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*RESEARCH ARTICLE*

# SENSITIVITY ANALYSIS AND FUTURE FARM SIZE PROJECTION OF BIO-FORTIFIED CASSAVA PRODUCTION IN OYO STATE, NIGERIA

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**ABSTRACT**

The study examined the costs and returns to bio-fortified cassava production and forecast the future farm size of bio-fortified cassava production in Oyo State, Nigeria. A multistage sampling technique was used to select our respondents. Primary data were used for the study which were collected through a well-structured questionnaire. Data collected were analyzed using descriptive, Markov chain, and budgetary analysis. The result of the study showed that TMS 01/0593, TMS 01/0539 and TMS 01/0220 were the mostly grown varies of bio-fortified cassava varieties in Oyo State, Nigeria. The result of the budgetary analysis showed that the average net return (net farm income) from the production of bio-fortified cassava was ₦196710.95 with RORI of 224.95%. The result revealed that at 35% increase in cost of production, the rate of return on investment dropped to 140.70% in which the investment will not be viable. The bio-fortified cassava farmers have a great potential to boost production through increases in farm sizes of the bio-fortified cassava famers until the year 2026 when equilibrium would be attained at about 2.85ha. In order to adequately achieve these goals, more improved varieties of bio-fortified cassava should be provided. Consequently, infrastructures should be put in place to help boost farmers moral in their cause of production.

**KEYWORDS**

Sensitivity Analysis, bio-fortified cassava, Markov chain, Farm size, Oyo State.

## 1. INTRODUCTION

Cassava is the world's fourth most important staple crop after rice, wheat and maize, and plays an essential role in food security. Due to cassava's growth characteristics and ability to grow in poor soils and regions prone to drought, it is preferred by resource poor farmers in many tropical countries (Mtunguja et al., 2019). Cassava (Manihot esculenta Crantz), a starchy root crop, is a major source of food security in Africa because of its ability to grow in low-quality soil, its resistance to drought and disease, and its flexible cultivation cycle (Meridian Institute 2013; Sanni et al., 2009). Cassava's harvestable portion, the tubers, can be stored underground until needed, making it an ideal food security crop (Nweke 2003). Cassava is the most widely consumed food staple in Nigeria (Sanni et al., 2009).

Cassava is an important staple food in Nigeria (Kolapo et al., 2020). According to a study about 177,948 million tonnes of cassava were produced in Africa (Otekunrin and Sawicka, 2019). Nigeria is regarded as the world's largest producer of cassava with a total of about 20.4 percent of the world export in year 2017 (Otekunrin and Sawicka, 2019). Cassava is a major staple food crop in Nigeria. As defined, a staple crop is the one that is been eaten regularly and which also provides larger proportions of the population's nutrients (Otekunrin and Sawicka, 2019). Cassava fulfil this purpose as it can be eaten raw or in a processed form. Cassava is an essential component of the diet of about 70 million Nigerians (FAO, 2013). Nigeria, being the largest producer of cassava in the world is producing an average annual estimate of 45 million metric tons which had been translated into a major global market share of about 19 percent (Hillocks, (2002); Phillips et al., 2004). A small fraction of cassava output in the country is produced for commercial use in the livestock feed, ethanol, textile, confectionery, and food industries, while the majority is produced by smallholder farmers for subsistence or small-scale processing (Knipscheer et al., 2007).

Cassava is adapted to growing on poor degraded soils and can tolerate low pH, high levels of exchangeable aluminum and low concentrations of phosphorus, conditions that typically limit crop growth (Howeler, 2002). Sandy soils have been also found to be suitable for cassava production because of easy root penetration and expansion of the growing root during carbohydrates partitioning. Sandy clay loam soils are also appropriate due to the high-water retention capacity which provides a good distribution of soil water for long periods even after the onset of dry season (Mtunguja et al., 2016b). Nevertheless, adequate soil nutrient availability important for increasing cassava production and dramatic differences in cassava yield has been reported, with changes in soil nutrient supply (Mtunguja et al., 2016b).

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Cassava is the main staple crop in Nigeria. While it is inexpensive and a good source of carbohydrates, it lacks nutritional value, as it is a poor source of protein, vitamins, and minerals (McNulty and Oparinde, 2015). Nigerians who are restricted to the consumption of a cassava-based diet are at risk of micronutrient malnutrition, which can cause blindness, stunting, and increased susceptibility to disease. To combat hidden hunger, HarvestPlus and its partners have bred provitamin A-rich yellow cassava varieties (McNulty and Oparinde, 2015). The production of biofortified vitamin-A cassava started in 2011 with the intervention of the International Center for Tropical Agriculture (CIAT) and the International Institute of Tropical Agriculture (IITA) which were funded by Harvest Plus program (Kolapo and Fakokunde, 2020; Kolapo et al., 2020). Five years after the intervention program, statistics revealed that over 1million of Nigerian farming households grows yellow cassava varieties that contains substantial quantities of vitamin-A even after processing (Kolapo et al., 2020). In Nigeria diets today, yellow bio-fortified cassava represents additional source of vitamin A (Saltzman et al., 2014).

However, majority of the bio-fortified cassava farmers were still producing on a small scale due to a myriad of factors including lack of general acceptance of the product despites its nutritional benefits to human population. According to a study, production of bio-fortified cassava is still on a relatively small farm size despites the release of the first wave of vitamin A cassava in 2011 (Ilona et al., 2017). Hence, to a large extent accounts for the low supply of bio-fortified cassava products like vitamin A yellow garri, fufu and high-quality cassava flour relative to the demand for these products thus necessitating the need to project the future farm size with a view to determining what the future holds for bio-fortified cassava production.

In commercial enterprises, profit is a major motivating factor. The profit and profitability levels of farm enterprises may be influenced by the farm size. This is because it is assumed that with larger farm size the cost of production is spread across the number of hectares and as such profitability is increased. Thus, it is necessary to examine the trend in size of farms to determine their intertemporal performance. The specific objective of the study were to described the socio-economic characteristics of the bio-fortified cassava farmers; forecast the future farm size of bio-fortified cassava production and estimate the cost and return to bio-fortified cassava production.

## 2. THEORETICAL FRAMEWORK

In other to project the future farm size of bio-fortified cassava production, Markov chain model was utilized. Markov chain are one of the conceptual devices used in analyzing the types of changes obtainable when there is movement from one state to another (Anders, 2016). It was first used in the study of Markov A.A in 1907 and has been used in various sectors ranging from agriculture, health and migration studies to forecast and predict future trend. In Agriculture it is useful in predicting and forecasting the behavior of farmers as they move from one categories of farm size to another. It is one of stochastic process in which the probability or likelihood associated with a set of possible future outcome is stated. A stochastic process refers to mathematical model with a sequence of random variables which assumes that any population of individuals or firms can be classified into various groups. As such, movements between states over time is regarded as a stochastic process (Olatidoye et al., 2018). A finite Markov process is one in which the outcome of a given trial (experiment) in the time (t + 1) essentially depends on the outcome of the trial in the preceding time period (t) and this dependence holds at all the various stages of the trial. Markov chains are often characterized by the dynamic property, such that as the present condition is known, prediction about the future outlook or behavior of the process remain the same, even if additional information about past history of the process is known (Anders, 2016). Finite Markov chain process often determined by specification of a given set of states ($S_1, S_2 \ldots S_n$). Only one state is achievable at a given time and it moves progressively from one state to another. The probability of moving from Si to $S_j$ is given for every pair category can be represented in the form of transition matrix P. $P_{ij}$ refers to the probability of moving from Si to $S_j$ in the next step. The element of the matrix must be non-negative, and the row sum of the elements is one. when all the initial probability is known, outcome of the nth step, can be gotten

$$P = \begin{pmatrix} & S_1 & S_2 \ldots S_n \\ S_1 & P_{11} & P_{12} \ldots P_{1n} \\ S_2 & P_{21} & P_{22} \ldots P_{2n} \\ \vdots & \vdots & \vdots \quad \vdots \\ S_n & P_{n1} & P_{n2} \ldots P_{nn} \end{pmatrix} \quad (1)$$

$$P = [P_{ij}] = \left[\frac{n_{ij}}{\sum_{j=1}^{n} n_{ij}}\right] \geq 0 \text{ (j = 1, 2, 3, - - -, m)} \quad (2)$$

Hence, the future path of the stochastic process is given by;

$P^{(0)} P = P^{(1)}$ state vector in time, t + 1

$P^{(1)} P = P^{(2)}$ state vector in time t + 2

$P^{(m-1)} p = p^{(m)}$ state vector in time t+m (3)

Therefore, $P^{(0)}$ $P^{(e)}$ gives the fixed probability vector, or equilibrium probability vector of the stochastic process.

Hence: $P^{(m)} \rightarrow P^{(e)}$ as $m \rightarrow \infty$

$P^{(o)} P^{(e)} = P^{(e)}$

$P^{(e)} P = P^{(e)}$ (4)

The equilibrium farm size indicates that the number of people entry a particular category of farm size is equal to the number of farmers leaving the group. The underlying assumptions on which Markov chain includes the following; The structure of the population when the transition probability is made remain constant, the underlying determinant of a change in one category of farm size is represented by a probability of individual movement from one category of farm size to another depends on the result proceeding of the period. There are several application of Markov model in Agricultural economics such as market structure and economic development. Empirical studies that employed the use of Markov chain include those of (Alimi et al., 2007; Baruwa et al., 2011; Olatidoye et al., 2018).

## 3. METHODOLOGY

### 3.1 Area of Study

The study was conducted in Oyo States, Nigeria. Oyo State is an inland state in South-Western Nigeria, with its capital at Ibadan. It is bounded in the north by Kwara State, in the East by Osun State, in the South by Ogun State and in the West partly Ogun State and partly by the Republic of Benin with a population of 5,591,589 people (NPC, 2006). Oyo State is homogeneous, mainly inhabited by the Yoruba ethnic group who are primarily agrarian but have a predilection for living in high-density urban centers. Oyo State covers approximately an area of 28,454 square kilometers. Oyo State is located in the rainforest vegetation belt of Nigeria on longitude of $2^0 38.66^1$N and $4^0 38.25^1$N and latitude $9^0 8.74^1$E and $7^0 1.68^1$E. Agricultural activities in Oyo State include the production of different varieties of arable food crops since the climatic conditions support the production of various food crops including cassava, maize, groundnut etc. A large proportion of the bio-fortified cassava were being produced in the State as the distribution of bio-fortified cassava stem started in Oyo State in 2011, hence the choice of the study area.

### 3.2 Sampling procedures and sample size

Multistage sampling procedures were employed for the study. The first stage involved purposive selection of two Local Government Areas (LGAs) because of the concentration of bio-fortified cassava producers in the areas. The second stage involved random selection of three communities from each of the selected LGAs. At the third stage, twenty-five bio-fortified cassava farmers were purposively selected from each community to make a total of 150 (One hundred and fifty) respondents. Primary data were used for the study. The primary data were sourced from cross-sectional survey of bio-fortified cassava farmers in the study area with the aid of well-structured questionnaire to cover information about the socioeconomic characteristics of respondent and inputs and outputs of bio-fortified cassava production. Data were collected in December 2018.

### 3.3 Analytical techniques

The data were analyzed using descriptive statistics, Markov Chain Analysis, Farm budgeting analysis (Gross margin sensitivity).

### 3.4 Markov Chain analysis

Markov Chain analysis was employed in this study to predict and forecast the future farm size of bio-fortified cassava farmers production. Markov Chain process is a stochastic model used in the analysis of economic variable with the availability of a time-ordered data. (Amina and Akhigbe, 2017). Bio-fortified cassava farmers were grouped according to some criteria of farm sizes (states). Secondly the evolution of bio-fortified cassava farmers through these states can be regarded as a stochastic process. The probability of moving from one state (t) to another (t+1) is a function only of the two states (t, t+1) involved. The movement of the bio-fortified cassava farmers within the farm size depends on the initial farm size attained and the number of years involved which is independent of the previous history (Ander, 2016). Within this framework, farm sizes cultivated are the variable whose movement over time is to be analyzed, and the following class intervals will be used in defining the admissible states.

**Table 1:** Distribution by size

| Class | Farm size in (ha) |
|---|---|
| S1 | 1-2 |
| S2 | 2.1-3 |
| S3 | 3.1-4 |
| S4 | 4.1-5 |

Therefore, in a year it is possible for a bio-fortified cassava farmer to be in any one of the four specified positions. Having defined the data and the ranges for each class, the year-to-year history of each bio-fortified cassava farmer in terms of his movement among the various classes was used in developing the transition matrix, which reflects the behaviour of the sample of bio-fortified cassava farmers. Let $u_{ij}$ represent the number of farmers moving from class i to class j through the years under consideration. The transition probabilities ($P_{ij}$) can be represented in the form of transition matrix P. Pij is the probability of bio-fortified cassava farmers transitioning from state i to j (one farm size category to the other).

$$\text{Pij} = \begin{matrix} \\ S_1 \\ S_2 \\ S_n \end{matrix}\begin{bmatrix} S_1 & S_2 & \dots S_n \\ P_{11} & P_{12} & P_{1n} \\ P_{21} & P_{22} & P_{2n} \\ P_{n1} & P_{n2} & P_{nn} \end{bmatrix}$$

$$P = [P_{ij}] = \left[\frac{n_{ij}}{\sum_{j=1}^{n} n_{ij}}\right] \geq 0$$

i. $\sum_{j=1}^{m} P_{ij} = 1$ (row summation of probability should equal to one)

ii. $P_{ij} \geq 0$ (for all i and j)

iii. $P_j = \frac{n_j}{N}$ (1,j = 1,2,3....,m)

The long run equilibrium is attained when the total number of bio-fortified cassava farmers entering a given farm category equals the number of farmers exiting. This is expressed as follows: eP = e.

$$(e_1, e_2, e_3,)\begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix} = (e_1, e_2, e_3,)$$

**Table 2:** First-order Markov model for farm size transitions

| Period 1 (t) | Period 2 (t +1) | | | | Total |
|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | $S_3$ | ......Sn | |
| $S_1$ | $n_{11}$ | $n_{12}$ | $n_{13}$ | ...$n_{1m}$ | $n_1$ |
| $S_2$ | $n_{21}$ | $n_{22}$ | $n_{23}$ | $n_{2m}$ | $n_2$ |
| $S_3$ | $n_{31}$ | $n_{32}$ | $n_{33}$ | $n_{3m}$ | $n_3$ |
| . | . | . | . | . | . |
| . | . | . | . | . | . |
| . | . | . | . | . | . |
| $S_m$ | $n_{m1}$ | $n_{m2}$ | $n_{m3}$ | $n_{mm}$ | $n_m$ |
| Total (Period t +1) | $n_1$ | $n_2$ | $n_3$ | n.m | N |

Source: Author's, 2019

### 3.5 Budgetary technique (Gross margin sensitivity)

The gross margin of the farm is a measure of output and farm profitability, which is a useful indicator in planning. Gross Margin (GM) is the difference between total revenue and total variable cost while Gross Margin Sensitivity (GMS) is the difference between total revenue and changes in total variable cost. Since parameters and the output have different measurement units, they are not directly comparable. This problem can be overcome by calculating the "elasticity" or the percentage change in output to a percentage change in other parameters (Pannell, 1997). The sensitivity is calculated to explore the impact of assumptions regarding the changes in farm sizes on the gross margin, by using the principle "what if" (Dachin et al., 2016). The sensitivity is interpreted as the elasticity of gross margin to changes in farm sizes by +/- 5%, 10%, 15 and 20%).

GM = TR-TVC (5)

NI=GM -TFC (6)

ROI = NFI/TC (7)

BCR = TR/TC (8)

TVC = Summation of all the variable cost which includes;

i. Land preparation
ii. Planting materials
iii. Chemical used
iv. Labour used (planting, weeding, fertilizer and pesticide application and harvesting)
v. Transportation

Where:
GM = Gross margin
NFI = Net farm income
TC = Total cost incurred
ROI = Return on investment
BCR = Benefit cost ratio
TVC= Total variable cost incurred
TFC= Total fixed cost incurred
TR= Total revenue generated from production

## 4. Results and Discussion

### 4.1 Socio-economic characteristics of respondents

Presented in Table 2 were the socio-economic characteristics of the bio-fortified cassava farmers. The mean age of the respondents were 47(±13.77) which implies that bio-fortified cassava farmers were young and active thus expected to be productive. They are also expected to be open to adoption of new innovation in agricultural practices. Majority (53%) of the respondents were women. This agree that cassava production in Nigeria were mostly common among the women gender (Oparinde et al., 2014). Majority (79%) of the respondents were married implying that they were responsible. It might be due to the fact that marriage is cherished among the producers. The mean years of formal education was 14.39 (±6.83) which implies that respondents were literate and thus, can read and write. The mean household size were 5.31 (±2.26). This implies that the respondents invariably had a medium to large family size and the use of family labor is possible. About 58% of the respondents had access to credit to facilitate their production of bio-fortified cassava. These might be due to the fact that the respondents belong to association.

The mean years of experience was 14.62(±6.92). This implies that respondents had been into cassava production for a long time even before the introduction of new improved bio-fortified cassava in 2011. Majority (86%) of the respondents belong to one association or the other. They can thus experience group benefits such as credit facility, inputs etc.

**Table 2:** Socio-economic Characteristics of Bio-fortified Vit-A Cassava Farmers

| Variables | Bio-fortified cassava farmers |
|---|---|
| Age (years) | 47(±13.77) |
| Female (%) | 53.00 |
| Married (%) | 79.00 |
| Formal education (years) | 14.39 (±6.83) |
| Household size (#) | 5.31 (±2.26) |
| Access to credit (%) | 58.00 |
| Years of experience (years) | 14.62(±6.92) |
| Membership of association (%) | 86.00 |

Figures in parentheses are standard deviation

### 4.2 Farm specific characteristics

Presented in Table 2 is the farm size of bio-fortified cassava farms. The result shows that majority (41.33% and 38% for 2017 and 2018, respectively) of the respondents cultivated between 1-2ha in the two years respectively. The mean farm size in 2017 and 2018 was 2.1ha and 2.19ha. The results imply that bio-fortified cassava farms were small scale. From Table 4, about 39.33% of the respondents inherited their farmland, 22% purchased their farmland, 24% rented their farmland while 14.67% of the respondents gotten their farmland through communal/gift. About 21.33%, 25.33% and 20.66% of the respondents grown TMS 01/0593, TMS 01/0539 and TMS 01/0220 respectively. These varieties of bio-fortified cassava were the second wave of the bio-fortified cassava distributed in 2016 and was observed to be an improved variety over the ones that were first released in 2011 as listed in Table 4, hence the reason behind cassava farmers adopting this varieties. Majority (55.33%) of the respondents practiced intercropping. This implies that they tend to maximize land resources for the production of bio-fortified cassava as crops like maize were observed to be intercropped with Bio-fortified cassava.

**Table 3:** Farm size of bio-fortified cassava farms

| Farm size (ha) categories | 2017 | Frequency (%) | 2018 | Frequency (%) |
|---|---|---|---|---|
| 1-2 | 62 | 41.33 | 57 | 38.00 |
| 2.1-3 | 49 | 32.67 | 52 | 34.67 |
| 3.1-4 | 36 | 24.00 | 37 | 24.67 |
| 4.1-5 | 3 | 2.00 | 4 | 2.66 |
| Mean | 2.14 | | 2.19 | |

**Table 4:** Farm specific characteristics

| Variables | Frequency | Percentage |
|---|---|---|
| **Mode of land acquisition** | | |
| Inherited | 59 | 39.33 |
| Purchase | 33 | 22.00 |
| Rent | 36 | 24.00 |
| Communal/Gift | 22 | 14.67 |
| **Varieties grown** | | |
| TMS 01/1371 | 16 | 10.67 |
| TMS 01/1412 | 19 | 12.67 |
| TMS 01/1368 | 14 | 9.33 |
| TMS 01/0593 | 32 | 21.33 |
| TMS 01/0539 | 38 | 25.33 |
| TMS 01/0220 | 31 | 20.67 |
| **Agricultural system practiced** | | |
| Sole cropping | 67 | 44.67 |
| Inter cropping | 83 | 55.33 |

### 4.3 Markov chain analysis for bio-fortified cassava farm size

The movement of bio-fortified cassava farmers from one farm size category to another between the two periods (2017 and 2018) were presented in Table 5. The farm size was categorized into four groups; 1-2ha, 2.1-3ha, 3.1-4ha and 4.1-5ha. From Table 5, the first cell on the first row ($S_1S_1$) contains the number of bio-fortified cassava farmers (53) that cultivated between 1-2ha in the first period (2017) and still remained in the same category in the second period (2018). The figure in the second cell of first row ($S_1S_2$) represents the number of bio-fortified cassava farmers (6) in the farm size category 1-2ha in the first period but had moved to 2.1-3ha farm size category in the second period. The figure (0) in the third cell of the first row ($S_1S_3$) implies that no farmer in the 1-2ha farm size category in 2017 had moved to 3.1-4ha in the second period (2018). This is applicable to fourth cell and for other rows of the transition matrix (Table 5).

The transition probability matrix corresponding to the transition matrix of Table 5 is shown in Table 6. The entries in the cells on the principal diagonal of Table 6 indicate the tendency for the farmers to remain within a given category of farm size. These entries show that there was a strong tendency (0.90, 0.85. 0.89 and 0.67) for those farmers cultivating farm size (1-2ha, 2.1-3ha, 3.1-4ha and 4.1-5ha) respectively to remain there. This implies that for a proportion of 0.90 in the first cell of the principal diagonal ($S_1S_1$) for example, as many as 90% of the farmers remained in that category in the second period (2018). The proportion in the second cell of the principal diagonal ($S_1S_2$) corresponding to farmers cultivating 2.1-3ha is 0.85 which implies that 85% of the farmers that cultivated 2.1-3ha stands in 2017 remained in this category in 2018.

However, the proportions in the cells to the right of each of the cells in the principal diagonal indicate the chances of moving to higher categories than that of the principal diagonal cell. Similarly, the proportions in the cell to the left of each of the cells on the principal diagonal indicate the chances of moving to lower categories than that of the principal diagonal cell. For example, the cells to the right of the first cell on the principal diagonal ($S_1S_2$, $S_1S_3$ and $S_1S_4$) contain 0.10 ,0.00 and 0.00 for 2.1-3ha, 3.1-4ha and 4.1-5ha respectively. This implies that the probability of farmers who cultivate 1-2ha category in period one to move to 2.1-3ha category and higher ones in period two is low.

**Table 5:** Transition matrix for farm size categories

| Farm size categories 2017 | 2018 | | | | |
|---|---|---|---|---|---|
| | $S_1$ 1-2 | $S_2$ 2.1-3 | $S_3$ 3.1-4 | $S_4$ 4.1-5 | Total 2018 |
| $S_1$ 1-2 | 53 | 6 | 0 | 0 | 59 |
| $S_2$ 2.1-3 | 4 | 44 | 4 | 0 | 52 |
| $S_3$ 3.1-4 | 0 | 2 | 32 | 2 | 36 |
| $S_4$ 4.1-5 | 0 | 0 | 1 | 2 | 3 |
| Total 2018 | 57 | 52 | 37 | 4 | 150 |

**Table 6:** Transition probability matrix for farm size

| Farm size categories 2017 | 2018 | | | |
|---|---|---|---|---|
| | $S_1$ 1-2 | $S_2$ 2.1-3 | $S_3$ 3.1-4 | $S_4$ 4.1-5 |
| $S_1$ 1-2 | 0.90 | 0.10 | 0.00 | 0.00 |
| $S_2$ 2.1-3 | 0.07 | 0.85 | 0.07 | 0.00 |
| $S_3$ 3.1-4 | 0.00 | 0.06 | 0.89 | 0.06 |
| $S_4$ 4.1-5 | 0.00 | 0.00 | 0.33 | 0.67 |

### 4.4 Equilibrium values, actual and projected pattern of changes in farm size of bio-fortified cassava farmers

The result of the actual and projected farm size for bio-fortified cassava farmers were presented in Table 7. The projection of the structure in which the farm size of the bio-fortified cassava farmers would attain assuming the trend observed on the field during 2017 and 2018 continues over time, implies that equilibrium will be attained in year 2026. In comparing the proportion of bio-fortified cassava farmers in different farm size in initial year with equilibrium year, the proportion of farmers in farm size 1-2ha and 2.1-3ha will decline from 0.09 and 0.70 to 0.06 and 0.30 respectively. Considering the proportion of bio-fortified cassava farmers in the farm size group of 3.1-4ha and 4.1-5ha, it would grow from 0.14 and 0.07 to 0.38 and 0.26 respectively. Furthermore, the mean farm size of bio-fortified cassava farmers on Table 7 shows an upward trend over time. At equilibrium, the mean farm size was 2.85 compared to 2.20 at the initial year in 2017. The result of this study implied that bio-fortified cassava farmers were small scale farmers but they could increase their production in the future if certain measures were put in place

| **Table 7:** Actual and projected structure of farm size among bio-fortified cassava farmers | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Farm Size** | **2017** * | **2018** ** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** | **2026** *** | **2027** |
| 1-2 | 0.09 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 |
| 2.1-3 | 0.70 | 0.65 | 0.59 | 0.51 | 0.48 | 0.45 | 0.42 | 0.33 | 0.30 | 0.30 | 0.30 |
| 3.1-4 | 0.14 | 0.19 | 0.24 | 0.33 | 0.35 | 0.36 | 0.37 | 0.37 | 0.38 | 0.38 | 0.38 |
| 4.1-5 | 0.07 | 0.08 | 0.09 | 0.09 | 0.10 | 0.12 | 0.14 | 0.24 | 0.26 | 0.26 | 0.26 |
| Total | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Mean | 2.20 | 2.25 | 2.30 | 2.40 | 2.45 | 2.55 | 2.65 | 2.70 | 2.75 | 2.85 | 2.85 |

*Actual year

**Starting (initial) state probability vector

***Equilibrium probability vector

| **Table 8:** Average costs andff return to bio-fortified cassava production per season | | |
|---|---|---|
| **Variables** | **Amount (₦)** | **% of total costs** |
| **A. Total revenue** | 284159.27 | |
| **Variable cost** | | |
| Land preparation | 42786.32 | 48.93 |
| Planting material | 8620 | 9.85 |
| Fertilizer | 1650 | |
| Herbicides | 3400 | |
| Labor cost | 14370 | 16.43 |
| **B. Total Variable Costs (TVC)** | 70826.32 | 81.00 |
| **Fixed cost** | | |
| Rent on land | 14850 | 16.97 |
| Depreciation on sprayer | 843 | |
| Depreciation on wheelbarrow | 929 | |
| **C. Total fixed costs (TFC)** | **16622** | **19.00** |
| **D. Total costs (B+C)** | **87448.32** | |
| **E. Gross margin (A-B)** | **213332.95** | |
| **F. Net Farm Income (A-D)** | **196710.95** | |
| Return on Investment (ROI) | 2.25 | |
| Benefit Cost Ratio | 3.25 | |

### 4.5 Costs and returns to bio-fortified cassava production

In other to ascertain the profitability of bio-fortified cassava production, the average gross margin, net returns, rate of returns and benefit cost ratio of the bio-fortified cassava farmers were calculated. The input used, costs, output data generated from the bio-fortified cassava farmers were used to compute the gross margin and net returns to bio-fortified cassava production. The average costs and returns for the bio-fortified cassava production were presented in Table 8. The result revealed the revenue generated for one production season was ₦284159.27. From Table 8, the cost of land preparation (₦42786.32) on individual cost accounted for a large proportion (48.93%) of the total costs with the total variable costs (₦70826.32) accounting for the largest proportion (81%) of the total costs. Rent on land (₦14850) accounted for a significant proportion 16.97% of the fixed cost with the total fixed costs accounting for just 19%.

The negligible small proportion of the fixed costs shows the crude method of agricultural small-scale practices. The average net return (net farm income) from the production of bio-fortified cassava in Table 8 was ₦196710.95. This implies that the production of bio-fortified cassava is a profitable enterprise. The return on investment, indicated that for every one naira invested in bio-fortified cassava production, the farmer gains ₦2.25. The implication is that bio-fortified cassava production is profitable. The result agrees with Ogunleye *et al*. (2019) in the Profitability of investment and farm level efficiency among groups of Vitamin A cassava farmers in Oyo State Nigeria who found out that bio-fortified cassava production is a profitable business enterprise. The benefit cost ratio of 3.25 shows that for every ₦3.00 return to bio-fortified cassava production, 25k is been spent on the cost of producing the bio-fortified cassava.

### 4.6 Rate of Return on Investment

$$RORI = \frac{TR - TCx100}{TC}$$

= 284159.27- 87448.32/87448.32 x 100

RORI= 224.95%

### 4.7 Sensitivity Analysis and Rate of Return on Investment

The rate of returns on investment of bio-fortified cassava production showed a high return in the enterprise (224.95%). The rate of returns on investment of bio-fortified cassava production was subjected to a sensitivity analysis to establish the point at which profitability might not be certain. With respect to input, increasing the costs from +10 to +30% did not significantly impact the rate of return on investment (Table 9). Furthermore, the result revealed that at 35% increase in cost of production, the rate of return on investment dropped to 140.70%. This implies that with outmost concern, bio-fortified farmers should try as much as possible to ensure that they cut the cost of production to a maximum of 30% hence, the investment will not be viable and might not be recommended for investment especially if the investment will be finance by bank loan. At the calculated revenue, the rate of return was 224.95% but when the revenue was reduced by 10%, rate of return dropped to 192.45%, at 30% drop in revenue, the rate of return dropped to 127.46%. Therefore, for the enterprise to remain profitable, the decrease in revenue should not go beyond 30%.

| **Table 9:** Sensitivity analysis of Rate of Return on Investment of bio-fortified cassava (Increasing Cost) | | | | |
|---|---|---|---|---|
| **Variable RORI** | **Cost** | **Return** | **RORI** | **Remark** |
| Actual cost | 87448.32 | 284159.27 | 224.95% | Actual estimate |
| +10% cost | 96193.15 | 284159.27 | 195.40% | Recommended |
| +15% cost | 100565.56 | 284159.27 | 182.56% | Recommended |
| +20% cost | 104937.98 | 284159.27 | 170.78% | Recommended |
| +25% cost | 109310.40 | 284159.27 | 159.95% | Recommended |
| +30% cost | 113682.81 | 284159.27 | 149.95% | Recommended |
| +35% cost | 118055.23 | 284159.27 | 140.70% | Not Recommended |

| **Table 10:** Sensitivity analysis of Rate of Return on Investment of bio-fortified cassava (Decreasing revenue) | | | | |
|---|---|---|---|---|
| **Variable RORI** | **Cost** | **Return** | **RORI** | **Remark** |
| Actual cost | 87448.32 | 284159.27 | 224.95% | Actual estimate |
| -10% cost | 87448.32 | 255743.34 | 192.45% | Recommended |
| -15% cost | 87448.32 | 241535.37 | 176.20% | Recommended |
| -20% cost | 87448.32 | 227327.41 | 159.95% | Recommended |
| -25% cost | 87448.32 | 213119.45 | 143.70% | Recommended |
| -30% cost | 87448.32 | 198911.48 | 127.46% | Not Recommended |
| -35% cost | 87448.32 | 184703.52 | 111.21% | Not Recommended |

## 5. Conclusions

The study examined the profitability of bio-fortified cassava production and projected the future farm size of the production of bio-fortified cassava in Oyo State, Nigeria. The study concluded that production of bio-fortified cassava is a profitable enterprise in Oyo State Nigeria. Bio-fortified cassava production can adjust positively to incidentals such as general price inflation and price changes for inputs and outputs that may occur in time. Our study concluded that bio-fortified cassava farmers were small scale farmers but they could increase their production in the future if certain measures were put in place. In order to adequately achieve these goals, more improved varieties of bio-fortified cassava should be provided, and also, infrastructures should be put in place to help boost farmers moral in their cause of production.

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