata* (water yam), [1]. In West African, *D. rotundata* is the most cultivated and preferred. According to IITA, after harvest and storage, the average profit per seed yam was estimated at about US$13, 000 per hectare. Yam is said to play a very important role in providing food and income of yam farmers in Nigeria. In addition, the West African region together produce approximately 83 per cent of yam in the world. However, Nigeria is the world's foremost producer of yams and accounts for 70 per cent of the world's supply [2]. Nutritionally, yam serves as a source of energy for households in Nigeria. It also adds to the protein content of the diet [3]. Similarly, the vitamin contents of some yam tubers include riboflavin, niacin (nicotinic acid) and carotene thiamine which are essential for human development. Some of the major reasons why farmers participate in yam cultivation is for consumption, generation of income through sales of ware yams and cultivation of planting material use while selling the surplus seed yams for extra income generation. Likewise, in Nigeria, yams are traditionally used during annual festivals and ceremonies for rituals rites. Thus, making yam a crop of great importance.

However, yam production has been affected by many constraints, such as pests and diseases, high cost of quality seed yams, high levels of post-harvest losses, high cost of labour, low and declining soil fertility [22]. When it comes to yam production, most yam farmers make use of previously saved seed tubers from the last harvest for propagation and these saved seed tubers most often than not are already affected by pests and diseases thereby leading to poor yields. Damage from infections caused by nematodes, viruses, and bacterial are leading causes of poor seed quality [4]. A yield loss of about 50 per cent due to viruses was reported in western Nigeria [5]. [4] noted that the incidence of Yam Mosaic Virus (YMV) and Yam Mild Mosaic Virus (YMMV) occurred in five states including the Federal Capital Territory (FCT) due to the exchange and utilization of diseased planting materials between these States. According to [6], a low multiplication ratio of seed yam from ratio 1:4 to 1:8 has been experienced thus, making it difficult for quality seed tubers to be multiplied rapidly for sale to yam farmers. the National Root Crop Research Institute and the CAY-Seed yam projects were launched in 2004 and 2014 respectively. These seed yam projects envisioned that seed yam farmers would engage in the production and sales of high-quality seed yams as yam remains the desired starchy staple for households in West Africa.

In Nigeria, studies on food crop production have shown that low productivity occurs in farm production due to inefficiency in resource use [7]. A farmer experiences increased productivity when resources are used efficiently, and new technologies adopted [23]. The study was carried out to examine how technically efficient the CAY- and NRCRI - seed yam farms were and what the costs and returns to seed yam production by CAY- and NRCRI - seed yam farms were. This study was based on the theory of efficiency which was developed by Farrell's pioneering work in 1957. Farell stated that the efficiency of a firm includes the technical and allocative components. In addition to these components, Farell defined economic efficiency as the capacity of a firm to produce a predetermined amount of output at the barest cost using a given type of technology. Economic efficiency is calculated when technical and allocative components of efficiency are multiplied [8]. Technical efficiency on the other hand occurs when a firm obtains maximum output from a given quantity of input. Furthermore, the technical efficiency level of a firm is determined by the distance of a firm's production level from the optimal production frontier. Efficiency is determined by the availability of resources needed to obtain a given amount of output. It involves comparing the existing level of production with a targeted level. Thus, a firm is efficient when it produces more with the available inputs. The theory provides a basis for determining how different seed yam farmers have adopted certain improved seed yam technologies and how these technologies have improved the productivity and efficiency of their farms. This research paper is further sectioned as follows: Section 2 provides the methodology of the study while section 3 presents the findings of the study. Section 4 makes available the conclusion and recommendations of the study.

II. METHODOLOGY

A. Study area

The study was carried out in Benue State and the Federal Capital Territory which are in Nigeria. These locations were selected because they were pilot sites were the CAY- and NRCRI-Seed yam projects were conducted. Nigeria is located on latitudes 4° and 14°N, and longitudes 2° and 15°E__of the Gulf of Guinea. Nigeria is in western Africa and has a land area of about 923,768 km^2. Nigeria's annual rainfall is between 1,500 to 2,000 mm per year. Similarly, the FCT is characterized by having a tropical wet and dry climate and lies between longitude 6.45^0E and 7.29^0 E and latitude 8.25^0 N and 9.4^0 N. The FCT has an annual rainfall of 1215-1500mm and a temperature of 28 °C to 30 °C. It also has a total population of 7,128,100 persons [9, 10]. Benue State lies between 7°20′N and 8°45′E experiences both dry and wet seasons. The annual rainfall varies between 1215-1500mm, while the temperature fluctuates between 21°C to 37°C. The land area for Benue state is about 34,059 km^2 (13,150 sq mi). Benue state has a total population of about 5,741.600 persons [10].

B. Sampling Techniques

Primary data was used for the study. Primary data were gotten from the use of structured questionnaire. The study adopted a multi-stage random sampling technique. The first stage was the purposive selection of the states because they were pilot sites for the seed yam projects. Further, the second stage was the purposive selection of villages due to their seed yam farming activities. Lastly, Seed yam farmers were randomly selected. A total of 283 seed yam farmers who participated in the seed yam projects were used for the study.

C. Analytical tools

The stochastic frontier model was used to evaluate the technical efficiency of CAY- and NRCRI-Seed yam farms. In addition, the study employed gross margin analysis to assess the costs and returns to seed yam production by the seed yam farms. t-test was used to test for the research hypotheses. Aigner, et al., (1977) simultaneously formulated the stochastic frontier model with [11] These researchers based their research works on Farrell's seminar paper of 1957 where he propounded the efficiency measure and defined productive efficiency as the production of a level of output at a low cost by a firm. According to [12], four methods of measuring and estimating efficiency exist. These methods include the deterministic statistical approach, parametric programming approach, non-parametric programming approach, stochastic frontier production approach [13]. The non-parametric programming and stochastic frontier production function have been called data envelopment analysis (DEA) and are used to assess the efficiency of a firm. The Stochastic Frontier Approach, an econometric frontier approach identifies the relationship between the expected output and input levels and breaks the error term into two parts namely, inefficiency component and random error.

The economic applications of the stochastic frontier model for production efficiency analysis have been assessed by different studies across Nigeria. For this research work, however, the Cobb Douglas Stochastic Frontier model was adopted to analyse the technical efficiency of CAY-and NRCRI - seed yam farmers' farms because it is a powerful tool used majorly to examine the effects of projects and interventions as it produces efficiency scores of individual units. These scores would be useful if corrective measures are to be applied. The formula according to [14] is implicitly expressed as follows:

$$yi = \beta_0 R_1^{\beta 1} R_2^{\beta 2} \ldots\ldots e^{ui.} \quad (1)$$

$$Lny_1=\beta_0+\beta_1 l nR_1+\beta_2 l nR_2+\beta_3 l nR_3+\beta_4 l nR_4+\beta_5 l nR_5+(V_i - U_i) \quad (2)$$

$$Lny_1=\beta_0+\beta_1 l nsetts+\beta_2 l nbiopest+\beta_3 l nfert+\beta_4 l nfarmsize+\beta_5 l nlabour+(V_i - U_i) \quad (3)$$

Where, the Cobb-Douglas functional form was used to assess the technical efficiency of CAY-and NRCRI - seed yam farmers' farms. The Cobb-Douglas production functional form for CAY-Seed yam farmers' farms is specified as:

Y_1 = Total farm output of ith farmer (kg)
R_1 = Quantity of setts planted (kg)
R_2 = Biopesticides used(kg)
R_3 = Quantity of fertilizer used (kg)
R_4 = Farm Size (Ha)
R_5 = Labour (man-days)
B = coefficient
V_i = random error
U_i = technical in-efficiency effects independent of V_i. Inefficiency model is defined as:

$$U_i = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 + \delta_5 z_5 + \delta_6 z_6 + \delta_7 z_7 \ldots \delta_{12} z_{12}$$

Where:
U_i = Inefficiency effect
Z_1 = Age (years)
Z_2 = Household Size (Number of Persons)
Z_3 = Farm experience (years)
Z_4 = Years of Schooling (years)
Z_5 = Source of Labour (Family=1, Hired=2, Both=3)
Z_6 = Source of Finance (Personal=1, Family Members=2, Bank=3, Cooperative=4, Money Lender=5)
δ_o = constant term
δ_1-δ_7 = coefficient.

Gross Margin Analysis was used to estimate the costs and returns to seed yam production of CAY- and NRCRI - seed yam farmers farms. This formula was used by [15]. The formula specification is stated thus:

$$GM = TR - TVC \quad (3)$$

Where:
GM = Gross Margin
TR = Total Revenue
TVC = Total Variable Cost

The t-test (two paired t test with unequal variance) was used to test the research hypothesis which states that.
H_0**:** There is no significant difference between the technical of CAY- and NRCRI-Seed yam farms. The equation is as follows:

$$t = \frac{(x - y) - (\mu x - \mu y)}{s\sqrt{\frac{i}{nx} + \frac{i}{ny}}} \quad (4)$$

Where:
t = t-test value
x = mean of technical efficiency of CAY-Seed yam farms
y = mean of technical efficiency of NRCRI- Seed yam farms
μ = mean weight
n = sample size
s = standard deviation

III. Results And Discussion

A. Socioeconomic characteristics

The findings of the study are discussed in this section. Figures 1, 2, and 3 shows some socio-economic characteristics of the seed yam farmers. Fig 1 revealed that men engaged more in the production in seed yams then women. This might be due to the tedious activities involved in cultivating seed yams. Similarly, fig. 2 showed that majority of the seed yam farmers were still within their active ages. This is understood to be an advantage particularly in the of technological uptake and use. Fig. 3 indicated that majority of the seed yam farmers has a farm size of between <0.5-2.9. This implies that most of the seed yam farmers were small holder farmers which means that perhaps, due to their farm sizes, quantities of seed yams produced may have been limited.

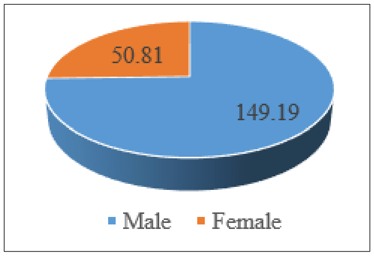

Fig. 1. The Gender proportion of CAY- and NRCRI- seed yam farmers

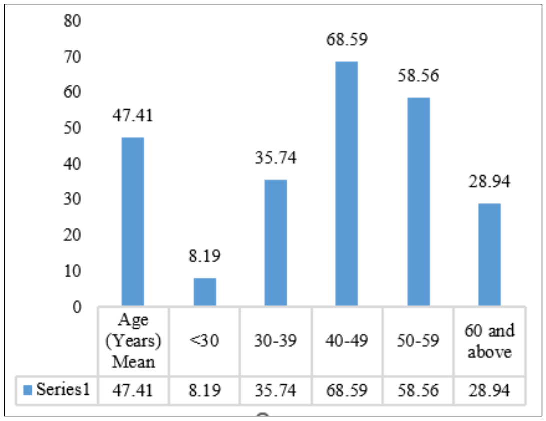

Fig. 2. The Proportion of Age of CAY- and NRCRI- seed yam farmers

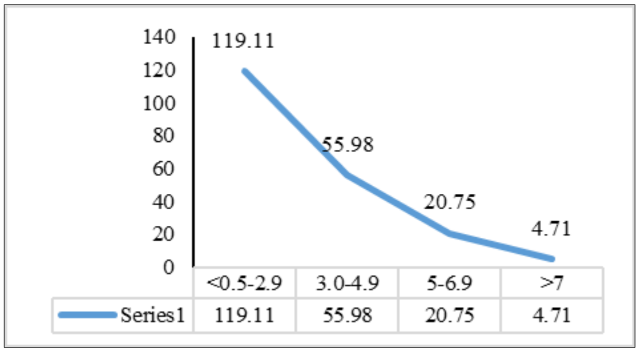

Fig. 3. The share of Farm size of the CAY- and NRCRI- seed yam farmers

B. Technical Efficiency and Inefficiency of seed yam farmers

The maximum likelihood estimation results in Table 1 shows that the values of sigma (σ^2) for CAY-Seed yam farms was 8.870 and 3.407 for NRCRI seed yam farms which were statistically significant. The values of gamma (γ) were 3.2E-06 for CAY-Seed yam farms and 0.970 for NRCRI seed yam farms and were not statistically significant. Thus, implying that the output of seed yams was not attributed to the technical efficiency but was because of the random noise. The values of the likelihood ratio for CAY-Seed yam farms were 56.57 and 0.2181 for NRCRI seed yam farmers. This implies that the pressure for the technical inefficiency or the one-sided specification was high for CAY-Seed yam farms and low for NRCRI seed yam farms.

The result further reveals that for CAY-Seed yam farms, 2 variables were significant for the technical efficiency while 4 variables were significant at 5% ($p < 0.05$). For NRCRI seed yam farmers, 2 variables were statistically significant for the technical efficiency while for the technical inefficiency, 1 variable was positive and statistically significant at 5% ($p < 0.05$). The coefficients for yam sett were positive and significant at 5% ($p < 0.05$) for both CAY- and NRCRI seed yam farms. This implies that seed yam farmers use 1 kg of yam sett, the output of seed yam would increase by 17.4% for CAY-Seed yam farms and 52.3% for NRCRI farms. This finding is supported by Shehu et al. (2010) who stated that an increase in the use of quality seeds would increase output. The coefficient for biopesticide was positive and significant at 5% ($p < 0.05$) for CAY-Seed yam farms but not significant for NRCRI seed yam farms. This implies that a unit increase in the use of biopesticide would increase the output of CAY-Seed yam farms at 22.5%. The coefficient for labour was positive and significant at 5% ($p < 0.05$) for NRCRI seed yam farms but not for CAY-Seed yam farms. This implies that an increase in Man days would lead to an increase in the output of seed yams by 28.2% for NRCRI seed yam farms. This result agrees with [16] and [17] who explained that an increase in the number of man-days of labour leads to an increase in the output of yam.

The result for the inefficiency variables reveals that the coefficient for age was positive and statistically significant at 5% ($p < 0.05$) for CAY-Seed yam farms. However, it was not significant for NRCRI seed yam farms, this implies that as farmers grow older, their level of technical inefficiency increases. This maybe because of farmers not being within active ages hence their low interest in adopting and utilizing new technologies. This result is supported by [18] who indicated that as farmers grow older, they become inefficient because of the continuous use of uncertified seeds which they preserved from previous harvest seasons. The coefficient for household size was positive and statistically significant 5% ($p < 0.05$) for both CAY – and NRCRI- seed yam farmers. This implies that the larger the household size, the more their technical inefficiency. This may be because of many dependents who do not adequately contribute to farming activities. This finding is in line with [19] who explained that larger household size could increase the inefficiency of the farmers.

Years of schooling was positive and statistically significant at 5% ($p < 0.05$) for CAY-Seed yam farmers and not for NRCRI seed yam farmers such that the more the years of schooling farmers has the higher the technical inefficiency of seed yam farmers. This might be because of the seed yam farmers not adequately applying proper knowledge for increased productivity. This result disagrees with the findings of [20] who reported that a year of schooling could lead to a reduction in inefficiency. Source of finance was negative and significant at 5% ($p < 0.05$) for CAY-Seed yam farmers and not for their NRCRI counterpart. Thus, indicating that when CAY-Seed farmers have more access to source of finance, their technical inefficient decreases. This is because access to more source of finance would enable the seed yam farmers to acquire more inputs for their seed yam production. This result disagrees with the findings of [19] and [20] who explained that farmers could easily divert finance to engage in other non-profit farm activities. Furthermore, Table 2 presents the t test results for the technical efficiency of the seed yam farmers. The result reveals that the mean efficiency of the CAY-Seed yam farms was about 20% while that of the NRCRI seed yam farms was about 17% which were generally low. In addition, there was no significant difference between the mean efficiency scores of CAY- and NRCRI - seed yam farms. This implies that both groups of seed yam farms had low technical efficiencies. This could be because of the seed yam farmers not making adequate use of efficient use of the available inputs such as fertilizers, biopesticides extension services support, and improved planting materials.

TABLE I. MAXIMUM LIKELIHOOD ESTIMATION OF THE TECHNICAL EFFICIENCY AND INEFFICIENCY OF CAY-AND NRCRI-SEED YAM FARMS

Variable	Coeff.	P-val.	Ceoff.	P-val.
Yam Sett	0.174**	2.996	0.523**	3.098
Biopest.	0.225**	3.265	0.033	1.123
Fertilizers	0.033	1.343	-0.037	-1.53
Labour	0.219	3.751	0.28**	3.665
Farm size	0.236	1.933	0.013	0.209
Constant	3.871**	8.914	3.25**	4.180
Ineff. Variable				
Age	0.361**	2.056	0.094	0.476
HH Size	0.153**	2.103	0.23**	2.608
FarmExp.	-0.162	-1.17	-0.074	-1.21
Schooling	0.125**	2.243	0.092	1.162
Labour	0.760	1.110	0.021	0.225
Finance	0.129**	-3.26	-0.100	-0.09
Sigma^2(σ)	0.447	8.870	0.141	3.407
Gamma	0.100	3.2E6	0.321	0.970
Like. ratio	56.70		0.218	

Note: ** = 5% significance level

TABLE II. T-TEST OF THE TECHNICAL EFFICIENCY SCORE OF CAY- AND NRCRI – SEED YAM FARMS

Technical Efficiency	No of Observations	Mean Score	Std. Dev	T-test of diff btw the mean of 1&2
CAY-Seed	133	0.1969411	0.3021601	0.8138
NRCRI	150	0.1746202	0.1383558	

C.Gross margin analysis

The result of the costs and returns to seed yam production by CAY- and NRCRI - seed yam farms are presented in Tables 3 and 4.

Table 3 shows the gross margin analysis representing the costs and returns to seed yam production by CAY- and NRCRI - seed yam farms. The result revealed the total output for CAY-Seed yam farms was 2761 kg/ha while that of NRCRI was 3151.64 kg/ha. Also, 1 kg of seed yams was sold at $ 0.16 by CAY-Seed yam farmers while NRCRI seed yam farmers sold 1 kg of seed yams for $ 0.065. The difference in the price of CAY-Seed yams could be because of preference, taste, and the reduced use of inorganic fertilizer. Table 3 further revealed that the total revenue for CAY-Seed yam farmers ($448.91) was higher than that of NRCRI seed yam farmers ($203.82). Also, the total variable cost for CAY-Seed yam farmers ($249.27) was higher than that of NRCRI seed yam farmers ($106.53). Lastly, the gross margin ($199.64) for CAY-Seed yam farms was also larger than that of NRCRI seed yam farms ($97.29). Thus, indicating that CAY-Seed yam farms had higher costs and returns as compared to the NRCRI seed yam farms. This could be due to size, taste, and high cost of seed yams in the Federal Capital Territory as compared with Benue State.

TABLE III. GROSS MARGIN ANALYSIS TO SEED YAM PRODUCTION BY CAY- AND NRCRI - SEED YAM FARMS

	CAY-Seed	NRCRI
Output (Ha)	2761 ($ 0.16)	3151.64 ($0.065)
Revenue	$448.91	$203.82
TVC	$249.27	$106.53
GM(TRTVC)	$199.64	$97.29

(Price in Parenthesis)

Table 4 gives the t-test result of the difference in the means of gross margin per hectare for CAY- and NRCRI - seed yam farms. The result reveals that there was a significant difference in the mean of the gross margin of CAY- and NRCRI - seed yam farms. This implies that CAY-Seed yam farms had a higher gross margin than the NRCRI seed yam farms. This could be because of CAY-Seed yam farmers selling their seed yams at higher prices. Hence, the null hypothesis was rejected.

TABLE IV. T-TEST FOR THE GROSS MARGIN OF CAY- AND NRCRI - SEED YAM FARMS

CAY-Seed (1)	NRCRI (2)	Total Sample (3)	T-test of diff between 1 &2
$199.64	$97.29	$159.55	4.382

IV. CONCLUSION

Seed yam production in Nigeria experienced a decline in previous years due to some factors which influenced the technical efficiency of the farms. This study focused on examining the technical efficiency and the costs and returns to seed yam production by CAY- and NRCRI - seed yam farms. The study revealed that men engaged more in the production in seed yams then women. This might be due to the tedious activities involved in cultivating seed yams. Similarly, the study showed that majority of the seed yam farmers were still within their active ages. This is understood to be an advantage particularly in the of technological uptake and use. Likewise, the study indicated that majority of the seed yam farms were smallholder farms. The values of gamma (γ) were not statistically significant. Thus, indicating that the output of seed yams was not attributed to the technical efficiency but was because of the random noise. The values of the likelihood ratio for CAY-Seed yam farms indicated that the pressure for the technical inefficiency or the one-sided specification was high for CAY-Seed yam farms and low for NRCRI seed yam farms. The result further reveals that for CAY-Seed yam farms, variables such as yam sett, biopesticides and labour were significant for the technical efficiency. For the technical inefficiency, age, household size, years of schooling and source of finance were statistically significant. The study concludes that the technical efficiency for CAY-and NRCRI-seed yam farms were low while the gross margin for CAY-Seed farms were higher than their counterpart. The study recommends that other external factors such as seed yam varieties use and compliance to technological use by farmers and the health of seed yam farmers should be considered as this will aid in improving the technical efficiencies of seed yam farms.

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