Economics of bio-fortified cassava varieties (BCVs) adoption and its gender implication among farmers in Oyo State, Nigeria

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ABSTRACT
Cassava bio-fortification is presented as a cost-effective approach, and it is predicted to provide some economic benefits to its adopter. On the other hand, gender-blind agricultural innovation delivery strategies impede short- and long-term impact among adopters. Due to a disregard for gender differences, many agricultural programs fall short of their objective. Recent studies in Nigeria are yet to adequately capture the gender differentials in the economic implication of BCVs adoption. This study, therefore, investigates the gender differentials in the economic implication of BCVs’ adoption among farmers in Oyo State, Nigeria. A multistage sampling procedure was used to select a total of 180 respondents for the study. Data collected were analyzed using descriptive statistics and budgetary techniques. Descriptive statistics revealed a significant difference between the socio-economic characteristics of male and female cassava farmers. The results suggested that BCVs’ production is profitable and can serve as a panacea for the economic improvement of households. Study findings thus concluded that the adoption of BCVs is economically beneficial to cassava farmers and thus recommended that concerted efforts are made to ensure all farmers adopt BCVs for planting. The study proposes an integration of gender-responsive strategies to further enhance the delivery of BCVs in Nigeria.

Keywords: Gender; bio-fortified cassava varieties; economic implications; budgetary techniques; Oyo State

Introduction
Cassava (Manihot esculenta, Crantz) is a staple food crop grown on marginal lands, particularly in Africa, Asia, and Latin America. Nigerian cassava production contributed 19% to the world cassava output from 2015 to 2018 (FAOSTAT, 2015; FAO, 2018) and Nigeria is currently the largest producer of cassava in the world with an annual output of over 59 million tons (FAOSTAT, 2019; Adeyemo & Kehinde, 2019; Kehinde & Olatidoye, 2019; FAOSTAT, 2019; Kehinde & Adeyemo, 2020; Ogunyinka & Oguntuase, 2020). Cassava is predominantly cultivated by over 30 million smallholder farmers as well as large numbers of processors and traders who depend on seasonal rainfall for its production (Tahirou et al. 2014; Afolami et al., 2015). This is possible because cassava...
has the capacity to give significant yield under
conditions of marginal soil and climate change;
hence the crop is drought tolerant (Anikwe &
Ikenganyia, 2018; Ekeleme et al., 2021).

Cassava is relatively resource-conserving and cheaper to produce (Obisesan,
2013; Sangoyomi, 2013); hence its role in
improving the livelihood of farmers and
food security of the nation cannot be over-
emphasized. Cassava is the most important
root crop providing over 50% of the calorie
consumption of more than 200 million people
(Oparinde et al., 2012). This is ascribed to
the fact that the root crop can be processed
into various products such as garri, fufu,
tapioca, chips, and cassava flour for human
consumption (Tahirou et al., 2014). As a
result, cassava plays a leading role in the local
food economy, especially in rural households
(Hartmann, 2011, FAOSTAT, 2013, FAOSTAT,
2019). Research has shown that four out of five
Nigerians in the rural area eat a cassava-based
meal at least once a week (Nweke et al., 2002;
Ezedinma et al., 2007; Aghaji et al., 2019).
This is attributed to the fact that cassava-based
meal, containing about 25% to 35% starch,
is an inexpensive and dependable source of
carbohydrates for most rural resource-poor
households (Azaino, 2008).

Despite the fact that cassava is the main
source of carbohydrates for rural resource-
poor households, it lacks some nutrients such
as protein, vitamins, and minerals (Phillips
et al., 2004; McNulty & Oparinde, 2015).
Though cassava in most cases provides a
solution to hunger and starvation, it does not
solve the problem of malnutrition otherwise
known as “hidden hunger”. According to Stein
& Qaim (2007), HarvestPlus (2014), FAO et
al. (2018), and FAO (2020), more than 850
million people suffer from hidden hunger in the
world, Nigeria inclusive. However, frequent
consumers of cassava are at greater risk in
terms of malnutrition, especially deficiencies
in vitamin A, iron, and zinc compared with
consumers of other diets (Phillips et al., 2004;
Gegios et al., 2010; McNulty & Oparinde,
2015). Micronutrient malnutrition, for instance,
vitamin A deficiency, results in societal costs
including learning disabilities among children,
increased mortality rates, lower worker
productivity, and high healthcare costs (Welch
& Graham, 2004; Grebmer et al., 2014).

Micronutrient malnutrition has serious
negative health implications on both men and
women but affects women more (Micronutrient
Initiative, 2014; Aghaji et al., 2019). Currently,
Nigeria has a high vitamin-A deficiency (VAD)
problem as over 30% of pregnant women and
20% of children under the age of five are vitamin-A deficient, resulting in different
categories of illnesses, and even death in most
cases (Maziya-Dixon et al., 2006; WHO,
2009; Micronutrient Initiative, 2014; Ayinde
& Adewumi, 2016; and Aghaji et al., 2019).
VAD also results in a high rate of impaired
vision in Nigeria such as night blindness and
xerophthalmia (Ayinde & Adewumi, 2016;
Aghaji et al., 2019).

In the light of the foregoing, the
Harvest-Plus programme was initiated under a
collaborative effort of the International Institute
for Tropical Agriculture (IITA), National Root
Crop Research Institute (NRCRI) Umudike,
as well as other local partners and Obafemi
Awolowo University Ile-Ife, to develop vitamin
A-rich cassava varieties suitable for many agro-
ecological conditions. This was to help solve
the problem of malnutrition among resource-
poor households in Nigeria (Oparinde et al.,
2014). The first wave of vitamin A cassava
varieties (UMUCASS 36, UMUCASS 37, and
UMUCASS 38) was released in 2011 and the
second wave (UMUCASS 44, UMUCASS
45, and UMUCASS 46) was released in 2013 (IITA, 2012; Oparinde et al., 2012; Harvest Plus, 2014). They are commonly referred to as NR07/0220, IITA-TMS-IBA070593, and IITA-TMS-IBA070539.

The Harvest-Plus project is built on the existing delivery pathway that empowers the rural population, where hidden hunger is prominent, to scale-up production and processing of vitamin A cassava to meet both food and income needs. Four states, which are Oyo, Imo, Akwa Ibom, and Benue States, were selected as centers to multiply them with all other states in Nigeria. In 2013, over 650 hectares of the three BCVs were multiplied in 272 villages while in 2014, the average stem yield on multiplication farms increased from 200 to 500-1000 bundles (HarvestPlus, 2014). Harvest-Plus also worked with the Ministries of Agriculture and Health. The Federal Ministry of Agriculture integrated the development and dissemination of bio-fortified food crops into the Agricultural Transformation Agenda (ATA) of the Federal Government in 2014 while the Ministry of Health included bio-fortified cassava in the new Micronutrient Deficiency Control Guidelines approved by the National Health Council in August 2013.

BCVs offer a low-cost strategy that improves the nutritional requirement of people and economic livelihood opportunities for all ages (Olaosebikan et al., 2019). The Federal Government of Nigeria and other international agencies envisaged that BCVs would alleviate malnutrition in addition to hunger through their ability to yield about 32 – 36 tons/ha, therefore generating an average annual farm income of about ₦55, 395 per ha (IITA, 2014; Afolami et al., 2015). BCVs also contain nutrients at least six times more than the common white-fleshed cassava because of the presence of beta-carotene thus making basic nutrients available to poor households, especially in rural communities (HarvestPlus, 2014).

The BCVs have provided up to 25% of the daily vitamin A requirements of children and women (Sagar et al., 2009; Omodamiro et al., 2012). Apart from the nutritional benefits accruing to bio-fortification, it is also a cost-effective means. Bio-fortified cassava assured the farmers of a greater yield and better income. Results on bio-fortified roots show that the monetary benefit associated with reduced health burden would be between ₦3.4 – ₦11.5 billion (771,654.00 USD – 90,551,181.00 USD) per year in the pessimistic and optimistic scenarios (Bamire et al., 2004; Afolami et al., 2015). Also, potential benefits from Vitamin A bio-fortification are estimated at 1.1 billion USD – 1.4 billion USD in Nigeria while the costs per DALY saved are estimated at 4 USD to 6 USD for Nigeria, which compares very favorably with the costs for alternative methods such as fortification and supplementation (Nguema et al., 2011). They also serve as means for crop diversification and increase employment opportunities for women through cassava processing (IITA, 2013).

Despite the nutritional, health, and economic benefits embedded in the improved cassava varieties, their adoption by farmers has been discouraging. Given this situation, it is expected that many research efforts will be focused on this direction. Many studies abound that assessed factors militating against the adoption of improved cassava varieties (Adesina & Baidu-Forson, 1995; Agwu & Anyaech, 2007; Ezubruo et al., 2010), the determinants of BCVs adoption in Nigeria (Olatade et al., 2016; Ayinde, 2017; Onyeneke et al., 2020), risk analysis in the production of vitamin A cassava variety (Ayinde, 2017),
the physio-chemical properties and sensory attributes of BCVs (Alake et al., 2016; Edoh et al., 2016), consumer acceptance and demand for BCVs (Oparinde et al., 2016; Birol et al., 2015), and expected economic benefits of BCVs (Ayinde & Adewumi, 2016). These studies only captured the determinants of BCVs and their acceptance but no studies exist on the economic implications of the adoption of bio-fortified cassava varieties.

Although Olaosebikan et al. (2019) carried out a gender-based study on the constraints affecting BCVs production, processing, and marketing of adopters, this study differs from other studies as it aimed at gender differentials in the economic implication of the adoption of bio-fortified cassava varieties. None exists to the best knowledge of the author, even though, studies revealed that there are gender variances in the adoption of innovation and the economic consequence of the adoption on both genders (Doss & Morris, 2001; FAO, 2014; Obisesan, 2014; Mishra & Sam, 2016; Gaya et al., 2017, Theis et al., 2018; Aduwo et al., 2019). There is thus the need to investigate the gender differentials in the economic implication of BCVs adoption in Oyo State, Nigeria.

Consequently, this study assesses the gender differentials in the economic implication of the adoption of bio-fortified cassava varieties among farmers in Oyo State, Nigeria. Specifically, it describes the socio-economic characteristics of cassava farmers in the area by gender; examines the gender differentials in the intensity of adoption, and estimates the cost of and return to BCVs by gender in Oyo State. Our empirical evidence shows that BCVs production is profitable and can serve as a panacea for the economic improvement of households. This is reflected in the fact that BCVs adopters earn higher net income than non-adopters although female adopters and non-adopters of BCVs have higher net income than their male counterparts.

The result stemming from this study will contribute to the body of literature by providing important information for implementing well-informed and gender-based policies relating to the cultivation of BCVs. Moreover, there exist research gaps in the literature on the adoption of and economic considerations of improved varieties of cassava, as well as gender differentials in the economic implication of BCVs. The result of this research will specifically contribute to the design and implementation of gender equitable strategies to upscale BCVs in Nigeria.

**Materials and Methods**

**Study area**

The study was carried out in Oyo State in the southwestern part of Nigeria. The State covers a total of 28,454 sq. km. of land mass and an estimated agricultural landmass of 27,000 sq km and a favourable climate for equatorial crop production and livestock rearing. The State is bounded with Ogun, Kwara, Republic of Benin, and Osun in the South, North, West, and East respectively (Sodiya & Oyeniran, 2014). The topography of the State is of gentle rolling low land and well-drained with rivers flowing from the upland in the North-South direction. The average daily temperature ranges between 25°C and 35°C and a vegetation pattern of rain forest in the south and guinea savannah in the north (Muhamad-Lawal et al., 2012). The State has a total population of 6,591,589 as of the 2013 census with a larger percentage being males (Sodiya & Oyeniran, 2014). The favorable climate of the area has encouraged around 70% of the inhabitants to engage in small-scale agriculture. Agriculture is the main
occupation of the people of Oyo State. The state is divided into four agricultural zones and two ecological zones. This favor the cultivation of different crops like maize, yam, and cassava among others which altogether boost the income of farmers, thereby improving their livelihood. Oyo is the state with the highest number of cassava growers in South-West Nigeria, cultivating ten thousand (10,000) hectares of land (FMARD, 2017).

Sampling procedure and sampling size
A multi-stage sampling procedure was used to select respondents for the study. The first stage involved a purposive selection of the Oyo State one of the states into which BCVs were introduced. The second stage involved purposive sampling to select three local government areas (LGAs) – i.e. Orire, Afijio, and Akinyele LGAs – with the highest population of cassava farmers. In the third stage, two villages were purposively selected in each of the three LGAs based on the fact that they have the highest population of cassava farmers in each LGA. In each village, a simple random technique was used to select a total of 30 respondents, comprising 107 male farmers and 73 female farmers making a total of 180 farmers.

Data collection and analysis
The data collected were for the 2016/2017 cropping season. Data were collected on
farmers’ socio-economic characteristics such as age, education, gender, household and farm size, adoption status of the farmer, and intensity of use of BCVs. Data were analyzed with the use of descriptive statistics and budgetary techniques such as gross margin and returns. The budgeting technique compares the costs and benefits of different choices by estimating the difference in gains or costs expected from them. Descriptive statistics were then used to describe gender differentials among study variables which involved the computation of means, standard deviation, frequency, and percentages.

Following Tufa et al. (2019) and Kehinde (2020), the adoption intensity was measured on the portion of land allotted to BCVs out of the total farm size. It is expressed in terms of the adoption index.

$$AI = \frac{\sum_{i=1}^{n} \beta_v}{\sum_{i=1}^{n} Lt}$$  \hspace{1cm} (1)

Where $AI = \text{adoption index}$

$\beta_v = \text{land grown to BCVs by farmer } i \ (i=1, 2, 3, \ldots \ldots \ldots \ n)$ and

$Lt = \text{total land area grown to cassava by the farmer}.$

Following Akinola & Owombo (2012), Ojo & Ogunyemi (2014), Itam et al. (2018), and Kehinde & Adeyemo (2020), the budgetary technique was employed to estimate the economics of BCVs’ adoption by looking at the costs and returns that accrue to the improved crop technology adoption. It also involves the use of gross margin (GM) and returns to analyze and compare profitability.

$$\Pi = TR - TC$$  \hspace{1cm} (4)

$$NI = GM - TFC$$  \hspace{1cm} (5)

Percentage GM = $\frac{GM}{TR} \times 100$  \hspace{1cm} (6)

Profitability Index = $PI = \frac{NI}{TR}$  \hspace{1cm} (7)

Rate of Return on Investment = $RRI = \frac{NI}{TC}$  \hspace{1cm} (8)

Where:

$P$ is price of cassava per ha.

$Q$ is quantity of cassava per ha.

$\Pi$ is profit per ha.

$TR$ is the total revenue which is the income from sales (₦/ha).

$TVC$ is the total variable cost of production, defined as the cost of cuttings, fertilizer, labour, herbicides, transportation, pesticides, and others (₦/ha).

$TFC$ is the total fixed cost of production, defined by the cost of land, hired land, and major farm equipment (₦/ha).

$TC$ is the total cost of production (₦/ha).

$RRI$ is the rate of return on investment per ha

$GM = \text{Gross margin (₦/ha)}$ and

$NI = \text{Net income (₦/ha)}.$

The test statistic: t-test

This involved an independent sample t-test.

$$t = \frac{x_1 - x_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$  \hspace{1cm} (9)
$\bar{x}_1$ = Mean NI, GM, PI, and RRI of adopters and non-adopters disaggregated by gender.
$\bar{x}_2$ = Mean NI, GM, PI, and RRI of adopters and non-adopters disaggregated by gender.
$S_1$ = Standard deviation of male adopters,
$S_2$ = Standard deviation of female adopters,
n$_1$ = sample of adopters.
n$_2$ = sample of non-adopters.

**Statements of hypothesis**

$H_0$ = There is no significant difference in the NI, GM, PI, and RRI of adopters and non-adopters of BCVs. i.e. $H_0 : NI_1 = NI_2$

$H_a : NI_1 \neq NI_2$

$H_0$ = There is no significant difference in the net income of male and female adopters of BCVs

$H_a$ = There is a significant difference in the net income of male and female adopters of BCVs.

**Results and Discussion**

**Socio-economic characteristics of cassava farmers by gender**

The age range with the highest frequency is 41 – 60 years among both adopters and non-adopters, followed by 21 – 40 years among adopters and non-adopters (over 26%). This shows the majority of the farmers are between 20 – 60 years and corroborates Mohammad-Lawal et al. (2012) and Durojaye & Ogunjimi’s (2015) findings that the majority of the cassava farmers in Oyo State are in their active years of production. The result shows that 37.08% of the non-adopters have between 1 – 10 years’ experience while 39% of adopters have over 20 years’ experience. This suggests that an average adopter is more experienced in farming than a non-adopter which would give the ability to exact the appropriateness of new technology for efficient production, hence standing a better chance of making accurate decisions (Kehinde et al., 2018).

Education is an important factor that enhances the proper decision on the adoption of new technology. From Table 1, the proportion (72.53%) of adopters who have access to education between primary school to tertiary institutions is greater than that of non-adopters (66.59%) while a greater proportion of non-adopters did not go to school at all. This indicates that adopters are generally more learned than non-adopters; therefore, adopters stand a better chance of making helpful judgments in their decision-making. This contrast with the findings of Tesfaye et al. (2016) but supports Owombo et al. (2012) that non-adopters are more educated than adopters. Also, 67.03% of adopters and 58.43% of non-adopters practice farming on a part-time basis. This implies that a greater proportion of adopters are more involved in part-time farming; this enables them financially to maximize the adoption of BCVs than non-adopters since they have other means of income to weather any unforeseen contingencies that may later arise.

The household size is an indication of the potential family labour available for farm work. There is a significant difference ($p \leq 0.05$) between the mean household size of adopters (5.98 ±1.54) and non-adopters (4.97 ± 1.59). This suggests that adopting households have larger family sizes which gave an edge in labour supply over non-adopting households and is in line with many studies in Sub-Saharan Africa (Asfaw et al., 2012; Kehinde & Adeyemo, 2017).
### TABLE 1

**Socio-economic characteristics of cassava farmers by gender**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pooled (n = 180)</th>
<th>Adopters (n = 91)</th>
<th>Non-adopters (n = 89)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adopters</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>t-test</td>
</tr>
<tr>
<td>Age (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-20</td>
<td>1.1</td>
<td>0</td>
<td>2.63</td>
</tr>
<tr>
<td>40-60</td>
<td>53.84</td>
<td>46.07</td>
<td>58.49</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>18.68</td>
<td>21.35</td>
<td>24.53</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>52.2</td>
<td>45.1</td>
<td><strong>3.00</strong>*</td>
</tr>
<tr>
<td>Farming experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-10 (%)</td>
<td>11.20</td>
<td>30.77</td>
<td>37.08</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>29.67</td>
<td>33.71</td>
<td>30.19</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>39.56</td>
<td>29.21</td>
<td>49.06</td>
</tr>
<tr>
<td><strong>Education (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>16.48</td>
<td>26.97</td>
<td>11.32</td>
</tr>
<tr>
<td>Koranic</td>
<td>4.40</td>
<td>2.25</td>
<td>7.55</td>
</tr>
<tr>
<td>Adult</td>
<td>2.20</td>
<td>0</td>
<td>3.78</td>
</tr>
<tr>
<td>Primary</td>
<td>39.56</td>
<td>37.38</td>
<td>32.08</td>
</tr>
<tr>
<td>Secondary</td>
<td>30.77</td>
<td>29.21</td>
<td>33.96</td>
</tr>
<tr>
<td>Tertiary</td>
<td>6.59</td>
<td>4.49</td>
<td>11.32</td>
</tr>
<tr>
<td><strong>Nature of farming (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part-time</td>
<td>67.03</td>
<td>58.43</td>
<td>54.72</td>
</tr>
<tr>
<td>Full-time</td>
<td>32.97</td>
<td>41.57</td>
<td>40.74</td>
</tr>
<tr>
<td><strong>Household size (Number)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>5.9</td>
<td>4.9</td>
<td><strong>4.33</strong>*</td>
</tr>
<tr>
<td><strong>Farm size (AC) (Mean)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.6</td>
<td>3.9</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses () are standard deviations; ***, **Significant at 1% 5% respectively.
Source: Field survey, 2018
From the gender analysis, while the majority of male adopters and non-adopters have over 20 years’ experience in farming, the majority of their female counterparts had between 1 – 10 years’ experience. This suggests that males are generally more experienced than females and cannot be far-fetched from the fact that there have been institutional barriers to farming among women decades back (Doss & Morris, 2001). Furthermore, both male adopters and non-adopters have larger farm holdings than females. This suggests that males own more land than women and are more opportune to maximize adoption (Doss et al., 2015, Kieran et al., 2015, Kieran et al., 2017). This implies the larger the size of the farm, the larger the size of land a farmer would likely devote to the cultivation of BCVs.

Also, the majority of the females either did not go to school at all or have only primary education, non-adopters especially. It thus implies that women are still generally less educated than men. This agrees with Adeyemo & Kehinde (2020) and Alao et al. (2020) that although female child education has increased over the year, there exists an education gap between men and women in sub-Saharan Africa. The study shows that about 54.72% of male and 84.21% of female adopters practice farming on a part-time basis while 59.25% of male and 57.14% of female non-adopters were involved in part-time farming. This means generally, women operate farming on a part-time basis than men. This is not surprising as women engage in processing and petty trade more than men.

**The intensity of BCVs adoption by gender**

The majority (67.03%) of the male farmers only devote 30% or less portion of land to BCVs cultivation while about 23.08% devote between 31% - 50% of their land to BCVs. This suggests that some reasons (like a small portion of the farm, inadequate capital, and inaccessibility of stems) as stated by some respondents are responsible for the relatively low intensity of adoption despite their high level of awareness. Among the males, 73.58% devote 30% or less portion of their land to BCVs cultivation while 16.78% use between 31% - 50% of their farms for BCVs. Furthermore, 57.89% and 31.58% of females devote between 0-30% and 31% - 50% of their farms to BCVs respectively. The intensity of adoption was generally low in the area as shown in the results despite the high level of awareness. This corroborates the findings of Afolami et al. (2015) that adoption rates of improved cassava varieties are low in the study area. Interestingly, male farmers adopted the technology more than their female counterparts and the difference is statistically significant (t-value = 2.88).

**TABLE 2**

*Intenity of BCVs adoption by gender*

<table>
<thead>
<tr>
<th>Portion of land (%)</th>
<th>Pooled (%) (n=91)</th>
<th>Males (%) (n=53)</th>
<th>Females (%) (n=38)</th>
<th>T-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>67.03</td>
<td>73.58</td>
<td>57.89</td>
<td></td>
</tr>
<tr>
<td>31-50</td>
<td>23.08</td>
<td>16.98</td>
<td>31.58</td>
<td></td>
</tr>
<tr>
<td>51-70</td>
<td>5.49</td>
<td>5.66</td>
<td>5.26</td>
<td></td>
</tr>
<tr>
<td>71-100</td>
<td>4.40</td>
<td>3.77</td>
<td>5.26</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.57</td>
<td>0.62</td>
<td>0.51</td>
<td>2.88***</td>
</tr>
</tbody>
</table>

Source: Field survey, 2018
Costs and returns to adopters and non-adopters of BCVs by gender

The results of costs and returns to BCVs production in the study area presented in Table 3 show that the average cost of the adopters (₦30,325.44/$100) is less than that of the non-adopters (₦36,711.24/$121). Also, the average variable cost of the adopters (₦14,989.61/$49) is significantly \( p \leq 0.05 \) less than that of the non-adopters (₦21,546.95/$71). The lower costs incurred by adopters might be because of favorable innate properties of BCVs that led to less expenses by adopters. The net income of adopters is significantly higher than that of non-adopters at \( p \leq 0.05 \) with a difference of ₦15,569.02/$51. The percentage gross margin of adopters is 0.09 higher than that of non-adopters. This is in line with Awotide \textit{et al.} (2015) that technology adoption has a positive effect on income (net income and gross margin).

Among the adopters, the average cost for males is less than that of females. Also, the variable and fixed costs of female adopters (₦17,263.02/$57 and ₦20,469.10/$67) are considerably higher than those of male adopters (₦13,359.62/$44 and ₦11,655.36/$38) at \( p \leq 0.05 \). This shows that female adopters incur higher costs of production at all levels than male adopters in cassava production in the study area. This might be due to the high labour cost faced by women. This is in consonance with Alderman \textit{et al.} (1996) that women spend more on labour than men which all together increases their cost of production.

However, the total revenue of female adopters is significantly higher than that of males while their net income is also higher than that of their male counterparts at \( p \leq 0.05 \). Also, the gross margin of female adopters has an average of ₦72,191.09/$237 higher than the males, with a percentage gross margin and profitability index of 0.82 and that of males 0.73 at \( p \leq 0.05 \). In addition, the profitability index of female adopters (1.19) is higher than that of male adopters (0.70) at \( p \leq 0.05 \). These suggest that females are able to make a higher profit per unit cost in the production of BCVs than their counterparts in spite of the higher costs incurred by females.

TABLE 3

Per hectare costs and returns structure to cassava varieties by gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pooled</th>
<th>Adopters</th>
<th>Non-adopters</th>
<th>t-test</th>
<th>Males</th>
<th>Females</th>
<th>t-test</th>
<th>Males</th>
<th>Females</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC</td>
<td>33482.86</td>
<td>30325.44</td>
<td>36711.24</td>
<td>1.63*</td>
<td>25014.98</td>
<td>37732.12</td>
<td>3.38***</td>
<td>35100.51</td>
<td>39196.37</td>
<td>0.58</td>
</tr>
<tr>
<td>TCV</td>
<td>18231.85</td>
<td>14989.61</td>
<td>21546.95</td>
<td>2.25**</td>
<td>13359.62</td>
<td>17263.02</td>
<td>1.98*</td>
<td>18544.15</td>
<td>26179.84</td>
<td>1.35*</td>
</tr>
<tr>
<td>TFC</td>
<td>15251.01</td>
<td>11655.36</td>
<td>15164.3</td>
<td>0.08</td>
<td>11655.36</td>
<td>20469.10</td>
<td>3.13***</td>
<td>16556.37</td>
<td>13016.53</td>
<td>1.31*</td>
</tr>
<tr>
<td>TR</td>
<td>82640.12</td>
<td>87180.7</td>
<td>79997.49</td>
<td>0.82</td>
<td>61714.95</td>
<td>122698.70</td>
<td>4.45***</td>
<td>63632.71</td>
<td>100160.3</td>
<td>2.16**</td>
</tr>
<tr>
<td>NI</td>
<td>49157.26</td>
<td>56855.27</td>
<td>41286.25</td>
<td>1.72**</td>
<td>36700</td>
<td>84966.58</td>
<td>4.11***</td>
<td>28532.20</td>
<td>60963.94</td>
<td>2.49***</td>
</tr>
<tr>
<td>GM</td>
<td>64408.26</td>
<td>72191.09</td>
<td>56450.55</td>
<td>1.58*</td>
<td>48355.34</td>
<td>105435.7</td>
<td>4.50***</td>
<td>45088.56</td>
<td>73980.46</td>
<td>0.48</td>
</tr>
<tr>
<td>%GM</td>
<td>0.75</td>
<td>0.77</td>
<td>0.68</td>
<td>1.58*</td>
<td>0.73</td>
<td>0.82</td>
<td>2.69***</td>
<td>0.68</td>
<td>0.70</td>
<td>1.99**</td>
</tr>
<tr>
<td>PI</td>
<td>0.91</td>
<td>0.91</td>
<td>1.14</td>
<td>1.04</td>
<td>0.70</td>
<td>1.19</td>
<td>2.02**</td>
<td>1.02</td>
<td>1.32</td>
<td>0.79</td>
</tr>
<tr>
<td>RRI</td>
<td>1.87</td>
<td>2.28</td>
<td>1.46</td>
<td>2.06**</td>
<td>1.75</td>
<td>3.01</td>
<td>1.84**</td>
<td>1.21</td>
<td>1.84</td>
<td>1.57*</td>
</tr>
</tbody>
</table>

Note: figures in parentheses are standard deviations, ****, ** and * indicates significance 1%, 5% and 10% respectively.
Source: Data Analysis, 2018
The higher revenue and net returns realized by females might be attributed to their involvement in processing cassava into other products (e.g. gari, flour, fufu, starch, even chips) all of which attract higher incomes than the mere sale of cassava tubers which is what men majorly engage in. This contradicts the findings of Naved (2000) and CIAS (2004) that women do not make substantial incomes from improved seed technology as men. Similarly, among the non-adopters, the total revenue of males (₦63,632.71/$209) is found to be less than that of females (₦100,160.3) at \( p \leq 0.05 \). Also, female non-adopters have ₦32,431.74/$107 higher than males at \( p \leq 0.05 \) while their percentage gross margin is 0.02 higher than that of males at \( p \leq 0.05 \). This is also in contrast with CIAS (2004) that women make low income from crop production.

**Conclusion and Recommendation**

This study assessed the gender differentials in the economic implication of BCVs adoption in the study area. This study shows that non-adopters (especially males) were relatively older in the study area. Most of the cassava-growing farmers are educated while the majority of respondents (especially females) practice farming on a part-time basis. Men generally own more land than females. This is in consonance with Doss & Morris (2001) and Adeyemo & Kehinde (2020) that a greater proportion of women are landless and as such, they occupy a rather tenuous position with regard to access to land. The majority of the farmers are aware of BCVs which only about average have adopted, with a lower percentage being females.

Results confirmed the importance of the adoption of BCVs as it increased the income (gross margin and net income) of adopters over non-adopters. Also, Female farmers incur higher costs (Total Cost, Variable Cost, and Fixed Cost) than male farmers. However, they made higher returns (Total Revenue, Gross Margin, and Net Income). Also, females have a higher percentage gross margin and profitability index. This confirms the fact that female farmers are more efficient in the area of income and returns to cassava production than men. Moreover, the females are involved in the processing and sales of cassava by-products like gari, fufu, starch, snacks, etc., which command more income than the mere sale of cassava tubers which is what most male farmers engage in.

Hence, females are good at processing and marketing products, and this gives them a comparative advantage over males. These indicate that the adoption of BCVs is generally a cost-effective means. From the findings of this study, it was observed that although women incurred higher production costs than men, they also had higher net income, profitability index, and rate of return on investment than men. This cannot be farfetched from the fact that women engage in processing activities more than men, which bring more money than sales of harvested tubers which men engage in mostly. Hence, it is recommended that the processing of cassava (i.e. value addition) should be more encouraged among the farmers, women especially.

Also, barriers to ownership of land by women should be removed as it has been observed from studies that land is pivotal to increasing the intensity of adoption, whereas both male adopters and non-adopters had a significantly larger expanse of land than their female counterparts. Based on the findings of this study, it is concluded that the adoption of BCVs for planting is profitable and capable of providing the necessary impetus for improving...
the livelihood of households. Awareness of BCVs among farmers should be intensified in order to facilitate increased adoption. Since education plays a major role in adoption, it is imperative that farmers in the area be enlightened on BCVs, extension approach used in the area should be participatory in nature.

Farmer Field School should be encouraged in the study area as it provides a better forum for farmers’ education. From the age distribution of respondents, it was quite obvious that the youth were not actively involved in cassava farming. It is therefore strongly recommended that the youth in the area should be encouraged to get involved in BCVs farming by providing them with loans and other necessary services. This study further suggests the formulation of gender-sensitive policies such as land reforms and affordable education for women farmers to reduce the gender gap and advance women empowerment in BCVs cultivation. These policies should also include creating equal opportunity access to credit institutions and public services such as extension services. Also, there is a need for the provision of various societal beneficial groups to the female household heads as this will improve their level of exposure and most importantly it will improve their income generating capacity.

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