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IMPACT OF IMPROVED CASSAVA VARIETIES CULTIVATION ON FARMING HOUSEHOLDS' WELFARE, THE CASE OF FARMERS IN IN ONDO STATE, NIGERIA.

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Abstract—Improved cassava varieties (ICV) were developed with several objectives among which are: to increase Households' income and reduce poverty, reduce Households' food insecurity, increase production and reduce various agricultural risks. Adoption rate of improved cassava varieties has increased translating to increase in annual income and annual consumption expenditure of farmers thus increasing welfare in Nigeria. Despite this adoption and production level, cassava production in Nigeria is still characterized by low yields compared to other cassava growing regions of the world. Cassava production in Nigeria from 2003 to 2010 is at about 29 metric tonnes per hectare short of her potential capacity of 40 metric tonnes per hectare. This study assessed the impact of improved cassava varieties' cultivation on farming Households' welfare in Ondo State, Nigeria. The study specifically described the socio-economic characteristics of the respondents, identified the improved varieties mostly cultivated in the study area, assessed the impact of improved cassava varieties' cultivation on poverty headcount and identified constraints militating against farmers in accessing improved cassava varieties in the study area. Multistage sampling procedure was employed to select 154 respondents for the study. Primary data were collected through the administration of a structured questionnaire. The analytical tools employed were descriptive statistics and Recursive Bivariate Probit (RBP) model. The results revealed that the respondents who were adopters and non-adopters were in their active age with a mean age of 43.50 years, some level of formal education and mainly male. The results also revealed various improved cassava varieties grown by the respondents in the study area and the least grown variety was vitamin A cassava. The results of Recursive Bivariate Probit model analysis for the impact of Improved Cassava Varieties (ICV) on the outcome variable of poverty headcount showed that the coefficients of household size and quantity of fertilizer used had significant positive effect on the poverty headcount of farmers in the study area. The study recommended that extension agents should be supported by both government and non-governmental organizations to visit the farmers regularly and orientate them about the use of input combinations that can therefore increase the farm output, thus their welfare.

Keywords—Cassava, Poverty Headcount, Households, Recursive Bivariate Probit Model, Farmers

Introduction

Agriculture plays an important role in the economic growth and development of sub-Saharan Africa (SSA). It employs majority of the labour force and provides a valuable source of raw materials and food commodities [12]. Majority of the poor in developing countries particularly sub-Sahara African countries depend heavily on agriculture for survival, as a result, agriculture is considered as a key fundamental for stimulating economic growth, overcoming poverty, and enhancing food security. The agricultural sector employs about 70% of the total labour force in SSA, with majority of these people located in the rural areas [15].

According to [9], Nigeria is a country in the SSA that covers about 98.3 million hectares with a largely rural population of about 180 million comprising 350 ethnic nationalities. The country measures 1200 kilometers (km) from East to West, and about 1500km from North to South. Nigeria is blessed with other natural resources such as petroleum and solid mineral deposits. These features implies that the country is endowed with vast physical and human resources required for accelerated development of its agricultural economy, but shared most of the agricultural problems identified in this region. One of the major causes of poverty in Nigeria is the decline in agricultural productivity consequent to over dependence on oil. Prior to the discovery of oil in the 1970s, agriculture was the mainstay of the Nigerian economy, accounting for about two-thirds of the gross domestic product (GDP) and 75% of export earnings [9]. From the standpoint of occupational distribution and contribution to GDP, agriculture was the leading sector. During this time, Nigeria was the world second largest producer of cocoa, largest exporter of palm kernel and palm oil. Nigeria was also a leading exporter of other commodities such as cotton, groundnut, rubber, and hides and skin [5]. With the oil boom, agriculture's contribution to Gross Domestic Product (GDP) declined to about 25% by 1980, later moved up to 41% by 2001 - 2004. Consequently, Nigeria moved from being a large exporter to a major importer of agricultural products [5]. The low agricultural output has led to the poor performance of the food subsector as food demand became higher than food supply. This has induced high increases in the country's food imports from about N8billion in 1996 to over N183billion in 2005 and increased the prices of major staple crops in the country [11].

In Nigeria, cassava plays a vital role in the welfare of the rural economy because of its capacity to yield under marginal soil conditions and its tolerance to drought. However, according to [26], cassava production in Nigeria is still characterized by low yields compared to other cassava growing regions in the world which may be due to planting of low yielding unimproved varieties. Thus cassava production in Nigeria has not yet reached a maximum production level.

However, the potential of the crop's contribution to better welfare that is lower poverty level is not clear since the crop is yet to be fully exploited in this part of the country. Therefore,

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with the various evidences, factor that contributes mostly to the increase in output has not been identified and thus the need to examine how improved cassava varieties adoption has contributed to the welfare of the farmers. This research therefore attempted to emphatically investigate the above issues and helps to bridge the existing information gap in generating empirical evidence.

The Specific Objectives are to: describe the socio economic characteristics of the respondents in the study area; identify the various improved cassava varieties planted by farmers in the study area; examine the impact of improved cassava varieties adoption on the poverty headcount of the farmers; identify the constraints faced by farmers in accessing improved cassava varieties.

Methods

Data Sources

Data for the study were obtained from primary source with the aid of well-structured questionnaire from cassava farmers in Ondo State, Nigeria. Some of the data collected include information on Households' composition and characteristics, cassava varieties planted and area planted costs of production, output and yield data. In this study, farmers were classified as adopter if they have grown at least one of the introduced improved cassava varieties for at least one season prior to year 2018 (the year the data for the study was collected) or still growing anyone presently and non-Adopter otherwise.

Sampling procedures and Sample Size

Multi-stage sampling procedure was used for the study. The first stage is purposive selection of four blocks which include Okitipupa, Ondo West, Akure North, and Akoko South-West of the four Agricultural Development Programme (ADP) zones based on intensity of cassava farmers. The second stage was random selection of two communities in each of the selected blocks. The last stage was random selection of cassava producing households that adopted any of the selected improved cassava varieties and cassava producing households that didn't plant any of the selected improved cassava varieties from each of the selected communities in Ondo State. A total of 154 completed questionnaires comprising of seventy nine adopters and seventy five non-adopters were computed and analyzed. Out of the overall cassava farmers sampled, data from 154 cassava farmers were used for the analysis while 6 were discarded due to incomplete information supplied by the farmers.

Analytical Techniques

This study investigates the impact of improved cassava varieties adoption on farming Households' poverty status. Given that this vector of outcomes is a linear function of a vector of farm and household characteristics, the outcome variables can be expressed as

$$Y_h = Z_h' \beta + C_h \gamma + \mu_{h,} \quad (1)$$

Where variable

Y_h - represents a vector of outcome variables;

Z_h - a vector of farm and Households' characteristics (example, extension visit, age, education);

C_h - as previously described is an indicator of household improved cassava varieties adoption status;

μ_h - is a random error term; and β and γ are vector of parameters to be estimated.

In impact evaluation, only observed attributes declared by the farmer in the course of the survey are known to the researcher, but unobservable factors like innate technical, social networking and managerial abilities are known to only the farmer. Potential selection bias may arise where the undeclared factors μ influence the selection. This implies the correlation coefficient of the error terms $\rho = corr\ (\varepsilon\ ,\ \mu\ ) = 0$, hence ordinary least squares (OLS) tend to yield bias estimates. In randomized control trial setting, this selection bias problem is addressed by randomly assigning individuals into treatment (adopters) and control (non-adopters) groups, such that the only differentiating factor among adopters and non-adopters is the technology [4].

However, in a non-randomized experimental situation like the adoption of improved cassava varieties, adoption is not random and selection bias may occur. The PSM approach is commonly used in impact evaluation of technology on household welfare, in particular when self-selection occurs (example, [18]). According to [1], a major drawback of the PSM approach is that it only accounts for observable factors. To simultaneously estimate the determinants and impact of adoption, while accounting for both observable and unobservable factors in an efficient manner, Recursive Bivariate Probit Model is employed. It is suitable for binary expected welfare indices like poverty status. It accounts for endogeneity and selection bias and it is used to jointly estimate adoption and impact of improved cassava varieties on poverty status.

Recursive Bivariate Probit Model

This study used Recursive Bivariate Probit Model to jointly estimate adoption and impact of improved cassava varieties on Poverty headcount. In evaluating the impact of a binary variable on a binary outcome like adoption on poverty headcount, other studies have employed Propensity Score Matching (PSM) for observed and unobserved heterogeneity between adopters and non-adopters [22]. The RBP model also consists of a selection equation previously described in "(2)" for the potentially endogenous binary variable and outcome equation, indicated in "(3)" expressed as

$$P_k^* = X_k' \delta + \varepsilon_{k\ ,}\ P_h = 1[P_k^* > 0\ ] \quad (2)$$

$$Q_{k\ ,} = R_k' \vartheta + P_k' \eta + \mu_{k\ ,} \quad (3)$$

Where variable:

P_k^* is the latent adoption outcome of farm household;

X_k includes all factors influencing improved cassava varieties adoption decision, such as household and farm-level characteristics;

Q_k represents poverty status for household *h*;

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R_k is a vector of household and farm-level characteristics (example age, education and prices);

P_k is an indicator of household improved cassava varieties adoption status as indicated previously;

μ_k & ε_k are random error terms;

δ, η and ϑ are parameters to be estimated.

The error terms are assumed to follow a bivariate distribution and expressed as [1]

$$\left(\begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}\right) \qquad (4)$$

Where ρ is the correlation coefficient among unobserved explanatory variables in both equations. As in the ESR model, for identification, it is important that the exclusion restriction on the exogenous variables hold, such that X_k and R_k must differ by at least by one variable [20]. The bivariate normal cumulative distribution function is specified as:

$$\frac{e^{-1/2(X_k^2 \; + R_k^2 \; -2\rho X_k R_k)/(1-\rho^2)}}{2\pi(1-\rho^2)^{1/2}} \qquad (5)$$

A significant ρ indicates correlation of the disturbance terms. The nonlinear conditional expectation for estimating the marginal effects is expressed as:

$$E\{P_k|Q_k, R_k\} = \frac{\emptyset\ (\vartheta\ X_{k,}\ \ (2Q_k - 1)\ \vartheta\ R_k,\ \ (2Q_k - 1)\ \rho\ )}{\emptyset\ [(2Q_k - 1)\ \vartheta\ R_k} \qquad (6)$$

The average treatment effect on the treated (ATT) is estimated as:

$$ATT = E(Q_{kA}|P = 1) - \ E(Q_{kN}|P = 1), \qquad (7)$$

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Where Q_{kA} is the expected probability poverty status from adoption; and Y_{kN} is the expected probability poverty status outcome in the counterfactual case.

Thus, the independent (explanatory) variables that were used are as specified below:

R_1 = Age (years),
R_2 = Sex (1 if male 0 otherwise),
R_3 = Household Size (Number),
R_4 = Farming experience (years),
R_5 = Marital status (1 if married and 0 otherwise),
R_6 = Membership of association (1 if a member of farmers' association and 0 otherwise),
R_7 = Access to improved cassava cutting (1 farmers with access and 0 otherwise),
R_8 = Contact with Extension Agent (1 if yes and 0 otherwise),
R_9 = Quantity of hired labour (man days)
R_{10} = Quantity of fertilizer used (kilograms)
R_{11} = Quantity of herbicide used (litres)
R_{12} = Years of formal education (years),
R_{13} = Awareness of the importance of ICV (1 if aware and 0 otherwise),
R_{14} = Farm Size (Number).

To the extent that potential endogeneity problems may arise in Recursive Bivariate Probit (RBP) estimation, this was accounted for to obtain consistent estimates. As the dependent variable is dichotomous, the two stage procedure of [10] was employed to account for endogeneity. Awareness of the importance of the improved was used as an instrument. Observed values awareness of the importance of improved cassava varieties and their corresponding residuals from the first stage was incorporated into the RBP model to enable consistent estimation of the parameters.

Foster-Greer-Thorbecke (FGT) Poverty Measures

The FGT is the most widely used model of poverty measurement because it is consistent and additively decomposable [16]. FGT model of poverty decomposition used by [3] was used to determine the incidence poverty of the adopters and non-adopters of improved cassava varieties in the study area and it is expressed as;

$$P_\alpha(y, z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z - y_i}{z}\right)^{\propto} \qquad (8)$$

Where:
Z = Poverty line
n = Number of households in the reference population or total sampled population
y_i = Per capita Expenditure of ith household
α = Poverty aversion parameter
The headcount index was obtained by setting α=0.
If α = 0, the index become P_0= q/n. This gives the head count ratio or the incidence of poverty which is the percentage of respondents in poverty that is whose per capita expenditure is below the poverty line.

Measurement of Poverty Line: This was done by categorizing the respondents into poor and non-poor groups using the two-third mean per-capita annual consumption expenditure as the benchmark, which was adopted from the studies carried out by [2]. Households whose mean annual consumption expenditure falls below the poverty line were regarded as poor while those with their annual consumption expenditure on or above the benchmark were regarded as non-poor.

$$Per-capita\ Annual\ Consumption\ Expenditure(PCE) = \frac{Consumption\ Expenditure}{Household\ Size}$$

$$Total\ Per-capita\ Consumption\ Expenditure\ (TPCE) = Summation\ of\ PCE$$

$$Mean\ TPCE\ (MTPCE) = \frac{TPCE}{Total\ Number\ of\ Households}$$

$$Poverty\ Line\ (PL) = \frac{2}{3} \times MTPCE \qquad (9)$$

Results and Discussion

Socio-economic Characteristics of Respondents

The descriptive statistics was used to present the socio-economic characteristics of the respondents in the study area. As shown in Table 1 majority (65.9%) of the respondents who were adopters of improved cassava varieties were between 30 and 59 years of age, while majority (78.7%) of non-adopters were between 30 and 59 years of age. This is an indication that majority of the respondents were still within the economically active age. It also implied that the respondents were agile and active to withstand the rigours of farming. The results is in agreement with [27] who opined that for farmers to be productive in farm chores, they must be young and active in order to contribute meaningful labour input into all the stages of production for efficient output realization which in turn results in consumptive and income opportunities with proportional household welfare. The result further reveals that majority (79% and 65%) of the respondents represent male adopters and non-adopters respectively. The domination by male respondents among the farmers could be the result of males having greater access to farm land than females. It could also be the result of the tedious nature of farming. This implies that cassava farming is mostly done by male farmers who have and could have access to land resource and are thus instrumental to cassava production than their female counterpart. It could also be that male farmers are more involved in the cultivation while the females are into processing and marketing. Reference [2] stated that domination by male respondents among the farmers could be the result of males having greater access to farm land than females and the tedious nature of farming. The educational status of the respondents reveals that majority (93.7% and 88.0%) of the respondents who were adopters and non-adopters respectively had at least primary school education. It indicated that only 6.3% of the adopters and 12.0% of non-adopters had no formal education. Therefore, it can be concluded that most of the sampled respondents in the study area were educated. This is in line with the findings of (26) who reported that there was no significant difference in the educational status of adopters and non-adopters of improved cassava production technology because most of the farmers were educated. The result shows that 62% and 54.7% of the adopters and non-adopters in the study area respectively had between one to five people per household, 32.9% (adopters) and 41.3% (non-adopters) had between six to ten people in their households. About 5.1% and 4% of the adopters and non-adopters respectively had the minimum of eleven people in their household. The average household size for the study area was 5. This is corroborated by the work of [26] who found no significant difference in the household size of adopters and non-adopters.

Majority (73.4% and 80%) of the adopters and non-adopters respectively were married. 21.5% and 14.7% represented the percentages of single persons that are adopters and non-adopters respectively. About 3.8% and 5.3% represent the percentages of widowed of adopters and non-adopters respectively. The low percentage of the divorced could be attributed to the value placed on marriage institution, which discouraged them from divorce in the study area. The marital status of farmers could have a lot of influence on the production performance as family members could supply farm labour. This result implies that the bulk of cassava production in the study area is carried out by married people. It also shows that singles persons are not interested in cassava production. This may be because of their preference for white collar jobs or their dependence on their parents for means of livelihood. This result is in agreement with the study by [17] that majority of farming households in South-East, Nigeria were married. About (45.6% and 40.0%) of the respondents that are adopters and non-adopters respectively had 1- 10 years of farming experience. This study affirmed the findings of [2] on cassava production that a good proportion of the respondents have farming experience of about 20 years or less. It is expected that farmers in the study area should be knowledgeable in the area of up-taking production risks. This suggests that the farmers had enough experience in cassava production to make the best decisions that will help boost their productive capacity.

Adoption of Improved Cassava Varieties

Table 2 revealed the adoption distribution of the respondents in the study area. Majority (87.5%) of the farmers adopted TME 419 variety among the introduced improved cassava varieties in the states because of its thin stem and larger yield compared to other varieties introduced. The result is similar to the findings [26] and [2] in South Western Nigeria, where most of the farmers were found to have adopted TME 419 among improved cassava varieties introduced to them. Farmers also established the fact that TME 419 was the best technology introduced to them because of its disease resistance and low water moisture content compared to other varieties. Also, 51.9% of the farmers adopted TMS 30572 cassava variety. About 45.6% of the farmers adopted TMS 30555 cassava variety. In the same vein, 25.3% adopted Pro-Vitamin A cassava variety. It was also observed that vitamin A cassava variety in the study area had the least adoption rate by the respondents which may be as a result of the low starch content of the variety of cassava as reported by the adopters in the course of the survey. However, farmers may not be aware of the health benefit they can derive from the consumption of this cassava variety.

Table 1: Distribution by Socioeconomic Characteristics

Variables	Adopter	Non-

	s		adopters	
	Freq	**%**	**Freq**	**%**
Age (Years)				
<30	17	21.5	9	12.0
30-39	14	17.7	20	26.7
40-49	22	27.9	17	22.7
50-59	16	20.3	22	29.3
60-69	6	7.6	4	5.3
≥70	4	5.1	3	4.0
Sex				
Male	62	78.5	49	65.3
Female	17	21.5	26	34.7
Education Level				
No Formal Education	5	6.3	9	12.0
Primary school education	7	10.1	14	18.7
Secondary School Education	29	35.4	34	45.3
Tertiary Education	38	48.1	18	24.0
Household Size				
1-5	49	62.0	41	54.7
6-10	26	32.9	31	41.3
>11	4	5.1	3	4.0
Marital Status				
Single	17	21.5	11	14.7
Married	58	73.4	60	80.0
Widowed	3	3.8	4	5.3
Divorced	1	1.2	0	0
Farming Experience(Years)				
01-10	36	45.6	30	40
11-20	24	30.4	17	22.7
21-30	8	10.1	16	21.3
31-40	7	8.9	7	9.3
41-50	3	3.8	5	6.7
51-60	1	1.3	0	0

Source: Computed from Field Survey Data, 2018

Table 2: Distribution of Respondents by Adoption of Improved Cassava Varieties

Adopted Varieties	Frequency	Percentage	Rank
TME 419	69	87.3	1st
TMS 30572	41	51.9	2nd
TMS 30555	36	45.6	3rd
Pro-Vitamin A	20	25.3	4th

Source: Computed from Field Survey Data, 2018
Note: Multiple Responses

Estimation of Adoption and Impact of Adoption on Poverty Headcount

The full information maximum likelihood approach is employed to jointly estimate the selection and outcome equation. Table 3 shows the Recursive Bivariate Probit (RBP) estimates of selection equation and impact of adoption on poverty headcount. The selection and outcome equations estimates are presented in columns 2 and 4, respectively.

As indicated in the methodology, identification of the model requires that at least one variable in the selection equation should not appear in the outcome equation. In RBP specifications, the variable representing farmers' awareness of the importance of improved cassava varieties was used as identifying instrument. It is expected that farmers' awareness of the importance of improved cassava varieties influence adoption decision but not directly on poverty headcounts.

The correlation coefficient (ρ) in the specification is significant, indicating that there is selection bias due to unobservable factors in adoption. Hence, the use of RBP model which accounts for both observable and unobservable factors is appropriate in this study [19]. The negative and significant sign for ρ indicate positive selection bias suggesting that farmers with lower poverty (non-poor) have higher probability of adopting the improved cassava varieties. The log likelihood ratio is significant at 1% indicating that the recursive bivariate regression model is overall a good fit.

The empirical results in the selection equation can be interpreted as normal probit coefficients, which represent the probability of adopting ICV. The coefficient of the variable farm size is negatively related and significant at 10%, indicating that as the farm size increases the probability of being non-adopter increases, which maybe as a result of the farmers inability to acquire enough improved cassava varieties to be planted on the farm and thus the negative relationship between farm size and improved cassava varieties adoption.

The extension contacts variable is positive and statistically significant in the selection specification, indicating that farmers with more contacts to extension services are more likely to adopt the improved cassava varieties. The result on extension contact is in line with other findings like [29], which show extension is a strong determinant of technology adoption. The estimate of the variable years of formal education, which is positive and statistically significant, suggests that more educated and informed farmers are more likely to cultivate improved cassava varieties on their farms, is a finding that is consistent with the findings in the literature that education is important in farmers' decisions to adopt agricultural technologies [1].

The variable quantity of herbicide used has a positive relationship with adoption and it is statistically significant at 1%. It means that as the quantity of herbicide used increase, it also increases the probability of being an adopter of improved cassava varieties. It implies that the farmers will continue to increase the quantity of herbicide used in production in order to maintain cassava field for proper growth and yield.

The variable quantity of hired labour has a positive relationship with adoption and it is statistically significant at

5%. It means that as the quantity of hired labour used increases, it also increases the probability of being an adopter of improved cassava varieties. The implication is that the farmers may increase the quantity of hired used in production in order perform farm operation timely for maximum yield. The coefficient of quantity of fertilizer used is significant at 1% and had positive relationship with the probability adoption. This implies that, an increase in the quantity of fertilizer used may increase the probability of adopting improved cassava varieties. The result confirms the *a priori* expectation that increase in the quantity of fertilizer used increases the probability of adopting of improved cassava varieties as farmers will ensure cassava output is at its maximum. Also interesting is the effect level of awareness of importance of improved cassava varieties variable, which is statistically significant at 1% and positively related to the probability of adoption. This result implies that as the level of farmer's awareness increase, the probability of adopting improved cassava varieties also increases. The estimates in Table 3 column 4 report the effects of adoption and household characteristics on poverty headcount. The estimate of ICV adoption is negative and statistically different from zero in the poverty headcount. This finding suggests the importance of ICV in poverty reduction. Especially in the study area, adoption of ICV will result to more yield with better quality which translate to higher income and better welfare. This finding is consistent with the result by [2] who indicated that adopters of improved cassava varieties have better welfare than the non-adopters in the study area. The negative and statistically significant estimates of farm size indicates that increase in farm size increases the probability of being non-poor. The result on farm size is in line with other findings like [7] which show that large farm size tends to have a negative impact on poverty in Nigeria. In the same vein, the positive and statistical significance of the household size variable is an indication that an increase in the member of household increases the probability of being poor.

The estimate for the farming experience variable is negative and statistically different from zero in the poverty headcount. The results indicate that increase in farming experience is likely to reduce the probability of being poor, hence increases household welfare. The variable for extension agent visit have negative and significant impacts on poverty headcount. This finding suggests that increase in the number of extension visit increases the probability of being non poor.

The estimate for the quantity of herbicide used is negative and statistically significant for poverty headcounts. Increase in the quantity of herbicide used increased the probability of being poor which may be as a result of lack of technical knowhow about application method of herbicide. The estimate for the quantity of hired labour is negative and statistically different from zero in the poverty headcount. The result indicate that increase in the quantity of hired labour increases the probability of being poor and this may be due to less efficiency from the hired labour, hence reducing household welfare. The variable for quantity of fertilizer used tend to have positive and significant impacts on poverty headcount. The positive coefficient in the outcome equations for the head counts specification indicates that increase in the quantity of fertilizer used will increase the probability of being non-poor. The marginal effect estimates of the RBP specification are interpreted as elasticities. For instance, marginal effect of the farm size, farming experience, extension agent visit, quantity of herbicide used and quantity of hired labour variables with negative and statistically significant estimates indicate that additional farm land, farming experience, number of extension agent visit, quantity of herbicide used and hired labour is more likely to reduce household poverty by 8.3%, 1.1%, 22%, 1.2% and 1.8% respectively. The positive and statistically significant marginal effect estimate of the household size variable suggests that an additional household member farmer is likely to increase the probability of being poor by 4.9%.

Welfare Impact of Improved Cassava Varieties Cultivation on the Household

The impact of adoption on Households' welfare was examined by the average treatment effects (ATT) on the expected outcomes that are estimated. Table 4 presents the ATT estimates of the Recursive Bivariate Probit specification estimates for poverty headcount. These ATT estimates account for other confounding factors including selection bias arising from potential systematic differences between adopters and non-adopters. The results reveal that adoption significantly reduces poverty. There is a negative impact of adoption on the poverty indices specification. Specifically, the RBP estimates on the impact of adoption on poverty headcount indicates an increase in the probability of reducing poverty from 69% points from non-adoption to 48% points from adoption. These findings follow that of [18] and [1] who report negative and significant impacts of technology on poverty indices for farmers in Zambia respectively. This supports the view that agricultural technologies have a major role in poverty reduction policy of developing economies.

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Table 3: Full Information Maximum Likelihood Estimates of Recursive Bivariate Probit Model for Adoption and Impact of Adoption on Poverty Headcount

	Selection		Poverty headcount		Marginal
	Coefficient	t-value	Coefficient	t-value	Effects
Constant	-1.919	-3.24	0.027	0.05	
ICV Adoption			-1.386***	-7.33	- 0.416
Age	- 0.006	-0.41	0.019	1.64	0.006
Sex	- 0.265	-0.96	0.075	0.31	0.022
Farm Size	- 0.272*	-1.82	- 0.276**	-2.01	- 0.083
Household Size	0.047	1.36	0.163***	3.51	0.049
Years of Formal Education	0.030*	1.90	- 0.036	-1.62	- 0.011
Farming Experience	0.002	0.12	- 0.037***	-3.15	- 0.011
Membership of Association	0.150	0.56	0.067	0.30	0.020
Extension Agent Visit	1.347***	4.55	-0.728***	-2.77	- 0.218
Quantity of Herbicide	0.101***	3.06	- 0.039*	-1.81	- 0.012
Quantity of Cassava Stem	- 0.005	-1.32	0.002	0.66	0.001
Quantity of Hired Labour	0.047**	2.01	- 0.061**	-2.23	- 0.018
Quantity of Fertilizer	0.006***	4.50	0.004***	3.24	0.001
Awareness of import. of ICV	1.195***	4.66			
ρ	-0.879***				
Log likelihood	-135.927***				

Source: Computed from Field Survey Data, 2018
*** Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level**

Table 4: Impact of Improved Cassava Varieties Cultivation on Households' Welfare

	Adopters	Non-Adopters	ATT
Poverty headcount index (%)	0.475	0.692	-0.217**

Source: Computed from Field Survey Data, 2018
* Significant at 10%; ** 5%, *** 1%

Constraints Faced by Adopters and Non-Adopters of Improved Cassava Varieties in the Study Area

Result in Table 5 indicated that the major constraints encountered by adopters in the study area were: high cost of transportation, non-availability of improved stem, high cost of improved stem, bad road network, insufficient of funds and identification problem in decreasing order of ranking. On the other hand, the major constraints encountered by non-adopters in the study area were: non-availability of improved stem, high cost of improved stem, high cost of transportation, bad road network, identification problem and insufficient funds in decreasing order of ranking. Adopters of improved cassava varieties major constraint is high cost of transportation which may be as a result of bad feeder roads into the farming areas. On the other hand non-adopters inability to access improved cassava varieties was ranked first which may be as a result of lack of enough extension agents or lack of good road for easy access into the rural areas. Results from both groups of farmers indicates that rural infrastructure such as good roads electricity etc. plays a very important role in the rate of adoption of improved varieties. Inefficiency in farming can be reduced significantly by improving rural infrastructure.

Table 5: Distribution of Respondents According to Constraints Faced in Accessing Improved Cassava Varieties in the Study Area

Constraints	Adopters		Non-Adopters	
	%	Rank	%	Rank
High cost of Transportation	26.8	1st	10.7	3st
Non-availability of Improved stem	25.6	2nd	38.7	1rd
High cost of Improved Stem	19.5	3th	34.7	2th
Bad Road Network	11.0	4th	6.7	4th
Insufficient Funds	8.5	5th	4.0	6th
Identification problem	8.5	5th	5.3	5th

Source: Computed from Field Survey Data, 2018

Conclusion

This study assessed the impact of adoption of improved cassava varieties on the welfare farming Households' in Ondo state, Nigeria. About 87.3% of the farmers adopted TME 419 which is the most widely adopted variety among the introduced improved cassava varieties in the state. The results also showed that cultivation of improved cassava varieties in the study area reduced the poverty level of cassava farming households thus increasing their welfare. Adoption of improved cassava varieties makes adopters to have lower poverty rate than the non-adopters affirming belief that cassava is pro-poor in nature. The results also demonstrated that, if the impact of ICV on these outcomes were estimated without accounting for observable and unobservable factors in the adoption decision process, sample selection bias could have occurred.

Recommendations

The following policy recommendations were proffered based on the findings of this study:

- The results of the study shows that years of formal education is low for non-adopters. Literacy level of the farming households will be a vital tool in alleviating poverty in the study area. Government policy should be geared towards making education affordable and accessible at all level. Adult and non-formal education will be of great assistance to the aged farming households;
- Rural households welfare in Ondo state through adoption of improved cassava varieties can be improved by giving rural farmers more access to improved cassava cuttings within the villages where they live;
- Extension agents should be supported by both government and non-governmental organisations to visit the farmers regularly and orientate farmers about the use of input combinations that can therefore increase the farm output;

Contributions to Knowledge

The study provided empirical evidences on the impact of improved cassava varieties cultivation on farming Households' welfare in Ondo state, Nigeria. The study further provided empirical information on determinants of adoption and impact of adoption on adopter using models that caters for farmers observable and unobservable characteristics. The study found out that ICV adoption reduced poverty and probability of crop failure in the study area.

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