AGRICULTURAL COOPERATIVE MEMBERSHIP, GENDER GAP, AND ADOPTION OF BIOFORTIFIED CASSAVA VARIETIES IN NIGERIA

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This study investigated agricultural cooperative membership, the gender gap, and the adoption of biofortified cassava varieties (BCVs) among cassava farmers in Oyo State. A multistage sampling procedure was adopted to select 180 cassava farmers for the study. Primary data were collected from the farmers using a pretested structured questionnaire. The data collected were analyzed using descriptive statistics and the Tobit regression model. Results show that there is a significant difference ($p \leq 0.05$) between the mean age of male (52.17±10.37) and female (44.97±12.54) adopters of BCVs. Also, the average farming experience of male (21.75±10.99) and female (17.18±10.73) adopters of BCVs are significantly different ($p \leq 0.05$). The results further show that about 58% of the 169 respondents aware of BCVs are male, while 42% are female. Similarly, 58% of the 91 adopters of BCVs are male, while 42% are female, and the average rate of adoption of BCVs in Oyo State was 50.56%. The adoption of BCVs by males is influenced by four factors: education, membership of cooperatives, extension contact, and assets owned by farmers, while primary occupation and membership of cooperatives influence the adoption among female farmers. The membership of agricultural cooperatives influences the adoption of BCVs by male and female farmers.

adoption, biofortified cassava varieties, agricultural cooperative, gender, Tobit regression model

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INTRODUCTION

It is widely believed that Africa is a continent mostly ravaged by severe malnutrition (FAO et al., 2018; Kehinde, Kehinde, 2020). Malnutrition is not necessarily caused by starvation but by the unavailability of diets containing adequate nutrients, otherwise known as micronutrient deficiency. Despite the large expanse of arable land and more than half of its population involved in agricultural activities, many people remain undernourished and deficient in basic nutrients, especially Vitamin A (Muller, Krawinkel, 2005; Low et al., 2017; Ilona et al., 2017). According to Stein, Qaim (2007), HarvestPlus (2014), and FAO et al. (2018), there are more than 850 million people who suffer from micronutrient deficiency in Africa, Nigeria inclusive. However, this deficiency has damaging implications on the health of both men and women, affecting the latter more. In addition, it has been established that a lack of Vitamin A affects almost 20% of pregnant women and about 25% of children under the age of five, which predisposes them to sicknesses such as diarrhoea and measles, stunted growth in children and even premature death (Maziya-Dixon et al., 2006; Micronutrient Initiative, 2009; IITA, 2014; Stevens et al., 2015). Numerous methods, ranging from nutrient supplementation, home food fortification, condiment fortification, etc., have been adopted to address vitamin A deficiency in Africa. However, none has effectively reached the poor, especially in rural communities (Onyeneke et al., 2019).

In a bid to address vitamin A deficiency among the poor, different food crops like potato, rice, maize, sorghum, and cassava were biofortified with micronutrients (vitamin A) in many African countries. In Nigeria, cassava was chosen because of its peculiarity in solving the problem of food insecurity in rural households (Ogunleye et al., 2017; Kehinde, Olatidoye, 2019; Kehinde, Adeyemo, 2020). It is interesting to note that most of the poor households in Nigeria depend on cassava for food, nutrition, and income sources. Four out of five rural dwellers in Nigerians eat a cassava-based meal at least once a week because cassava is an inexpensive and dependable source of carbohydrates (Adeyemo, Kehinde, 2019; Kehinde, Olatidoye, 2019; Kehinde, Adeyemo, 2020; Iromini et al., 2021). In this regard, cassava has the potential to address the micronutrient deficiency of rural households in Nigeria. Considering this, HarvestPlus introduced biofortified cassava varieties in 2011 (IITA, 2013). These varieties include the first series such as UMUCASS 44, UMUCASS 45, and UMUCASS 46; and the second series of pro-vitamin A varieties are NR07/0220, IITA-TMS-IBA070593, and IITA-TMS-IBA070539. Introducing these varieties makes basic nutrient requirements available to poor households, especially rural dwellers (HarvestPlus, 2014). They contain higher amounts of beta-carotene and are at least six times more nutritious than the common, white-fleshed cassava. These varieties are also expected to enhance cassava yield as they resist the cassava mosaic virus. They generate income, simultaneously alleviating poverty and food insecurity (Oparinde et al., 2012; IITA, 2013; Bansode, Kumar, 2015; Oluponna, Kehinde, 2022).

Despite the nutritional, health, and economic benefits embedded in BCVs, their adoption by farmers has not been encouraging (Ayinde et al., 2017). According to Adesina, Baidu-Forson (1995), Agwu, Anyaeche (2007), Ezeburio et al. (2010), and Iromini et al. (2021), some of the factors hindering the adoption of improved cassava varieties include non-availability of inorganic fertilizers and agrochemicals, high labor cost, input unavailability, land ownership, age, high cost of improved varieties, lack of finance, lack of processing facilities and gender discrimination in the accessibility of the improved cassava varieties. Although Olatade et al. (2016), Ayinde et al. (2017) and Onyeneke et al. (2019) have attempted to examine the determinants of biofortified cassava adoption in Nigeria while Olaosebikan et al. (2019) carried out a gender-based study on the production, processing, and marketing of biofortified cassava adopters, none has succinctly defined the adoption rate of BCVs by gender. Nevertheless, evidence abounds that there are differences in how men and women respond to adopting new technologies (Gaya et al., 2017, Adesiyan et al., 2023). Gender difference is one of the major factors influencing the adoption of new technologies (Gaya et al., 2017; Gebre et al., 2019). The adoption rate of improved technologies has been generally low among women (Odendo et al., 2009; Kehinde et al., 2016; Doss et al., 2019; Adeyemo, Kehinde, 2020). This could be ascribed to some socio-cultural values and norms, where females lack the freedom to participate in different meetings and consequently have little access to information and credit to adopt improved technologies (Odendo et al., 2009; Kehinde et al., 2018).

In addition, the socio-cultural values and norms keep female farmers retrogressive in their socio-cultural life, resulting in living in appalling socio-economic situations. However, they make up 67% of the agricultural labor force and produce about 75% of the food. Unfortunately, female farmers may not come out of their present situations without a positive external intervention. Recently, many programs have attempted to empower female farmers but failed (Akter et al., 2019). Interestingly, agricultural cooperatives hold the potential to empower female farmers, particularly the economically weak ones, when other attempts fail (Gebremichael, 2014). The purpose of many agricultural cooperatives (especially women cooperatives) is to induce and encourage female farmers to adopt improved technologies and increase their agricultural production (Ogunleye et al., 2020; Kehinde et al., 2021; Akinola et al., 2023). The adoption of innovation by females could be successfully improved by encouraging female farmers to participate in agricultural cooperatives that target gender equality. These set of cooperatives help female farmers overcome social and cultural constraints that might limit their access to agricultural technologies such as fertilizers, seeds, agrochemicals, and farm equipment, among others (Ogunleye et al., 2017; Adeyemo, Kehinde, 2020; Adeyemo, Kehinde, 2021; Kehinde, Ogundeji, 2022).

For several years, agricultural cooperatives have been an effective way by which people exert control over their economic livelihoods. Cooperatives play vivacious roles in transferring agricultural technologies to their members through specialized extension services, ensuring members' access to credit, motivating the farmers to change their practices and improving their farm productivity (Hellin et al., 2009; Nwankwo et al., 2009; Baden, Pionetti, 2011; Francesconi, Heerink, 2011; Abebaw, Haile, 2013; Kehinde, 2021; Kehinde, Tijani, 2021; Adekunle et al., 2023). Although cooperatives improve gender relations and create a safe space for female farmers to improve their incomes and overall socio-economic status (World Bank, 2009; Jones et al., 2012; Kolapo et al., 2021), their roles in bridging the gender gap in adoption remain unclear but should not be undermined. However, cooperative membership and gender gap in the adoption of BCVs among farming households form the basis of this study. Accordingly, this paper specifically describes the socio-economic characteristics of cassava farmers by gender, examines the gender differentials in the level of awareness and adoption of BCVs among cassava farmers, and determines the effect of agricultural cooperative membership on the adoption of BCVs among farming households by gender.

LITERATURE REVIEW

Technology is defined as a set of knowledge, inputs, and management techniques that are combined with productive resources to produce a desired result. Technology is critical in any field, whether it is agriculture, construction, business, manufacturing, or any other. It makes our work easier and more efficient. Most technologies are presented to overcome various limitations. As a result, this hints at why farmers choose certain technologies. Agricultural technology is described as using technology to help farmers improve and promote their businesses (Olayide, 1980). Traditional and modern technology are the two sorts of technology. Traditional technology is referred to as indigenous technology. They are primarily Indigenous or upgraded technology types that have long been domesticated by farmers and have lost their original traits due to cross-breeding. Large, complex, mechanized, and capital-intensive modernized large-scale farming with better technology are examples of modern technology. Crop variety enhancements, agroforestry, soil and water conservation/management, conservation agriculture methods, integrated pest management, and livestock and fodder innovations are all examples of agricultural technology. Adoption of an agricultural innovation is a decision accompanied by a desire to employ the innovation; the use of the innovation provides a competitive advantage over alternative approaches. According to Kaine (2008) and Awotide et al. (2015), the four stages of technology adoption are awareness, persuasion, decision, and confirmation. On the other hand, final adoption is defined at the individual farmer level as the degree of application of new technology in long-run equilibrium when the farmer has full knowledge of the new technology and its potential (Sunding, Zilberman, 2001). As a result, innovation adoption might be described as a farmer's first non-trial application of an idea, method, or technology (Langyintuo, Mungoma, 2008).

Many factors influence the adoption of improved agricultural technologies. Different farmers live in distinct geographical contexts, different socio-cultural perspectives, and varied economic environments with different farming investment capitals; hence, these factors vary (Javier et al., 2005; Kassie et al., 2014; Challa, Tilahun, 2014). Institutional factors refer to the extent to which institutions impact smallholders' technology adoption (Meinzen-Dick et al., 2004). All agricultural development services, including finance, insurance, and information distribution, are provided by institutions. They also include facilities and mechanisms that enhance farmers' access to productive inputs. The rate at which farmers use innovations largely depends on sensitization, mentoring, and demonstration by extension agents (Lawal, Oluyole, 2008). According to Adenle et al. (2014) and Liverpool-Tasie et al. (2017), better training of farmers, creating awareness and educating the public, increasing scientific capacity, engaging local scientists and farmers, upgrading infrastructure, and capacity building, among others, are important steps in developing and adopting new technology. These factors can be summed up as communication channels and social networks. Institutions also include embedded norms, behaviours, and practices in society; these can encourage or discourage the adoption of a particular technology by members of that society. For example, the practice that the production of certain types of crops is exclusively for the male members of society can limit the adoption of a particular technology in Sub-Saharan Africa if the crop to be promoted is grown mainly by women. In some countries, female-headed households are discriminated against by credit institutions, and as such, they are unable to finance yield-raising technologies, leading to low adoption rates. Also, technical factors such as the degree of complexity, compatibility, and special features directly influence the initial cost levels of innovations (Cantono, Silverberg, 2009), influencing their adoption.

Furthermore, another characteristic that could have either a positive or negative effect on adopting agricultural technology, as observed in some adoption literature, is the farmer's age. Age can have positive and negative effects (Adesina et al., 2000). Adesina, Baidu-Forson (1995) and Shekania et al. (1996) argue that older farmers may have more experience in crop production and are more exposed to the potential of modern technology than younger farmers. On one hand, younger farmers are more likely to adopt new technologies than their older counterparts. This is because older farmers tend to be more efficient in their practices; hence, they require much greater returns to change their practices than younger and inexperienced farmers who are just starting and have lower marginal productivity. In addition, the decision to adopt an agricultural technology depends on a variety of factors (Mendola, 2005; Calatrava-Leyva et al., 2005; Shiferaw et al., 2014; Onyeneke et al., 2020), which includes farm households' asset bundles and socioeconomic characteristics, characteristics of the technology proposed, perception of need, and the risk-bearing capacity of the household.

A farmer's financial situation may have a favourable impact on agricultural technology adoption. Wealthier farmers are more likely to afford the cost of new technologies (Akinola et al., 2010). This factor considers whether farmers have the physical (material) and abstract (educational) assets required for technology adoption. Technology adoption will be limited due to a lack of resources (Meinzen-Dick et al., 2004;

Akinola et al., 2010). According to Amadi et al. (2020),, the perception variable is significant in measuring farmers' perceptions of a problem (e.g. vitamin A deficiency). Farmers' perceptions of the severity of the problem to be solved will determine their reaction to the technical innovation planned to fix the problem to a considerable extent. Furthermore, farmers' subjective choices for technology attributes may significantly affect technology adoption. Farmers' adoption of technology may represent rational decision-making based on farmers' assessments of the appropriateness (inappropriateness) of the technologies under investigation attributes (Adesina, 1992). Another critical aspect of farmers' perception is their expectations about the risks and rewards associated with the technology. Farmers' ideas about the additional costs and benefits of adopting improved technology greatly impact whether or not they use it. The main benefit of increasing technology usage is that it allows farm businesses to overcome revenue or capital constraints by increasing loan availability (Kehinde et al., 2018; Kehinde et al., 2024). However, in most Sub-Saharan African countries, one of the most noticeable elements of credit is the lack of an educational package alongside finance for small rural farmers (Chidzonga, 1993). The expense of technology is a significant barrier to adoption (Bisanda, Mwangi, 1996). The removal of seed and fertilizer price subsidies in Sub-Saharan Africa since the 1990s as a result of World Bank-sponsored Structural Adjustment Programs has exacerbated this limitation (Chidzonga, 1993; Bisanda, Mwangi, 1996).

MATERIALS AND METHODS

Description of Study Area

The study was carried out in Oyo State in the Southwestern part of Nigeria (Fig. 1). The State covers a total of 28,454 sq. km of land mass and is bounded by Ogun State, Kwara State, Republic of Benin, and Osun State 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 ^{0}C and 35 ^{0}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 the larger percentage being males (Sodiya, Oyeniran, 2014). Agriculture is the main occupation of the people of Oyo State. The presence of two ecological zones gives room to the cultivation of several food crops which boost farmers' income, thereby improving their livelihood.

Sampling procedure and sampling size

A multi-stage sampling procedure (Table 1) was used to select respondents for the study. The first stage involved a purposive selection of the Oyo States being one of the States into which BCVs were introduced. Harvest-Plus project built on the existing delivery pathway that empowers the rural population (where hidden hunger is prominent) to scale up vitamin A cassava production and processing to meet food and income needs. Four states, Oyo inclusive, are used as centres to multiply the stems that spread to all other states in Nigeria. The second stage involved the stratification of the Local Government Areas (LGAs) in the State into two, based on BCVs dominating area: BCVs dominating LGAs and non-BCVs dominating LGAs. The third stage was the simple random selection of three LGAs from each stratum within the BCVs dominating LGAs and the other three from non-BCVs dominating LGAs. The six LGAs were carefully selected with maximum distance to avoid diffusion and spillover effects. In the fourth stage, two villages were purposively selected in the three LGAs of each

Fig. 1. Map of Oyo state

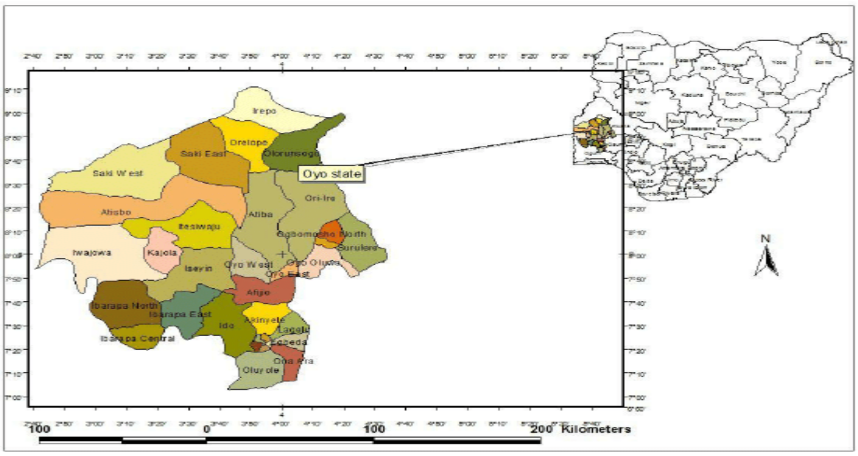

Table 1. Sampling procedure for the study

State	Adopters					Non-adopters				
	BCVs dominating LGAs	Villages		Cassava farmers		Non-BCVs dominating LGAs	Villages		Cassava farmers	
		Proportion used	Number of villages	Proportion used	Number of registered farmers		Proportion used	Number of villages	Proportion used	Number of registered farmers
Oyo	Orire	2	18	35	73	Ona-ara	2	13	29	39
	Afijio	2	15	29	53	Atiba	2	16	29	43
	Akinyele	2	10	27	48	Egbeda	2	20	31	57
Total	3	6	43	91	174	3	6	49	89	139

Source: Authors' Computation

stratum. In the selected villages, a simple random technique was used to select 180 farmers (91 adopters and 89 non-adopters), comprising 107 male and 73 female farmers. The survey was conducted from June 2017 to March 2018, and the data were collected at the household level. Data were collected on farmers' socio-economic characteristics such as age, education, gender, household and farm size, adoption status of the farmer, intensity of use of BCVs, and so on.

Data analysis

Data are analyzed with descriptive statistics and the Tobit regression model. Following Akinola et al. (2010), this study employs the Tobit regression model to determine the effect of cooperative membership on adopting BCVs among farming households in Oyo State by gender. Many scholars have used various models to investigate the factors influencing technology adoption. Feder et al. (1985) employed correlation to investigate the interrelationships of many factors that influence adoption. Tetteh et al. (2011) also employed Pearson correlation to find the association between adoption and the independent variables and pair-wise ranking to prioritize the restrictions. Olumba, Rahji (2014) investigated the factors influencing the adoption of better crop varieties using Pearson Product Moment Correlation (PPMC) and a multiple regression model. However, these methods only provide qualitative information about the impact of multiple factors, with each correlation potentially containing misleading effects from other variables. The use of Logit and Probit to determine factors influencing agricultural technology adoption is appropriate; however, the use of the Ordinary Least Square (OLS) regression technique is not, as the estimates may be biased (Feder et al., 1985). Ayanwale, Adekunle (2008), Lambrecht (2014), Tahirou et al. (2015), and Kehinde et al. (2016) used a probit analysis to establish the determinants impacting adoption rates; unfortunately, these studies are vulnerable to other biases and are only confined to binary decisions. Furthermore, essential information about the variables under investigation is ignored because a dummy rather than a continuous variable is used in the Probit or Logit model. Also, it does not provide information on the intensity of adoption of a given alternative (Langyintuo et al., 2003; Waithaka et al., 2007).

As a result, Mbaga-Semgalewe, Folmer (2000); and Saka, Lawal (2009) investigated the continuous model, which allows for the measurement of intensity of use. The normality of disturbances, on the other hand, is inappropriate for such regressions; as a result, the estimated standard errors and t ratios produced by an ordinary least-squares regression are insufficient for testing hypotheses about the role and importance of various factors in the adoption process (Feder et al., 1985). Adeoti (2009), on the other hand, used the Heckman two-stage technique, which included first estimating the adoption process and then the adoption impact. In examining the drivers of adoption, Mignouna et al. (2011) employed joint Tobit and Double-Hurdle (DH) models against logistic analysis (Kavia et al., 2007) and the Heckman procedure (Adeoti, 2009). This is because the factors influencing farmers' adoption should not necessarily be the same as those influencing the intensity of use, even if they are linked. Furthermore, Doss, Morris (2001) agreed that the decision to accept one technology impacts the decision to intensify it. They used a two-stage strategy because the adoption process and intensity are connected. Beshir et al. (2012) used the Tobit model to examine the drivers of adoption and intensity of usage, but they did so on the premise that the same set of factors influences the two decisions and are mutually exclusive events (Greene, 2003; Tufa, Tefera, 2016).

The Tobit regression model developed by Tobin (1958) is a hybrid of discrete and continuous dependent variables that express the relationship between a non-negative exogenous dependent variable (Y) and a vector of explanatory variables (X). The Tobit model is relevant in this study because of its ability to avoid the censoring biases that the Ordinary Least Square (OLS) estimator could present. It is obvious from the data collected that some sets of farmers did not adopt BCVs; hence, the intensity of adoption by this set is censored at zero. Thus, the Tobit model censored farmers' decisions to adopt at zero. The model was then employed to simultaneously analyze the decision to adopt and the intensity of adoption.

The stochastic model underlying Tobit (T o b i n, 1958) may be expressed by the following relationship:

$$\begin{aligned} &Y_i^* = X_i\beta + \mu i \\ &Y_i^* = Y_i \text{ if } Y_i^* > 0 \\ &Y_i = 0 \text{ if } Y_i^* \leq 0 \\ &i = 1, 2, \ldots, N \end{aligned} \tag{1}$$

where N is the number of observations, therefore, Y_i* is the latent (unobservable variable) adoption intensity which depends on the latent variable Y_i being greater than zero and conditional to adopt, X_i is the vector of explanatory variables hypothesized to influence intensity.

The dependent variable in this model is defined as the share of land cultivated with BCVs specified as:

$$AI = \frac{\sum_{i=1}^{n} \beta v}{\sum_{i=1}^{n} Lt} \tag{2}$$

where βv = land grown to BCVs by farmer i (i= 1, 2, 3,……….n) and Lt = total land area grown to cassava by the farmer.

Since the model assumes that there is an underlying stochastic index equal to ($X_t\beta + u$t), which is observed only when it is positive (A k i n o l a et al., 2010), and hence qualifies as an observed latent variable. Thus, the expected value of Y in the model, according to T o b i n (1958), is:

$$E(Y) = X\,\beta f(z) + \sigma f(z) \tag{3}$$

where z = X β/σ, *f(z)* is the unit normal density, and *F(z)* is the cumulative normal distribution function. Hence, the expected value of Y for observation above the limit Y* is X β plus the expected value of the truncated normal error term (A m e m i y a, 1984):

$$\begin{aligned} E(Y) &= E(Y / Y > 0) \\ &= E(Y / u > -X\beta) \\ &= X\beta + \sigma f(z) / F(z) \end{aligned} \tag{4}$$

According to M c D o n a l d, M o f f i t (1980), equation (4) can be decomposed by considering the effect of a change in the ith variable of *X* on *Y:*

$$\partial E(Y) / \partial X_i = Fz \times \partial EY^* / \partial X_i + EY^* \times \partial Fz \partial X_i \tag{5}$$

Thus, the total change in Y can be disaggregated into two very intuitive parts: (1) the change in Y of those above the limit, weighted by the possibility of being above the limit, and (2) the change in probability of being above the limit, weighted by expected value of Y if above the limit. The two partial derivatives are also calculable (M c D o n a l d, M o f f i t, 1980):

$$\partial F(Y) / \partial X_i = f(z)\beta i^* / \sigma \tag{6}$$

and, from equation (5):

$$\partial E(Y^*) / \partial X = \beta_I \left[1 - zf(z) / F(z) f(Z)^2 / F(Z)^2\right] \tag{7}$$

Using *F*(*z*)= *f*(*z*) for cumulative normal density and *f'*(*z*) = -*zf*(*z*).

However, Tobit coefficients don't directly measure the correct regression coefficient above the limit. The Marginal Effects (ME) of the independent variables on some conditional mean functions need to be examined to interpret the estimation results. From the common OLS model, y = xβ + ε, there is only one conditional mean function, E (y) = xβ, and M E (y)/ $Mx_i = \beta_i$, where x_i is the i[th] independent variable. This makes interpretation easy: β_i measures the marginal effect on y of the i[th] independent variable. In the Tobit model, though, there are three different conditional means: the latent variable y*, the observed dependent variable y, and the uncensored observed dependent variable y / y > 0. Accordingly, interpretation depends on whether one is concerned with the marginal effect of x on y*, y, or y / y > 0. Once the marginal effect of interest is determined, the marginal effects of x on the appropriate conditional expectations are examined. The three marginal effect expression are derived using standard results on moments of truncated/censored normal distributions as follows:

$$\frac{M\,E\,(y*|x)}{M\,x} = \beta \tag{8}$$

$$\frac{M\,E\,(y|x)}{M\,x} = \Phi\,\beta \tag{9}$$

$$\frac{M\,x\,M\,E\,(y|y > 0, x)}{M\,x} \tag{10}$$

where δ(α) = λ(α)(λ(α) – α), λ(α) = ↓(α)/(1- Φ (α)), and α = -(xβσ). Only for the latent index y* can β be interpreted as the marginal effects of the independent variables. Data collected were processed using Microsoft Excel, and STATA was the analytical software used for the analysis

The model is empirically specified as follows:

$$Y_i^* = \beta_0 + \beta_1 \text{Age} + \beta_2 \text{Eucation} + \beta_3 \text{Householdsize} + \beta_4 \text{Primaryoccupation} + \beta_5 \text{Cooperative membership} + \beta_6 \text{Landownership} + \beta_7 \text{Assets} + \beta_8 \text{Extension} + \beta_9 \text{Labour} + \beta_{10} \text{Mechanization} + \mu i \tag{11}$$

Y_i^* represents the adoption of i[th] cassava farmer, in which the measure of the intensity of adoption, according to S a k a, L a w a l (2009), is got through the adoption index, which is measured by the size of land put under the cultivation of the BCVs over the total size of land cultivated to the crop (improved and unimproved varieties).

The definitions of the independent variable are: Age of farmer (in years); Years of schooling (years); Household size is the number of people living together under the same roof; Primary occupation is whether farming is practised as a primary occupation or not

Table 2. Description of variables

Variables	Unit	Expected sign	Description
Age	Year	±	Measured in years
Education	Years spent in school	±	Measured in years spent in school
Household size	Number of persons	±	Measured in the number of household members
Primary occupation	Dummy	±	1= if the farmer mainly engages in farming 0= otherwise
Cooperative membership	Dummy	±	1= if the farmer belongs to a cooperative 0= otherwise
Land ownership	Dummy	±	1= if the farmer owns land 0= otherwise
Extension contacts	Dummy	±	1= if the farmer has contact with an extension agent 0= otherwise
Asset	Naira	±	Measured in Naira
Labor	Dummy	±	1= if a farmer hires labor 0= otherwise
Mechanization	Dummy	±	1 = If farmer uses a tractor 0= otherwise

(Farming =1; otherwise =0); Cooperative membership is membership in farmers' group or association (yes =1; no =0); Landownership is whether the land used for farming is owned by the farmer or not (yes =1; no =0); Assets is number of assets owned by the household (₦); Extension is whether they have access to services of extension agent on BCVs; Labor is whether the farmer employed hired labour on the farm (yes = 1, no = 0); Mechanization is whether a farmer uses tractor or not (yes= 1, no= 0). Where β_0 is the constant term, $\beta_1, \beta_2, \beta_3, \ldots, \beta_n$ are the parameters of the respective explanatory variables in the model, and μi is the error term. The rationale behind the inclusion of this model is based on the literature review (Table 2).

Education is assumed to positively influence farmers' decision to adopt new technology. The education level of a farmer increases his ability to obtain, process, and use information relevant to adopting a new technology (Mignouna et al., 2011; Lavison 2013). Several studies (Bamire et al., 2002; Akinola, Sofoluwe, 2012) have shown a positive relationship between education and technology adoption. The age of farmers influences their decision to adopt technology in several ways. Young farmers are up to date with new methods and practices. Therefore, they are more willing to take the risk of using new technology than older farmers. This implies that farmer's age and technology adoption are inversely related (Akinola et al., 2010; Onu, 2013). On the contrary, Kariyasa, Dewi (2011) note that older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate information on technology than younger farmers. Household size is the number of persons that pool resources together, live under the same roof, and eat from the same pot. They can be related by blood or not. A large household size working on the farm reduces the expenditure on hired labor and is assumed to positively affect technology adoption (Bekele, Mekonnen, 2010; Akinola, Owombo, 2012). Household size is used to measure labor availability. Mignouna et al. (2011) note that a larger household can relax the labor constraints required when adopting modern technology. Cooperative membership influences the social interaction and exchange of ideas among farmers (Bamire et al., 2002; Akinola et al., 2010). Katungi, Akankwasa (2010) find that farmers participating more in cooperatives are likely to engage in social learning about the technology, raising their likelihood of adopting the technologies. Assets are measured as a dummy (1 if owned and 0 otherwise) and are measures of individual farmers' assets. Farmers who own assets are likely to adopt new technology. It is hypothesized that those who own assets have greater confidence in adopting improved technology (Bekele, Mekonnen, 2010). Hired labor implies that a greater labor force is available for the timely operation of farm activities and more labor hours will be spent on the operations involved in new technology (Bekele, Mekonnen, 2010; Akinola, Owombo, 2012). It is hypothesized that hired labor is positively related to new technologies. Land ownership measured as a dummy (1 if owned and 0 otherwise), is a measure of the rights an individual farmer has over his or her farmland. Farmers who cultivate land owned by others may be less likely to invest in new technologies. This may be due to the perceived insecurity of the tenancy. It is hypothesized that land ownership is positively related to new technologies. Those who own farmland

Table 3. Socio-economic characteristics of cassava farmers by gender

Variables	Pooled (n=180)			Adopters (n=91)			Non-adopters (n=89)		
	Adopters	Non-adopters	t-test	Males	Females	t-test	Males	Females	t-test
Age (yrs)	49.67 (14.08)	49.16 (11.81)	0.26	52.1 (10.37)	44.97 (12.54)	**2.99*** **	50.81 (15.73)	47.91 (11.05)	0.94
Farming experience (years)	19.85 (11.06)	16.93 (9.50)	**1.89** **	21.75 (10.99)	17.18 (10.73)	**1.98** **	17.80 (10.26)	15.60 (8.15)	1.07
Farm size (Ac)	4.65 (5.28)	3.96 (4.08)	-0.98	6.24 (6.16)	2.44 (2.40)	**3.61*** **	4.93 (4.71)	2.46 (2.14)	**2.91*** **
Household size (#)	4.97 (1.59)	5.98 (1.54)	**4.33*** **	-	-	-	-	-	-
Education (%)									
None	16.48	26.97		11.32	23.68		18.52	40	
Koranic	4.40	2.25		7.55	0		3.70	0	
Adult	2.20	37.08		3.78	0		0	0	
Primary	39.56	37.38		32.08	50		35.19	40	
Secondary	30.77	29.21		33.96	26.30		35.19	20	
Tertiary	6.59	4.49		11.32	0		7.40	0	
Nature of farming (%)									
Part-time	67.03	58.43		54.72	84.21		59.25	57.14	
Full-time	32.97	41.57		40.74	15.79		40.74	42.86	

Note: Figures in parentheses ( ) are standard deviations; ***, **Significant at 1% and 5%, respectively.

Source: Field Survey (2018)

have greater confidence in taking investment risks on their farms (B e k e l e , M e k o n n e n , 2010). Lack of land ownership can discourage agricultural technology adoption (Z e n g et al., 2018). Extension visits refer to the farmer's contact with the extension agent to get advice during the last cropping season. Therefore, extension contact is expected to positively influence farmers' adoption of improved technologies (K i d a n e , 2001; O w o m b o et al., 2011; O g u n l e y e et al., 2021). Primary occupation is the main engagement of the farmers. This is measured as a dummy, where (0) is a non-farming occupation and (1) is farming as an occupation. A farmer whose primary occupation is farming is expected to have a higher probability of adopting improved cassava varieties than farmers whose primary occupation is not farming (A k u d u g u et al., 2009). This could be traced to the fact that a farmer whose primary occupation is farming would be willing to improve their farm business to increase their stream of income and, hence, adopt innovations on time (O g u n d i p e et al., 2019). Mechanization in terms of tractor usage may spur technological innovation in agriculture such that farmers will adopt many other effective labor-saving technologies (S a y et al., 2018; C a v a l l o et al., 2015). This is attributed to the fact that the tractor enables more efficient production and use of energetic resources, which might lead to adopting more technologies.

RESULTS

Socio-economic characteristics of cassava farmers by gender

As shown in Table 3, the average age for the entire sample is 58.6 ± 13.3 years, while that of adopters is 49.67± 14.08 years and non-adopters 49.16 ± 11.81 years. 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). Also, the mean years of farming experience of adopters (19.85 ± 11.06) are significantly ($p \leq 0.05$) higher than that of non-adopters (16.93 ± 9.50). Only 16.48% of the adopters have no formal education, while 39.56%, 30.77%, and 6.59% completed primary, secondary, and tertiary education, respectively. In addition, the majority (67.03%) of adopters practice farming on a part-time basis. This implies that a greater proportion of adopters have other sources of income which could be a leverage for adopting BCVs and maximizing its benefits than non-adopters.

The gender analysis reveals a mean age difference between male (52.17 ± 10.37) and female (44.97 ± 12.54) adopters to be significant at $p \leq 0.05$. This indicates that male adopters are older than female adopters. Male adopters (21.75 ± 10.95) also have more experience in farming than their female (17.18 ± 10.73) counter-

Table 4. Awareness and rate of adoption of BCVs

Status	Pooled	%	Males	%	Females	%
Aware	169	93.89	98	57.99	71	42.01
Not aware	11	6.11	9	81.82	2	18.18
Adopters	91	53.85	53	58.24	38	41.76

Source: Field Survey (2018)

parts. Furthermore, both male adopters (6.24± 6.16) and non-adopters (4.93± 4.71) have larger farms than female adopters (2.44± 2.40) and non-adopters (2.46 ± 2.14), respectively. 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 are involved in part-time farming.

Awareness and rate of adoption of BCVs

Table 4 shows that 94% of the farmers are aware of BCVs. This comprises 58% males and 42% females. Meanwhile, about 51% of farmers have adopted BCVs, while 49% have yet to adopt them. The adoption rate of male farmers (58%) is higher than their female counterparts (42%).

Test for multicollinearity and heteroskedasticity

Multicollinearity refers to the presence of linear relationships among the explanatory variables considered in the model. The model yields wrong signs of coefficients, high standard errors of coefficients, and high R^2 values in multicollinearity. To check for multicollinearity, each variable's variation inflation factor (VIF) is estimated. If the VIF exceeds 10, that variable is said to be highly collinear and can be excluded from the model. The result presented in Table 5 shows that none of the model's variables have a VIF greater than 10. The result further shows that the mean value is 1.19. This indicates no problem of multicollinearity among the independent variables considered in the model. The result of heteroskedasticity is also presented in Table 5. The Bresch-Pagan test (0.05) is not statistically significant. This shows that the error terms across the observations have constant variance, and there is no problem of heteroskedasticity in the observation.

Table 5. Test for multicollinearity and heteroskedasticity

Variables	VIF	1/VIF
Age	1.12	0.892
Household size	1.04	0.961
Years of education	1.13	0.885
Primary occupation	1.41	0.709
Cooperative membership	1.06	0.943
Land ownership	1.36	0.735
Asset	1.18	0.847
Labour	1.05	0.952
Extension contact	1.33	0.751
Mechanization	1.21	0.826
Mean VIF	1.19	S
Heteroskedasticity		
Test	X^2	P value
Bresch-Pagan (BP) test	0.05	0.834

Source: Field Survey (2018)

Effect of agricultural cooperative membership on adoption intensity of BCVs by gender

The effect of cooperative membership on farmers' adoption of BCVs among the entire sample and by gender is shown in Table 6. Generally, household size, education, primary occupation, land ownership, farm association, extension contact, and assets significantly impacted adoption at varying levels. An additional increase in household size increases adoption by 0.01ha. Education positively impacts the adoption of BCVs by increasing it by 0.05ha. A unit increase in ownership of land significantly ($p \leq 0.05$) leads to a 0.03ha increase in adoption. Also, being a cooperative member increases the adoption of BCVs by 0.08ha. Access to extension visits and assets increases the adoption of BCVs by 0.05ha and 0.02ha at $p \leq 0.05$, respectively. Meanwhile, an additional increase in farming as a primary occupation decreases adoption intensity by 0.06ha at $p \leq 0.05$.

A gender analysis indicates variations in the factors influencing the adoption of BCVs between male and female farmers. Education, farmers' association membership, extension contact, and assets positively influence the adoption of males at different levels of significance. A unit increase in the level of education increases adoption by 0.06ha at $p \leq 0.05$. Membership of cooperatives and assets increase adoption by 0.08 ha and 0.02 ha, respectively, at $p \leq 0.05$. Also, access to extension services increases adoption by 0.04 ha among male farmers. Whereas, for the female farmers, a unit increase in practising farming as a primary occupation results in a 0.08 ha decrease in the adoption of BCVs. On the other hand, membership of agricultural cooperatives increases adoption by 0.07ha among female farmers. Interestingly, membership in agricultural cooperatives increases the adoption

Table 6. Effect of cooperative membership on adoption intensity of BCVs by gender

Variables	Pooled (n=180)		Gender			
			Male (n=107)		Female (n=73)	
	Coefficient	M. E.	Coefficient	M. E.	Coefficient	M. E.
Age	-0.002 (-0.99)	-0.01 (-0.99)	-0.002 (-0.71)	-0.001 (-0.71)	-0.003 (-0.88)	-0.001 (-0.88)
Household size	0.029* (1.84)	0.010* (1.85)	0.024 (1.11)	0.007 (1.12)	0.050* (1.90)	0.019* (1.90)
Education	0.174*** (3.07)	0.054*** (3.33)	0.210*** (2.67)	0.057*** (3.05)	0.093 (1.02)	0.034 (1.05)
Primary occupation	-0.169*** (3.66)	-0.058*** (-3.60)	-0.098* (-1.67)	-0.031 (-1.58)	-0.225** (-2.47)	-0.078*** (-2.70)
Labour	0.006 (0.12)	0.002 (0.12)	-0.0059 (-0.84)	-0.019 (-0.80)	0.117 (1.35)	0.044 (1.40)
Mechanization	0.075 1.60)	0.02 (1.62)	0.063 (1.09)	0.019 (1.10)	0.103 (1.26)	0.039 (1.28)
Land ownership	0.104** (2.10)	0.035** (2.15)	0.095 (1.53)	0.028 (1.56)	0.053 (0.59)	0.020 (0.60)
Agricultural Cooperative membership	0.227*** (4.71)	0.076*** (4.82)	0.250*** (4.26)	0.076*** (4.28)	0.178** (2.00)	0.066** (2.07)
Extension contact	0.1465*** (3.04)	0.049*** (3.16)	0.136*** (2.32)	0.041*** (2.36)	0.104 (1.19)	0.038 (1.23)
Asset	0.063** (2.57)	0.021** (2.61)	0.076** (2.39)	0.023** (2.45)	0.064 (1.38)	0.024 (1.38)
Constant	-0.640*** (-4.31)		-0.694*** (-3.40)		-0.596** (-2.03)	
Log-likelihood	-43.891		-14.2804		-24.7331	
LR chi^2	98.68		69.43		35.53	
Prob>chi^2	0.000		0.000		0.000	
Pseudo R^2	0.5292		0.7085		0.4180	

Note: The figures in parentheses represent the t-ratios, while ***, ** and * represent significance levels at 1%, 5% and 10%, respectively.

of both males and females by 0.08 ha and 0.07 ha, respectively, at p≤0.05.

DISCUSSION

The non-adopters are relatively older, making them unwilling to change the traditional practices they have been used to over the years. This result is in tandem with Kinuthia, Mabaya (2017), who state that as a farmer's age increases, the chances of accepting and adopting new technologies decrease. The household size indicates the potential family labour available for farm work. The adopting households have larger family sizes, which gives them an edge in labour supply over non-adopting households. This implies that adopting households have fewer labour constraints which make it easier to adopt improved crop varieties (Amare et al., 2012; Asfaw et al., 2012; Kehinde, Adeyemo, 2017; Adedipe et al., 2017). Also, an average adopter is more experienced in farming than a non-adopter; this corroborates Adedipe et al. (2017) and Kehinde et al. (2022), who state that increased years of farming experience enable them to make accurate decisions on the appropriateness of new technology for efficient production. Education is an important factor that harnesses the proper decision to adopt new technology. The result reveals that a greater proportion of the non-adopters have no formal education. This indicates that adopters are generally more learned than non-adopters. Therefore, adopters stand a better chance of making accurate decisions. This result is consistent with many other agricultural technology adoption studies in sub-Saharan Africa that have reported education as having a positive influence on adoption (Guo et al., 2020; Abegunde et al., 2020; Wossen et al., 2018; Wossen et al., 2017).

The gender analysis of the socio-economic characteristics of the farmers reveals that males are more knowledgeable about the efficiency of new technologies due to longer years of experience in farming practices. Furthermore, the result suggests that men have more access to land holdings than women and, therefore, are more opportune to maximize the use of BCV adoption. This is in line with FAO (2002), Doss et al. (2013), Patel et al. (2014), and World Bank (2014), that women lack land rights independently of their husbands or male relatives. The larger the size of the farm, the larger the land a farmer would likely devote to the cultivation of improved varieties of crops. Also, most females either never went to school at all or have only primary education, especially non-adopters. This implies that females are generally less educated than their male counterparts. Practising farming on a part-time basis enables a farmer to weather the risks that may accrue to new technology adoption. The majority of female adopters practised farming on a part-time basis. This supports the fact that more women are involved in off-farm activities than men and is congruent with Doss et al. (2018), who posits that women are more involved in food processing and preparation.

Farmers' awareness is very important in adopting BCVs as a new agricultural technology because it serves as a means of initial information to the farmers. It is, however, important to note that most farmers were already aware of BCVs, although the female farmers were more aware of BCVs than their male counterparts. This corroborates the findings of O n y e n e k e et al. (2019) that awareness of BCVs has increased over the years since their dissemination. Meanwhile, a fairly large number of farmers have yet to adopt it. This suggests that some reasons (like a small portion of the farm, inadequate capital, and inaccessibility of stems), as stated by some farmers, are responsible for the relatively low adoption rate despite the high level of awareness. However, the adoption rate of male farmers is higher than their female counterparts. It is also observed that females are much more aware of BCVs than males, yet their adoption rate is lower than that of the males. This depicts that females seem to have fewer resources and decision-making abilities when deciding what technology to/not to adopt than males. This is in line with the position of A m a e c h i n a (2002), D o s s (2011), and J o s h i et al. (2016) that men have continued to dominate farming decision-making despite the significant roles of women in agricultural activities.

Generally, household size, education, primary occupation, land ownership, farm association, extension contact, and assets significantly impact adoption at varying levels. The plausible explanation for a positive relationship between households and the adoption of BCVs is that households with more members will devote more land to BCV cultivation. This is in line with the observations of S i m t o w e et al. (2016), J a l e t a et al. (2018), and K e h i n d e, A d e y e m o (2017) that adopting households have significantly larger households than non-adopting households. Education has a positive impact on the adoption of BCVs. This suggests that education enables farmers to make better and more informed decisions on new technologies. This confirms the position of D i m a r a, S k u r a s (2003), T a h i r o u et al. (2015), G u o et al. (2020), and A b e g u n d e et al. (2020) that increasing level of literacy increases adoption. A unit increase in ownership of land significantly increases in adoption. Also, being a member of a cooperative society increases adoption. This supports the position of T u f a, T e f e r a (2016) that membership in farmers' organizations improves farmers' access to input services (fertilizers, seeds, and chemicals) and technology transfer among the farmers. Access to extension visits and assets increased the adoption of BCVs. This shows that farmers who own more properties are more inclined to adopt new technologies such as BCVs as they are reliant on cash realizations from such assets in case of any contingency. This corroborates the findings of A k i n o l a et al. (2010) that assets owned increase the adoption of improved technology, whereas an additional increase in farming as a primary occupation decreases adoption. This suggests that those with farming as their major occupation would devote a smaller portion of land to new technologies than other farmers whose major engagement is in other forms of occupation. This might be because they stand a greater risk if the new technology does not pay off. This is in line with the findings of L e m c h i et al. (2005) that a greater proportion of non-adopters have farming as their primary occupation than adopters.

A gender analysis indicates variations in the factors influencing the adoption of BCVs between male and female farmers. Education, farmers' association membership, extension contact, and assets positively influence adoption by male farmers. A unit increase in the level of education increases adoption. This suggests that education gives an edge in maximizing the advantages of improved technologies among men. Membership of agricultural cooperatives and assets increases adoption by male farmers. This indicates that males are more privileged to become members of agricultural cooperative societies and own more assets than their females' counterparts. This aligns with studies that men have more access to membership in farmers' groups than women while the latter remain underrepresented in organizations (H a u g e n, B r a n d t h, 1994; A d e s i n a, D j a t o, 1996; A k t e r, 2017). Also, access to extension services increases adoption by 0.04 ha among male farmers. This suggests that men have more access to extension services than their female counterparts. This corroborates the findings of D o s s, M o r r i s (2001) that women enjoy less access to extension services than men. Meanwhile, for female farmers, a unit increase in practising farming as a primary occupation results in a 0.08 ha decrease in adopting BCVs. This might be because women who practice farming fully have greater chances to be aware, develop an interest, and accept new technologies. They have fewer resources to bear the risks that might come with adopting improved technologies than others who are engrossed in other non-farming occupations. Membership in agricultural cooperative societies increases adoption among female farmers.

Surprisingly, membership in agricultural cooperatives increases the adoption by both males and females. This suggests that increased chances of being a member of both male and female gender would yield more results in adopting BCVs in Oyo State. This is attributed to the fact that agricultural cooperatives have capacities to encourage technology adoption through many pathways, such as better access to information and credit facilities (K e h i n d e, T i j a n i, 2021; K e h i n d e et al., 2022a; A y a n w a l e et al., 2023). This implies that most farmers who belong to agricultural cooperatives have the opportunity to be introduced to BCVs. Thus, they have an edge in knowledge over others. It can be ascribed to the cross-fertilization of ideas among farmers, which exposes farmers to a wide range of ideas through training and extension services, which may positively change their attitude toward innovation.

This study agrees with the observation of Kolade, Harpham (2014), Kehinde et al. (2022b) and Oyenpemi et al. (2023) that information on access to improved technologies and benefits accrued to adopting such innovations is more easily obtainable in cooperatives. Furthermore, agricultural cooperatives help their members to adopt new technology through trade credit and financial support from financial institutions. The result also agrees with the study of Toluwase, Apata (2013) and Ayanwale et al 2024 who find that agricultural cooperatives are among the feasible approaches to bridging the gender gap and improving farmers' productivity. Agricultural cooperatives are, therefore, helpful and effective tools that help female farmers adopt improved technologies, improve their livelihoods, and lift them out of poverty. This stresses the fact that agricultural cooperatives conduct business in a way recognized as the most effective route to transformational development by putting people in charge of their destinies, increasing financial security for the members, and contributing directly and indirectly to gender equality (Armando, 2009; Mwangi et. al., 2012).

CONCLUSION

This study investigated agricultural cooperative membership, the gender gap, and the adoption of biofortified cassava varieties among cassava farmers in Oyo State. A multistage sampling procedure was used to select 180 cassava farmers for the study. The data collected were analyzed using descriptive statistics and the Tobit regression model. The study shows that non-adopters (especially males) are relatively older. Most cassava-growing farmers are educated, while most female farmers practice farming part-time. Men generally own land than women. This aligns with the finding of Frank (1999) and Doss, Morris (2001) that a greater proportion of women are landless, and as such, they occupy a rather tenuous position concerning access to land. The majority of the farmers are aware of BCVs, which only a little above average have adopted, with the lower percentage being females. Results confirm the importance of membership of cooperatives in bridging the gender gap in adopting BCVs. While household size and primary occupation are germane factors that influence the adoption by females, education, extension contact, and assets constitute important factors that increase BCV adoption intensity among males. This suggests that while strategizing to increase the adoption of BCVs among farmers, education and asset ownership should be encouraged among men as this increases the intensity of adoption among male farmers. Female farmers should be encouraged to practice a diversified farming system and harness family labour. Both men and women should be encouraged to join farmers' groups because this would give room for better access to key information and inputs.

CONFLICT OF INTEREST

The authors declared no conflicts of interest concerning this article's research, authorship, and publication.

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