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Land Tenure, Land Property Rights and Adoption of Bio-Fortified Cassava in Nigeria: Implication for Policy Recommendations

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Abstract

The study investigated land tenure, land right and rental system as it relates to adoption of bio-fortified cassava in Nigeria. The study was conducted in three states in Nigeria where bio-fortified cassava technology was first released in Nigeria including Oyo, Benue and Akwa-ibom. Multistage sampling techniques was used to select 360 bio-fortified cassava farmers. Descriptive statistics, t-test and cragg's double hurdle model were used to analyzed the data collected. The result of the study showed that the mean age of the farmers was 48(±11.36). The land tenure system practiced in the bio-fortified cassava producing areas in Nigeria is governed by inheritance (23%), purchasing (19.7), gifting (31.7) with temporary arrangements through rentals (25.6%). The tenant bio-fortified cassava farmers pay about ₦31,000 per acre per year in land for cash agreement or 4-7% of the actual yield of the bio-fortified cassava in land for cassava outputs agreements. However, this agreement between the landlords and tenant bio-fortified cassava farmers were verbal where both parties try as much as possible to honor the agreements.

Variables such as access to credit, landownership status, access to bio-fortified cassava stems and extension contacts influenced the decision to adopt bio-fortified cassava technology while age, perception and training influenced the intensity of adoption of bio-fortified cassava technology. The result of the t-test analysis showed that there was a significant difference in the farm sizes (34739.467 at 1%) and yields (0.593 at 1%) of the landlords and tenant bio-fortified cassava farmers. The findings of the study indicated that tenant bio-fortified cassava farmers were being faced with the problem of insecure land access, thus the need to implement policies that will increase access to land resources among the tenant farmers in Nigeria.

Keywords: Land rights, Rental system, Bio-fortified cassava, double-hurdle, Nigeria.

INRODUCTION

Cassava is an important staple food in Nigeria. Cassava is a starchy crop which contributes to the staples of millions in sub-Saharan Africa (SSA). According to Otekunrin and Sawicka (2019), about 177,948 million tonnes of cassava were produced in Africa. 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 by Otekunrin and Sawicka (2019), a staple crop is the one that is been eaten regularly and which also provides larger proportions of the population's nutrients. 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).

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. 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. In Nigeria diets today, yellow bio-fortified cassava represents additional source of vitamin A (Saltzman *et al*., 2014). However, about six varieties of bio-fortified cassava have been introduced so far since 2011 when the first three set of the bio-fortified cassava were introduced. The adoption rate of these varieties of bio-fortified cassava is very low which had been ascribed to factors including, land ownership status, gender, age, access extension services, level of education, and income among others (Ayinde *et al*., 2017).

Considerable weight was attached to the land ownership status of the adopters of the bio-fortified cassava. One of the major constraints faced by bio-fortified cassava production in Nigeria is the problem of land tenure (Ilona *et al.,* 2017). Hart (1982) described the land tenure situation in Africa as confusing and conflict-ridden. Constraints relating to insecure land tenure have continued to discourage Africans from making needed agricultural investments (CAPRI, 2005). Secure access and rights to land are fundamental to the achievement of food security and sustainable rural development especially in Nigeria. Insecure and limited access to land has contributed to low agricultural outputs and poverty (Huggins and Pottier, 2011). Therefore, understanding the dynamics associated with different types of land rights and tenure is crucial to any agricultural development effort. Lack of assurance of land rights for a long period of time and unequal land distribution hamper agricultural development by limiting land access to many needy Nigerians, relegating them to the status of land tenants. For bio-fortified cassava technology to succeed and contribute to reduction in vitamin-A deficiency (VAD), realization of increased farmers' income, increased yield and improved farmers welfare particularly Nigeria, it is essential that issues related to the land tenure regime and land rental system are addressed. Land for bio-fortified cassava production must be secured for a long period of time to ensure continuous cultivation of this improved technology. Adoption of the bio-fortified cassava technology will be a mirage if land tenure, as it relates to the landlord-tenant relationship, is not addressed. This requires research to examine land tenure, land rights and the rental system in Nigeria with a view to improving the adoption of bio-fortified cassava production. This study examined the land rights regime and land rental system as it relates to the adoption of bio-fortified cassava technology in Nigeria. The specific objectives of the study are to examine: 1) the rental system in bio-fortified cassava production areas in Nigeria; 2) the nature of the land rights regime among landlords and tenants; examined the effect of land ownership status on the adoption and intensity of adoption of bio-fortified cassava and 4) examine the significant differences in farm sizes and yields bio-fortified cassava of the landlord and tenant.

Literature review

The relationships between land tenure, agricultural production and adoption of technology have been thoroughly studied in Africa and there is ample evidence as a basis for the development of improved land policies in support of food security. The land tenure issues that affect food security include manifestations of unequal distribution of land, sub-optimal utilization of land and insecure tenure. The stability of tenure, rather than ownership, may be more important in encouraging farmers to invest in soil productivity and adopt sustainable land-use practices. Migot-Adholla *et al.* (1990) revealed that, the investment behavior of farmers depends on the security of land tenure. Thus, farmers are considerably more likely to improve lands they own, or for which they have long-term use rights, than lands they operate under short-term use rights. Farmers' ability to recover investments in soil productivity do tend to be less certain when they collectively own the land or operate it under a lease agreement (de Janvry and Sadoulet, 2005). To explore relationship between property rights and technology adoption in small holder agriculture, the literature suggests that the three important dimensions of property rights are exclusivity, security and transferability (Kagwanja, 2006; Kameri-Mbote, 2006). The exclusivity dimension refers to the way that relationships among potential right holders are defined. It is generally hypothesized that, the degree of exclusivity has a positive effect on the incentive to produce, invest and adopt technology. The greater the exclusivity, the greater is the incentive to adopt technologies that are fixed to the land. Also, Baland and Platteau (1996) suggest that, there may be circumstances in which less exclusive land rights may help people to pool the risks associated with new innovations or technologies. Feder and Feeny (1993) distinguish different possible effects of insecure property rights on technology adoption and noted that, rights of short duration provide a direct disincentive for farmers to undertake investments in land. Similarly, when the breadth or assurance of rights is inadequate, local rules may not protect an individual's claim to benefits from investments. Whether breadth or assurance is hypothesized to be linked to technology adoption depends upon the specific technology/property rights context such as the payback period of the technology. The transferability of land rights, including rental, bequest, temporary and permanent gift, and sale, may affect technology adoption in three ways. First, restrictions on transferability may reduce the incentives of current residents to adopt technologies likely to generate benefits beyond their likely tenure. Place *et al.* (1994) described key components of tenure security to be freedom from interference from outside sources, continuous use, and ability to reap the benefits of labor and capital invested in the resource. It is generally accepted that, at least in sub-Saharan Africa, there are both direct and feedback relationships between property rights and technology adoption. The property rights that govern the use of a particular plot of land will affect farmers' adoption and use of technology on that land. Also, the adoption and use of technology has feedback effects on property rights. Otsuka and Kalirajan (2006) found that, customary land institutions have evolved toward individualized systems in order to provide appropriate incentives to invest in tree planting. This is may be related to the changes occurring along a continuum from communal to individual to rented/shared land. Customary land tenure systems, under which often farmers do not hold title to the land they cultivate, have been charged with failing to provide farmers with adequate incentives to adopt new technologies that could enhance production.

Methodology

Area of Study

This study was carried out in Nigeria. Nigeria is located in West Africa on the Gulf of Guinea and has a total area of 923,768 km^2 making it the world's 32^{nd} largest county. It shares a 4,047 km border with Benin(77km), Niger(1497km), chad (87km), Cameroon (1690km) and has a coastline of a least 853km. Nigeria lies between latitude 4^o and 14^o North and longitude 2^o and 15^o East. The far South is defined by its tropical rain forest climate where annual rainfall is 60 to 80 inches (1524mm to 2032mm) per year. The coastal plain are found in both the South-West and the South-East, this forest zones most southerly portion is defined as salt water swamp also known as the mangrove swamp. The tropical climate in the area favors the growth of some varieties of annual crops such as groundnut, yam, cassava, maize, rice, cowpea, plantain and banana and the tree crops include cocoa, kola nut and palm produce. There are two distinct seasons in Nigeria, namely the rainy season which last from March to October and the dry season which comes up with harmattan and last from November to February. Nigeria is the most populous country in Africa and account for about 18% of the continent total population. Nigeria was one of the first country in sub-Saharan Africa where bio-fortified cassava was introduced in 2011, hence the choice of the study area.

Sampling procedures and sample size

Multistage sampling procedures were employed for the study. The first stage involved purposive selection of three States because the introduction of bio-fortified cassava in 2011 started in these States. This included Oyo, Benue and Akwa-ibom State. The second stage involved purposive selection of two Local Government Areas (LGAs) because of the concentration of bio-fortified cassava producers in the areas. The third stage involved purposive selection of three communities from each of the selected LGAs. At the third stage, ten bio-fortified cassava farmers were purposively selected from each community to make a total of 360 (Three hundred and sixty) 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, land tenure system, land right and rental system, farm sizes and yield of bio-fortified cassava farmers. Data were collected in June 2019- November, 2019.

Analytical techniques

The data were analyzed using descriptive statistics, T-test, Cragg's double hurdle model

Descriptive statistics

Descriptive statistics was used to summarized the socio-economic characteristics of the bio-fortified cassava farmers.

T-test

T-test was used to determine significant differences in the yields and farm sizes of landlords and tenant biofortified cassava farmers.

The Cragg's model two-step estimation procedure

The Cragg's model was chosen for this study because it relaxes the restrictive assumption of the Tobit model that the factors influencing the discrete decision (adoption decision) and the continuous decision (intensity of use) as well as their effects are the same. Hence, in the Cragg's model, the coefficients of the dependent variables of the first and second hurdle are different.

The first step analyses the factors influencing the decision of farmers to adopt bio-fortified cassava varieties, while the second step deals with the intensity of use of the adopted bio-fortified cassava varieties by gender.

Step 1: Probit model for the discrete adoption decision

For the Probit model, we assume that the decision of the 'i'th farmer to adopt a technology or not depends on an unobservable utility index Y_i^*, that is determined by the explanatory variables, and that the higher the value of this utility index the higher the probability that the farmer will adopt the technology. The adoption probability (dependent variable) Y_i is limited between the values of 1 and 0.

$$Y_i = \begin{Bmatrix} Y_i^* \text{ if } Y_i^* > 0 \\ 0 \text{ if } Y_i^* \leq 0 \end{Bmatrix}$$

The Probit model is expressed as:

$$\text{Prob}(Y^* > 0) = F(X'\beta) = \Phi(X'\beta) = \int_{-\infty}^{X'\beta} \emptyset(Z)dZ$$

Where; $F(X'\beta)$ = cumulative degree of freedom of the standard normal distribution

$Y_i^* = X'\beta + e_i$

$X'\beta = \beta_0 + \beta_1 AGE + \beta_2 EXP + \beta_3 EDUYRS + \beta_4 ACCCRE + \beta_5 FINCOME + \beta_6 HHSIZE + \beta_7 LNDWNSHP + \beta_8 ASSN + \beta_9 PERCEPTN + \beta_{10}$ ACCBIO-FSTM $+ \beta_{11} AWARE + \beta_{12} TRAINIING + \beta_{13} EXTN$

Where; AGE = Age (years); EXP = Experience (years); EDUYRS =Years of Education (years)

ACCCRE = Access to credit (1=access; 0=no access); FINCOME = Farm income (₦); HHSIZE = Household size (#); LNDWNSHP = Land ownership (1=owned; 0=otherwise); ASSN = Association membership (1=member; 0=non-member); PERCEPTN = Perception (1=good; 0=otherwise); ACCBIO-FSTM = Access to bio-fortified cassava stem (1=access; 0=no access); AWARE = Awareness (1=aware; 0=not aware); TRAINIING = Training (1=yes; 0=no); EXTN = Extension contacts (#)

Step 2: Model for the continuous decision (intensity of use using uncensored observations)

$$E(Y|Y^* > 0) = X'\gamma + \sigma\lambda\left(\frac{X'\gamma}{\sigma}\right)$$

Here the Cragg's model makes use of uncensored observations i.e. the observations with zero adoption level were not cut out of the observation, thus giving a better representation of the population.

$$X'\gamma = \gamma_0 + \gamma_1 AGE + \gamma_2 EXP + \gamma_3 EDUYRS + \gamma_4 ACCCRE + \gamma_5 FINCOME + \gamma_6 HHSIZE + \gamma_7 LNDWNSHP + \gamma_8 ASSN + \gamma_9 PERCEPTN + \gamma_{10} ACCBIO\text{-}FSTM + \gamma_{11} AWARE + \gamma_{12} TRAINIING + \gamma_{13} EXTN$$

Where; Y = Intensity of Adoption

Where; AGE = Age (years); EXP = Experience (years); EDUYRS = Years of Education (years); ACCCRE = Access to credit (1=access; 0=no access); FINCOME = Farm income (₦); HHSIZE = Household size (#); LNDWNSHP = Land ownership (1= owned; 0=otherwise); ASSN = Association membership (1=member; 0=non-member); PERCEPTN = Perception (1=good; 0=otherwise); ACCBIO-FSTM = Access to bio-fortified cassava stem (1=access; 0=no access); AWARE = Awareness (1=aware; 0=not aware); TRAINIING = Training (1=yes; 0=no); EXTN = Extension contacts (#)

EMPIRICAL RESULTS AND DISCUSSION

Socio-economic characteristics of the biofortified cassava farmers in Nigeria

Socio-economic characteristics of the bio-fortified cassava farmers were presented in Table 1. From Table 1, the mean age of the farmers was 48(±11.36) which shows that the farmers were in their productive and active age. They are thus expected to have adequate energy to carry out farming activities on their farmlands. Majority (68%) of the bio-fortified cassava farmers were male and this shows that production of bio-fortified cassava were men dominated in Nigeria. This might be due to the fact that men have more access to land resources in Nigeria than women. This might also be due to the fact that men are more prone to adopting new agricultural technology than women. This agreed with Ogunleye *et al.,* (2019) that production of bio-fortified cassava were mainly popular among the male cassava farmers. Majority (76.45%) of the respondents were married indicating that they were responsible. The mean years of formal education were

12.72 (±4.87). This shows that bio-fortified cassava farmers were literate as they possess basics educational qualities needed to be a successful farmer. This might have influenced their decision to adopt improved cassava varieties (bio-fortified cassava) instead of local cassava stems as they were better informed. This result agreed with Oparinde *et al.* (2017). The average household size was 8.25 (±4.32) which indicates that they had a relatively large household size. Thus, the use of family labour is possible in the production of bio-fortified cassava. About 72% of the respondents do not have access to credit which might be responsible for the small scale farming they practiced. It might also be due to lack of collateral needed to obtain loan. The average years of farming experience was 16.84(±8.76) years which implies that majority of the respondents have been into cassava production for many years even before the introduction of bio-fortified cassava and are thus expected to have the necessary experience to boost their production. Majority (79%) of the respondents were into one form of cooperative society or the other. This agree with Ehinmowo and Ojo (2014); Adeniyi *et al*., (2015). Thus, bio-fortified cassava farmers tend to enjoy group dynamics which might help them in accessing farm inputs which will increase their bio-fortified cassava output.

Table 1: Socio-economic Characteristics of Bio-fortified Cassava Farmers

Variables	Bio-fortified cassava farmers
Age (years)	48(±11.36)
Male (%)	68.23
Married (%)	76.45
Formal education (years)	12.72 (±4.87)
Household size (#)	8.25 (±4.32)
Access to credit (%)	72.00
Years of experience (years)	16.84(±8.76)
Membership of association (%)	79.00

Figures in parenthesis are standard deviation

Land rental system in Bio-fortified Cassava Production

Presented in Table 2 is the land rental system in bio-fortified cassava production among the tenants. As obtained from the farmers, there were three mode of land rental system. Bio-fortified cassava farmers were found to either give part of the cassava outputs/yields realized to the land owners, make payment for the use of the land or they give part of the cassava yield and still pay certain amount to the landlords. As presented in Table 2, about 46.7% of the tenants gave between 4-7% of their total yield to their landlords who gave them the farmland, 33.7% make payment for the use of the farmland. In this case the tenants do not need to give the landlord part of the yield they obtained from the use of their rented farmland. In the third case, the biofortified cassava farmers were mandated by their landlord to give part of their yield (4-7%) and also pay certain amount of money as regarding the use of the same farmland. This however depends on the types of agreement they both entered to. From Table 2, the length of tenancy is usually one cropping season and incase of payment, money is being paid annually. It can be observed that an average amount of ₦31,000 were being paid for an acre of farmland. The nature of agreement between the landlord and the tenant was verbal. There is no written agreement as they based their agreement on trust. However, in the case where the tenant does not honor the mutual agreement they had verbally, the landlord then revoke the use of the farmland by the tenant. Although, as ascertained by the tenants, these three forms of land rental system do not make the biofortified cassava farmers land secured as the landlords might decides to revoke the land at any period of time. This might definitely affect the continuous adoption of biofortified cassava as there is no guarantee that the tenant farmers will continue to have access to farmland. This study is similar to the result of Alarima *et al*. (2012) who found that that sawah rice farmers were being faced with land tenure problem in Nigeria.

TABLE 2: Land rental system in biofortified cassava production among the tenants

Rental system	Freq (%)	Cost	length of tenancy	Nature of agreement	Security of tenancy
Land for cassava outputs	43 (46.7)	4-7% of actual yield.	one cropping season	verbal	not secured
Land for cash	31 (33.7)	₦19,500.	Year	verbal	not secured
Both (Land for cassava outputs and Land for cash)	18 (19.6)	4-7% of actual yield and ₦19,500.	one cropping season and a year	verbal	not secured
Total	92 (100.0)				

Figures in parenthesis are percentages

Land Property Right for Landlords and Tenants involved in Bio-fortified Cassava Production

The land source in bio-fortified cassava production were presented in Table 3. About 23% of the respondents inherited their land, 19.7% bought their land, 25.6% rented their land while about 31.7% of the respondents were gifted their farm land. It could be said that all lands were based on communal system and were allocated to the owners who then have the control of the land and this solely rests with the landlords. All the land through customary modes by the landlords and the decision to transfer the land use for bio-fortified cassava production or deciding about the farm size of the land to be use for bio-fortified cassava production solely depends on the landlords. Regarding the factors that can affect the mode of land acquisition in Nigeria, about 49.7% of the respondents ascertained that social relationship between landlords and intending tenants and can be a deciding factor where the farmland will be given out to the tenants or not. About 35% ascertained that the decision to give farmland to tenants depends on the social status of the tenants, 51.1% said its depends on the financial status of the tenants while majority (90.8) of the respondents agreed that the decision of the landlords to give out farmland to tenants depends on the ethnicity to which the tenants belong to. This result revealed that tenants who are of the same ethnic groups in Nigeria had higher chances of obtaining farmland from the landlords for bio-fortified cassava production. This might be due to sometime language barrier and culture. Farmers who are financially buoyant can also purchase farmland irrespective of their ethnic group.

Regarding the right to use the land for bio-fortified cassava production as presented in Table 4, only the landlords (land owners and those who purchase their land) had the right to mostly use their farm land to any extent as they want. The tenants were only allow to use the land for the said purpose (production of bio-fortified cassava) and usage outside of this is primarily excluded for the right of the landlords. The result in Table 4 revealed that only the landlords reserves the right to sell the land, give out the land and re-allocate the land. This result agrees with Alarima *et al*. (2012) that only landlords reserved the right to sell and re-allocate land in Nigeria.

TABLE 3: Land source in bio-fortified cassava production

Variables	Frequency	Percentage
Mode of land acquisition		
Inherited	83	23.0
Purchase	71	19.7
Rent	92	25.6
Gift	114	31.7
Land tenure		
Private	--	--
State	--	--
Customary	360	100.0
Variables affecting mode of land acquisition*		
Social relationship	179	49.7
Social status	126	35.0
Financial status	184	51.1
Ethnicity	327	90.8

***Multiple responses allowed**

TABLE 4: Land rights in bio-fortified cassava production of landlords and tenants

Variables	Landlords Freq (%)	Tenants farmers Freq (%)
Right to use (limitation)		
Right to use the land for growing other crops	256 (71.1)	104(28.9)
Right to use the land for gathering forest products	310 (86.1)	50 (13.9)
Right to choose type of farming	298 (82.8)	62 (17.2)
Right to leave the land fallow	217 (60.3)	143 (39.7)
Right to make decisions about how the land will be used	267 (74.2)	93 (25.8)
Right to transfer		
Right to sell the land	360 (100.0)	--
Right to give out the land	360 (100.0)	--
Right to re-allocate the land	360 (100.0)	--

Figures in parentheses are percentages

Effect of land ownership status on adoption and intensity of adoption of bio-fortified cassava

The effect of land ownership status on the adoption and intensity of adoption of bio-fortified cassava were examined using the cragg's double-hurdle model. A two steps estimation procedure comprising of Probit regression (decision to adopt) and Truncated regression (intensity of adoption) of the bio-fortified cassava. The result of the probit model (first hurdle) used in examining the influence of land ownership status on the decision to adopt bio-fortified cassava varieties were obtained using maximum likelihood estimation technique and were presented in Table 5. The likelihood estimates of the probit regression indicated that the Chi-square statistics of 81.495 was highly significant ($p< 0.0001$) which suggested that the model has a strong explanatory power. The decision to adopt the bio-fortified cassava was significantly influenced by factors such as access to credit, land ownership, access to bio-fortified cassava stem and extension contacts.

Access to credit was positive and significant at 10% level of probability on the decision to adopt the bio-fortified cassava. This implies that access to credit will increase the likelihood of adopting bio-fortified cassava by 75.2%. This is true because in order for the farmers to adopt the technology, they will require capital and since they might have been short of capital, it might affect their decision to adopt the technology. However, having access to credit might facilitates them adopting the bio-fortified cassava in the sense that they will have capital to obtain the bio-fortified cassava stem and also, in the case that the farmers does not own a land or have access to free land, the farmers could use the credit facility obtained in form of loan to rent or purchase their farm land.

The land ownership status of the respondents had a positive coefficient which was significant at 1% probability level as regarding the decision to adopt the bio-fortified cassava in the area. This implies that farmers who have their own farm land were likely to adopt the technology. Thus, land ownership status will increase the likelihood of adoption of bio-fortified cassava by 8.4%. Another variable that affect the decision to adopt the bio-fortified cassava varieties was access to bio-fortified cassava stem. Access to bio-fortified cassava stem was positive and significant at 5% level of probability. This implies that farmers who had access to bio-fortified cassava stem had the likelihood of adopting bio-fortified cassava technology. Thus, access to bio-fortified cassava stem increased the decision to adopt the bio-fortified cassava technology by 84.5%. This agree with Oparinde *et al.* (2017).

Furthermore, extension contacts was another factors that significantly affect the decision to adopt the bio-fortified cassava technology. Extension contacts was positive and significant at 5% probability level. This implies that farmers who had access to extension services were likely to adopt the bio-fortified cassava technology. This is true because access to quality information might help them gain knowledge about the economic gain they might obtained if they adopt the bio-fortified cassava technology. Thus, access to extension services increases the likelihood of adopting the bio-fortified cassava technology by 96.6%.

The result of the second hurdle (truncated regression) which is the intensity of adoption of the bio-fortified cassava technology was presented in Table 6. Age, farmer's perception and training significantly affect the intensity of the adoption of the bio-fortified cassava technology.

Age was positive and significant at 5% level of probability. This implies that as farmers grow older, they tend to gain more knowledge and experience about the economic gains associated with bio-fortified cassava technology which might influence their decision to intensify its adoption. Thus, age increase the intensity of adoption of bio-fortified cassava technology by 6.6%. Also, farmer's perception about the bio-fortified cassava technology was positive and significant at 1% probability level. This implies that the adopters had a positive perception about the bio-fortified cassava technology and might have influenced their decision to intensify the adoption of the technology. Thus, farmers perception about the bio-fortified cassava technology will increase the intensity of adoption of the bio-fortified cassava technology by 15.8%. Furthermore, training was positive and significant at 5% probability level. This implies that the more the training the farmers received about the important farming operation activities involved in bio-fortified cassava production the more they tend to intensify the adoption of the bio-fortified cassava technology. Thus, training increases the intensity of adoption of the bio-fortified cassava technology by 6.7%.

Table 5: Effect of land ownership status on the adoption and intensity of adoption of bio-fortified cassava

Variables	First hurdle (Probit regression)		Second hurdle (truncated regression)	
	Coefficients	**Std. Err.**	**Coefficients**	**Std. Err.**
Age	-0.0052	0.0166	0.0660**	0.0277
	(-0.31)		(2.39)	
Experience	0.0300	0.0214	0.0063	0.0261
	(1.40)		(0.24)	
Years of education	0.0608	0.0374	-0.0352	0.0514
	(1.63)		(-0.69)	
Access to credit	0.7528*	0.4055	0.6025	0.4326
	(1.73)		(1.39)	
Farm income	-0.1518	0.4517	-0.3338	0.4181
	(-0.34)		(-0.8)	
Household size	1.01e-06	8.29e-07	-0.00559	9.14e-07
	(1.22)		(-0.61)	
Land ownership	0.0840***	0.0311	-0.0039	0.0252
	(-2.70)		(-0.16)	
Association	0.6517	0.4209	0.0567	0.4910
membership	(1.55)		(0.12)	
Perception	-0.5341	0.5139	1.5836***	0.5849
	(-1.04)		(2.71)	
Awareness	0.0241	0.4053	-0.3313	0.5147
	(0.06)		(-0.64)	
Access to bio-stem	0.8452**	0.4246	1.0502	0.5670
Training	(2.11)		(1.05)	
	0.5949	0.4461	0.0677**	0.0336
	(1.33)		(2.02)	
Extension	0.9669**	0.4919	0.6378	0.5904
	(1.97)		(1.08)	
Constant	-0.7005	1.1355	3.7001*	2.1137
	(-0.62)		(1.75)	
	Number of observations = 360			
	LR Chi2 (26) = 81.495			
	Prob > chi^2 = 0.0001			
	Log likelihood = -71.75930			

Figures in parentheses are t-values; ***= significant at 1%, **= significant at 5%, *= significant at 10%.

Differences in the farm sizes and yields of landlords and tenants involved in bio-fortified cassava production in Nigeria

The result of the t-test computed to compare the difference in farm size and yield of landlords and tenants that cultivated bio-fortified cassava varieties were presented in Table 6. The result shows that there is a significant difference (t=4.72) in the farm sizes of the landlords and tenants. This implies that land rights determine to a large extent the farm size of bio-fortified cassava production in Nigeria This also suggest that tenant's access to farmland is not equal to that of the landlords. Thus, the types of rights and tenure that an individual possesses determines the control over the land and also the size of the land that will be allocated for bio-fortified cassava production in Nigeria. This can affect the decision to adopt the bio-fortified cassava varieties. Furthermore, the result presented in Table 6 revealed that there was a significant difference (t=15.47) in the yields of landlords and tenants bio-fortified cassava farmers. This might be due to the fact that landlord bio-fortified cassava farmers had access to more land resources in the area. Also, the opportunity to control land might have placed the land owners at an advantage in terms of receiving advice from extension agents. Land can constitute an economic advantage in agricultural production. The security of tenure can also provide sufficient insurance against farm-related risks, which, in turn, are related to increased investment in farms over the medium- and long-terms (Alarima *et al.*, 2012). This result agrees with (Hayes *et al.*, 1997; Roth and Dwight, 1998; Li *et al.*, 1998) and Alarima *et al.*, 2012) who all reported a significant difference in the farm sizes and yield of landlords and tenants involved in agricultural production.

TABLE 6: Difference in the farm sizes and yields of landlords and tenants of bio-fortified cassava farms

Variable	Mean difference	Standard error difference	T-test
Farm size (ha)	34739.467***	148296.531	4.72
Yield (kg)	0.593***	9.173	15.47

CONSLUSIONS

The study observed that there were disparities in the land rights of the landlord and tenant bio-fortified cassava farmers. The rights to use and control farmland by the tenant bio-fortified cassava farmers were limited and affected their decision to adopt the bio-fortified cassava technology. Although, Bio-fortified cassava technology promised a higher yield and income to farmers, it however requires a substantial amount of land in which only the landlords have access to such land resources. This however, calls for more secure land and longer tenancies on the land for tenant bio-fortified cassava farmers in Nigeria. Access to land for tenants will increase the adoption of bio-fortified cassava technology which will increase their yield and income. Access to land by the tenants will afford them the opportunity to increase their farm size which will lead to an increased yield. Therefore, tenants need more secure access to land to provide them with the opportunity to adopt the bio-fortified cassava technology so that they will have higher yield. In addition, more social capital is needed since the land rights and rental system were still majorly through communal tenure arrangement. This will help the tenants to secure more land for a longer period of times. Government should re-enact a law that will make land accessible for the tenants in Nigeria so as to reduce the problem of land rights between the landlords and tenants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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