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Welfare impact of adoption of improved cassava varieties by rural households in South Western Nigeria

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Abstract

Low adoption of modern agricultural technologies amongst farmers in Nigeria has been identified as one of the main reasons for the low agricultural productivity and increase in poverty level. The general objective of this study is to examine the welfare impact of farm households adoption of improved cassava varieties in Southwestern (SW) Nigeria using poverty as an indicator. It utilizes cross-sectional farm household level data collected in 2013 from a randomly selected sample of 312 cassava producing households (186 in Ogun State and 126 in Osun State). The data obtained were subjected to descriptive and inferential statistical analysis such as Foster, Greer and Thorbecke (FGT) poverty measure and Logit regression model. The results revealed that adoption of improved cassava varieties increases the annual income and the annual consumption expenditure of producing households' thus increasing welfare in the SW Nigeria. An analysis of the determinants of adoption with logistic regression model showed that access to improved cassava cuttings within the villages, use of radio, farming experience and farming as a major occupation are significant factors influencing adoption of improved cassava varieties in the study area. In order to achieve the much desired poverty reduction and generate an improvement in farming households' welfare in SW Nigeria, efforts should be intensified in ensuring that farmers have access to adequate improved cassava cuttings at the right time and place. All programs, strategies and policies that would promote farmers' education on the technology and consequently lead to improved adoption should be pursued.

Keywords: Impact; Technology adoption; Cassava farmers; Logit model; Poverty alleviation; South-western Nigeria

Background

Cassava is an important regional food source for about 200 million people (nearly one-third of the population) of sub- Saharan Africa (Abdoulaye *et al.*, 2014). In Nigeria for instance, cassava root and leaves do not only serve as an essential source of calories but as a major source of income for rural households. Cassava provides food and income to over 30 million farmers and large numbers of processors and traders in Nigeria (Abdoulaye *et al.*, 2014). Technological improvement (such as improved cassava varieties) is the most important factor in increasing agricultural productivity and reduction of poverty in the long-term (Solomon 2010; Solomon *et al.*, 2011). To increase productivity, technology must be adopted in the production process and the rate of adoption of a new technology is subject to its profitability, degree of risk associated with it, capital requirements, agricultural policies and socioeconomic characteristics of farmers (Shideed and Mohammed 2005). The adoption of innovation is the last step in a decision process to make full use of an innovation having considered that such will impact positively on the livelihood of the adopter. This study is of significance because eradication of rural poverty through adoption of new agricultural technologies has been a major concern for the underdeveloped and developing countries and donors for many decades.

Intensification of better agricultural production system is one of the ways of increasing the welfare of farmers. This can be achieved if farmers take advantage of improved crop variety such as cassava. Some direct impacts of agricultural technologies (such as changes in agricultural productivity and farm income) are relatively easy to measure quantitatively, which is probably why they have been the focus of most impact research. It is however difficult to establish the causal effect of farming technology on welfare, but at the same time this is necessary if we want to know the extent of agricultural enhancement of the poor.

The general objective of this study is therefore to examine the impact of adoption of improved cassava varieties on welfare of rural farmers in SW Nigeria using poverty as an indicator.

The specific objectives of the study are to:

i. Investigate the socio-economic characteristics of adopters and non-adopters of improved cassava varieties;
ii. Analyze the poverty level between adopters and non-adopters of improved cassava varieties;
iii. Determine the factors influencing the adoption of improved cassava varieties and
iv. Make the necessary policy recommendations.

This study aims to contribute to the literature by providing a micro-perspective on the impact of agricultural technology on farm households. Assessing the impact of households' technology adoption can assist with setting priorities, providing feedback to the research institutions and scientists, guiding government policy makers and those involved in technology transfer to have a better understanding of how technological adoption helps in reducing poverty in farming communities.

This introduction is followed by a stylized review of relevant theories and empirical evidences on the link between adoption of agricultural technologies and farmers' welfare, poverty, food security in section two. The third section presents the study methodology, data and their sources, while the forth section presents the results and their discussions. The final section provides the study summary and conclusions.

Literature review

Agriculture plays a unique role in reducing poverty through the use of new technologies (Adofu *et al.,* 2013). Agricultural productivity growth is becoming increasingly difficult without developing and disseminating cost effective yield increasing technologies to meet the needs of increasing number of people to expand the area under cultivation or rely on irrigation (Pender and Gebremedhin, 2006; Datt and Ravallion, 1996; Hossain et al. 1992). Shideed (1998) identified two general properties of technological improvement. The first is the development of a new production function such that a greater output is achieved from a given input level. The second property is that the technological improvement must monetarily increase the discounted profits (or decrease losses) of the firm. Adoption of new technologies normally involves two stages: the decision to either adopt or not and the second stage involves how much of the new technology to adopt or use (or extent of adoption) (Mercer and Pattanayak, 2003). Farmers would never adopt an innovation if outputs are not increased from given resources, and/or if inputs are not decreased for a given output (Heady, 1952). Agricultural technology adoption is often a sequential process. Farmers may adopt a new technology in part of their land first and then adjust in later years based on what they learn from the earlier partial adoption (Xingliang and Guanming, 2011).

There is a large literature on the adoption of agricultural technology (Rogers, 2003; Sunding and Zilberman, 2001; Feder and Umali, 1993). Adoption of improved agricultural technology apparently offers opportunity to increase production and income substantially (Nweke and Akorhe, 2002) and reduce food insecurity (Nata *et al.*, 2014). Adoption of agricultural technology depends on a range of personal, social, cultural and economic factors as well as on the characteristics of the innovation itself (Pannell *et al.,* 2006; Omonona *et al.,* 2006; Prokopy *et al.*, 2008; Shiferaw *et al.,* 2008; Eze *et al.,* 2008; Kassie *et al.,* 2009; Yesuf and K¨ohlin, 2008; Owusu and Donkor, 2012; Challa and Tilahun, 2014).

It is clear from this brief empirical review of literature that the impact of adoption of improved agricultural technologies on either poverty or welfare has a positive impact on poverty reduction and human welfare. For example, Hossain *et al*., (2003) in Bangladesh reveals that the adoption of improved varieties of rice has a positive impact on the richer households but had a negative effect on the poor, Dontsop-Nguezet et al. (2011); Kijima *et al.,* (2008); Diagne (2006) studies on the impact of New Rice for Africa (NERICA) in Nigeria, Uganda and Cote d'Ivoire also found that the adoption of NERICA has a positive and significant influence on farmers welfare, poverty reduction and yield respectively. Likewise, Mendola (2007) and Adeoye et al. (2012) adopting the Propensity Score Matching (PSM) method and Local Average Treatment Effect (LATE) respectively confirmed the positive effect on household wellbeing arising from the impact of agricultural technology adoption on productivity and rural rice farmers' welfare in Bangladesh and Nigeria respectively.

Methods

Data sources

The study used primary data collected from a cross-sectional survey of cassava farmers from Osun and Ogun States with the aid of a structured questionnaire. The survey collected valuable information on several factors including household composition and characteristics, land and non-land farm assets, livestock ownership, household membership of different rural institutions, cassava varieties and area planted, costs of production, yield data for different crop types, indicators of access to infrastructure, household income sources and major consumption expenses.

Sampling procedure

A multistage sampling technique was used for this study. The first stage was the purposive selection of two states (Ogun and Osun States) in the SW Nigeria. The two states were purposively selected among other cassava producing states due to the intensity of cassava production in the two states. The second stage was the purposive selection of one Agricultural Development Programme (ADP) zone out of the three existing zones in Osun State and two zones out of existing four zones in Ogun. The selection was based on their agrarian nature and large production of cassava tubers and the unequal number of zone was based on the number of existing zones per state. In the third stage, we purposively selected three blocks in each of the selected zones based also on the intensity of cassava farmers. The fourth stage was the random selection of four communities in each of the selected blocks. The last stage was the random selection of eight cassava producing households from each of the selected communities in Ogun making a total of 192, while in Osun State, we randomly selected eleven cassava farmers leading to a total of 132. This selected number of farmers per community was based on the proportion of cassava farmers. The difference in the number of respondents selected per the two states was based on the existing size of cassava farmers. Out of the overall 324 cassava farmers sampled, data from 312 cassava farmers were finally used for our analysis while 12 (6 each from Ogun and Osun States) were discarded due to incomplete information supplied by the farmers.

The conceptual/analytical framework

We assumed that for a farmer to make decision on whether or not to adopt the improved cassava varieties, he/she must have first examined the benefit obtainable from the adoption and benefit derived from non-adoption. A farmer is likely to adopt the improved varieties, if the expected utility derived from adoption is greater than the expected utility from non- adoption.

Conditional on cross-sectional data availability, we estimated poverty level of cassava producing households based on their adoption of improved cassava varieties. The data obtained were subjected to descriptive and inferential statistical analysis. Descriptive statistics for this study include frequency tables, percentages and means. The inferential analyses adopted for the study are FGT (1984) poverty index measurement and logit regression model. The use of logit model in economics is based on random utility theory (Train, 2007). Households are assumed to choose the alternative(s) that maximize their utility subject to a set of constraints (Train, 2007; Mas-Colell, 1995). Indirect utility, the basis for this analysis, measures the maximum utility that a household achieves subject to some constraints (Mas-Colell et al. 1995). According to the random utility theory, indirect utility has both a deterministic component and a random (unobservable) component.

Poverty analysis

The analysis of poverty was based on P-alpha (α) measure proposed by Foster, Greer and Thorbecke (FGT) 1984. The use of FGT class of measure requires the definition of poverty line, which was calculated on the basis of disaggregated data on per capita annual consumption expenditure following Amao and Awoyemi (2008). The FGT measure was based on a single mathematical formulation as follows:

$$P_\alpha = \frac{1}{N}\sum_{i=1}^{q}\frac{(Z-Y_i)^\alpha}{(Z)} \qquad (1)$$

Where; z = the poverty line obtained as 2/3 mean per capita annual expenditure

q = the number of individuals below poverty line

N = the total number of individual in reference population.

Y_i = the annual per capita expenditure of household *i* and,

α = the degree of aversion and takes on the values 0, 1, 2. In this study we only look at the poverty incidence among adopters and non- adopters of improved cassava varieties in the study area (that is when α = 0).

The poverty line is a predetermined and well-defined standard of annual income or value of consumption. In this study, the poverty line was based on the annual expenditure of the households. Two third of the mean per capita annual expenditure (2/3 of MPCHE) was used as the moderate poverty line. Respondents above this value are classified as non-poor (those spending greater than 2/3 of MPCHE) and those below it as poor.

Classification of respondents as adopters and Non-adopters and determinants of adoption of improved cassava varieties

In this study, a farmer was defined as an adopter if he or she was found to have grown at least one of the introduced improved cassava varieties for at least one season prior to year 2013 (the year the data for the study were collected) and had the variety on his/her farms in the year 2013. Thus, a farmer could be classified as an adopter and still grow some traditional varieties. The adoption variable was therefore defined as 1 if a farmer is an adopter of improved cassava variety and zero otherwise. This study adopted the logistic regression to assess the factors that determine the farmers' decision to adopt improved cassava varieties. The use of logit model for this analysis is consistent with the literature on adoption (Rogers, 1983; Alston *et al.*, 1995) which describes the process of adoption as taking on a logistic nature. The response variable was binary, taking values of one if the farmer adopts and zero otherwise. However, the independent variables were both continuous and discrete. The logistic distribution (logit) has advantage over the others in the analysis of dichotomous outcome variable in that it is extremely flexible and easily used from mathematical point of view with a meaningful interpretation (Greene, 2008). Further is the fact that it has been applied in similar studies by Green and Ng'ong'ola (1993); Boahene *et al.,* (1999); Nkonya *et al.,* (1997); Shakya and Flinn (1985); Feder et al. (1985) and Rogers (1995). The parameter estimates of the model are asymptotically consistent and efficient. The binary logistic model does not make the assumption of linearity between dependent and independent variables and does not assume homoskedasticity. Another advantage of using the logit model is that it does not require normally distributed variables and above all, the logit model is relatively easy to compute and interpret. Hence, the logistic model is selected for this study. The probability that a farmer will adopt at least one improved cassava variety was postulated as a function of some socioeconomic and demographic characteristic factors given in Table 1. Following Pindyck and Rubinfeld (1998), the cumulative logistic probability model which is estimated is econometrically specified as:

$$P_i = F(Z_i) = F(\gamma) + \sum_i \lambda_i X_i = \frac{1}{1 + e^{-Z_i}} \tag{2}$$

Where P_i is the observed response for the i^{th} observation of the response variable P. It is the probability that a farmer will adopt at least one improved cassava variety or not given X_i; P_i =1 for an adopter (i.e. farmers who adopt at least one improved cassava varieties) and $P_i = 0$ for a non-adopter (i.e. farmers who do not adopt improved cassava varieties); e denotes the base of natural logarithms, which is approximately equal to 2.718; X_i represents the explanatory/ independent variables, associated with the i^{th} individual, which determine the probability of adoption (P); λ_i and γ are parameters to be estimated. The function, F may take the form of a normal, logistic or probability function. $\boldsymbol{Z_i}$ is the cumulative density function of $\boldsymbol{P_i}$ (probability that a farmer will adopt at least one improved cassava variety).

$$1 - P_i = \frac{1}{1 + e^{Z_i}} \tag{3}$$

Logit model could be written in terms of the odds and log of odds, which enables one to understand the interpretation of the coefficients. The odds ratio implies the ratio of the probability (P_i) that a farmer adopts, to the probability (1-P_i) that the farmer is a non-adopter.

If the disturbance term U_i is taken into account, the logit model becomes

Table 1 Description of the variables used in the logit model

Variables (X_i)	Definition
Gender	Gender of household head,1 male and 0 otherwise
Marital status	1 if married and 0 otherwise
Main occupation	1 if main occupation is farming and 0 otherwise
Years of farming experience	Number of years of experience in farming
Frequency of extension contact	Number of contacts farmers had with extension agent in the last one year
Access to credit	1 if a farmer has access and 0 otherwise
Price of improved cassava cuttings	Price of a bundle of cassava stick in naira
Farm size	Total area of land cultivated by farmers in Hectare
Years of education	Number of years of formal education of household head
Ownership of land	1 if farmer owns land and 0 otherwise
Membership of association	1 if a member of farmers' association and 0 otherwise
Access to improve cassava cutting within the village	1 if a farmer has access and 0 otherwise
High level of knowledge of traditional cassava varieties	1 if a farmer has high knowledge of traditional varieties and 0 otherwise
Access to radio	1 if farmer owns a radio, 0 otherwise
Total income	Proxy for total annual expenditure in naira

Source: Authors (2013)

$$Z_i = \Upsilon + \sum_{i=1}^{m} \lambda_i X_i + U_i \quad (4)$$

This procedure does not require assumptions of normality or homoskedasticity of errors in predictor variables (Alexopoulos, 2010). The analysis was carried out using STATA version 11.0.

Results and discussion

Socioeconomic characteristics of respondents

Descriptive statistics such as frequency distributions and percentages are used to provide information on some of the institutional variables as they relate to the farmers. As shown in Table 2, majority of the farmers (75.6 %) were males and 24.4 % were females. 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 for cassava production than their female counterpart. This contradicts the findings of Adisa and Okunade (2005); Akinnagbe et al. (2008) and Nsoanya and Nenna (2011) who asserted that women are the backbone of agricultural sector and agricultural production. The result further revealed that majority (85.6 %) of the farmers were married, 9.6 % were single while 2.9 % were widowed and 1.9 % were fully divorced. This implies that the respondents were dominated by married men and women who invariably contributed to increase in household size farm labour (Torimiro, 2005). Also, 56.4 % of the respondents are Christian, 38.3 % are Muslim and 5.1 % are of traditional religion.

The educational background of the respondents revealed that 27.2 % had never been to school, 20.4 % had at least primary education, 15.3 % attempted secondary school education and 16.6 % completed secondary school education. In addition, 3.2 % attempted tertiary education while only 7 % completed tertiary education with certificates. This implies on the aggregate that the majority of the farmers had one form of education or the other, and thus had the advantage of adopting innovation, since education helps in adopting improved agricultural technologies as observed by Ozor and Madukwe (2005). It buttresses the reason why most of the farmers adopted at least one of the improved cassava varieties. This is also corroborated by the work of Nsoanya and Nenna (2011) and Ayoade (2013).

Majority of the respondents (91.7 %) have farming as their primary occupation while only 8.3 % did not. A good proportion of the respondents, 67 % also have farming experience of about 20 years or less. The age distribution of the farmers revealed that 31.7 % were aged between 30–40 years while 29.5 % were aged between 41–50 years, 15 % of the farmers had age below 30 years and 12.8 % were between 51–60 years while 10.9 % of the respondents were above 60 years. This implies that majority of the farmers are in their active years, with an advantage of transferring innovations that enhance farm productivity. It is expected that improved varieties of cassava will be adopted at a faster rate in this area, which is in line with the observation of Onu and Madukwe (2002); Awotide et al. (2012). This is also corroborated by the work of

Table 2 Respondents' distribution by socioeconomic characteristics

Variables	Frequency (n = 312)	Percentage (%)
Gender (dummy variable)		
Male	236	75.6
Female	76	24.4
Marital status (categorical variable)		
Single	30	9.6
Married	267	85.6
Divorced	6	1.9
Widowed	9	2.9
Religion (categorical variable)		
Islam	120	38.5
Christianity	176	56.4
Traditional	16	5.1
Education Level (categorical variable)		
Never went to School	85	27.2
Attempted Primary School	31	9.9
Completed Primary School	64	20.4
Attempted Secondary School	48	15.3
Completed Secondary School	52	16.6
Attempted Tertiary Education	10	3.2
Completed Tertiary Education	22	7
Primary Occupation (dummy variable)		
Farming	286	91.7
Non-farming	26	8.3
Farming experience (continuous variable in years)		
Less than or equal to 10	106	34.0
11–20	104	33.3
21–30	53	16.9
Above 30	59	15.7
Age (continuous variable in year)		
Less than or equal to 30	47	15.1
30–40	99	31.7
41–50	92	29.5
51–60	40	12.8
above 60	34	10.9
Households Size (continuous variable)		
1–4	131	42.0
5–8	131	42.0
above 8	50	16.0

Note: A dummy variable represents a variable created to represent an attribute with two distinct categories; continuous variable is a variable that takes any value in a certain range; categorical variable is a variable with more than two classes
Source: Field Survey Data, 2013

Ayoade (2013) and Babasanya et al. (2013) who stated that farmers that are in their productive state usually experience high farm output and enhance the spread of innovation. The household size was relatively high; with 42 % of the farmers having household size that ranged between 1–4 members and 5–6 members each while 16 % had household members that are above 8. This contributes to the adoption of improved cassava technology by the farmers since having large household size brings an opportunity of expanding farm size, generating more revenue and meeting the welfare need of the households.

Adoption of improved cassava varieties

No agricultural technology will have an impact either directly or indirectly unless farmers adopt it (Meinzen-Dick et al. 2004). Table 3 revealed that, only 22 % of the sampled respondents were actually adopters of improved cassava varieties in the study areas, while the majority (78 %) were non- adopters. This might probably be due to their strong believe or trust of the traditional cassava varieties they are used to planting or non-availability of improved stem cuttings for planting. Majority (60.2 %) 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 while 39.8 % did not. This result is similar to the findings of Ojo and Ogunyemi's (2014) in Ekiti State where 60.6 % farmers were found to have adopted TME 419 among improved cassava varieties introduced to them in the state. The 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, 10.3 % of the farmers adopted TMS 980505 cassava variety and most (89.7 %) of the farmers, did not. In the same vein, 2.9 % adopted TMS 980815 variety while 97.1 % did not. We also observed that

Table 3 Respondents' distribution by adoption of improved cassava varieties

Variable	Frequency	Percentage
Adoption		
Adopters	68	21.8
Non-adopters	244	78.2
Adoption of TME 419		
Yes	41	60.2
No	27	39.8
Adoption of TMS 980505		
Yes	07	10.3
No	61	89.7
Adoption of TMS 980815		
Yes	2	2.9
No	66	97.1
Adoption of TMS 980326		
Yes	0	0
No	68	100

Source: Field Survey Data, 2013

none of the respondents adopted TMS 980326 in the study area, as shown in Table 3, probably as a result of unawareness or non acceptance of this cassava variety. There is need to improve the diffusion of these innovations in the study area and its environs if researchers are convinced that they are actually improved and rewarding varieties.

Households' endowments (assets) and adoption status

Households' endowment is usually used as a measure of wealth and can reveal a lot about the living conditions of the farming households (Awotide *et al.,* 2012). A well-endowed household is assumed to adopt improved agricultural technology more than the less endowed one. This is because as the asset becomes larger the household gets more money, materials and equipment to practice the new technology of production (Challa and Tilahun, 2014). A comparison of household assets was made between adopters and non-adopters of improved cassava varieties. This was done with a view to examine if adopting improved varieties has any effect on households' assets. The result of the analysis is presented in Table 4. In the pooled sample, many farmers about 80 % of the respondents are owners of their farm land. Similarly, 85 % and only 78 % of the respective adopters and non-adopters own their farm lands. This suggests that access to farm land is not a constraint to cassava production and adoption of high yielding improved varieties in the study area.

Households' assets such as radio, television, mobile phone and electricity are vital in the dissemination of information about the improved varieties which can influence adoption. Among the non-adopters only 27 % and 43 % respectively have mobile phone and access to radio, compared to respective 88 % and 96 % of the adopters. This implies that some of the non-adopters may not be aware of the improved cassava varieties through the telephone and radio hence their low adoption level. As regards access to electricity, only 10 % of the non-adopters and 16 % of

Table 4 Respondents' adoption status by household endowments

Household Endowments	Pooled data	Adopters	Non-adopters
	(n = 312)	(n = 68)	(n = 244)
Owns of farm land	249 (79.8)	58(85.3)	191(78.3)
Own motorbike	144(46.2)	35 (51.5)	109 (44.7)
Owns car	60 (19.2)	11(16.2)	49 (20.1)
Have cemented house	256 (82.1)	57 (83.8)	199 (81.6)
Good well	143 (45.8)	30 (44.1)	113(46.3)
Access to good electricity	45 (14.4)	7 (10.3)	38(15.6)
Possess generator	90 (28.8)	24 (35.3)	86 (27.0)
Good road	16 (5.1)	16 (23.5)	0 (0.0)
Have access to good sanitation	89 (28.5)	7 (10.3)	82(33.6)
Have access to television	87 (27.9)	15(22.1)	72(29.5)
Have access to radio	108 (34.6)	65(95.5)	43(17.6)
Have access to mobile Phone	87(27.9)	60(88.2)	27(11.1)

Legend: Values in parentheses are percentage of the total observations
Source: Computed from data from field survey, 2013

the adopters had access to electricity. Lack of access to electricity could be a major constraint militating against adoption. This is because farmers could have radio and television but without adequate supply of electricity at the right time, they might be missing out on important information aired when electricity was not available. This finding is corroborated by the finding of Awotide *et al.,* (2012).

Furthermore, households' endowments such as: cemented house wall and floor, good sanitation, ownership of generator, motorcycle and car could all combine to improve the wellbeing of the farming household members and also encourage adoption of improved cassava varieties. However, not many of the respondents were endowed with most of these assets. For instance, only 10 % and 34 % of the respective adopters and non-adopters had access to good sanitation facility. Similarly, only 24 % and 0 % of the respective adopters and non-adopters had access to good road network. Although many of the respondents, 82 % live in their own houses, the adopters seem to be better-off as a larger percentage of 84 % of them live in cement plastered house walls and floors.

Impact of adoption of improved cassava varieties on annual income and annual consumption expenditure

Following Asfaw (2010), two proxies are used to measure household welfare outcome in this study, namely annual income (from crop) and household annual consumption expenditure. Thus we estimated two welfare outcome functions, one for adopters and another for non-adopters. Table 5 presents the descriptive analysis of the impact of adoption of improved cassava varieties on annual income from cassava production, income from other crops, total agricultural expenditure, per capita consumption expenditure, average farm size and the incidence of poverty among the farmers. The average area cultivated by all the farmers was 2.9 ha. There was a significant difference in farm size of adopters and non-adopters, with non-adopters having larger farm size (3.2 ha) than the adopters (2.9 ha). The finding was not consistent with the finding of Diagne et al. (2009) and Mendola (2006) who found a significant positive difference in farm size between the technology adopters and non-adopters with the adopters cultivating larger farm size. However, despite the higher area cultivated by the non-adopters, they seem to be not better-off in terms of annual household income. The lower holdings of adopters could be the result of inadequate access to inputs. The result of the analysis in Table 5 showed that, the

Table 5 Analysis of the impact of adoption of improved cassava varieties

Variable	Pooled data (n = 312)	Adopters (n = 68)	Non-adopters (n = 244)	Mean difference
Mean annual income from cassava production	196,780.50	210,967.20	155,571.40	55,395.78***
Mean annual income from other crops	226,217.90	241400.00	150,307.70	91,092.31***
Mean annual total agricultural expenditure	112,599.00	119,120.60	107,790.60	11,330.00***
Per capita annual consumption expenditure	33,719.10	36,407.80	32,969.80	3,438.00***
Average farm size (ha)	3.05	2.90	3.20	0.29***
Percentage of Poor producing households (P_0)	59.90	55.90	61.10	0.05

NB: *T*-test was used to test for difference in socio-economic/demographic characteristics between adopters and non-adopters. Legend: ***Significant at P < 0.01
Source: Field survey data, 2013

average annual farm income of the adopters of the cassava varieties was ₦210, 967.2 while that of non-adopters of the technology was ₦155, 571.4 with significant mean difference of ₦55, 395.8. This implied that the adopters of improved cassava varieties had a significantly higher annual income than the non-adopters and consequently are able to spend more (₦119, 120.6) on agricultural production than the non- adopters with annual expenditure value of ₦107,790.6.

In terms of the welfare impact of adoption of improved cassava varieties, a comparison was made between the consumption expenditure of adopters and non-adopters. Per capita annual expenditure reflects the effective consumption of households and therefore provides information on the food security status of households. Annual per capita consumption expenditure of the adopters was ₦36,407.8 while that of non-adopters was ₦32,969.6 with significant mean difference of ₦3,438.0 indicating that the adopters had more annual per capita consumption expenditure than non-adopters. This implies that the adopters had a better welfare than the non-adopters. The analysis of the incidence of poverty showed that about 50 % of the cassava farmers were poor. The incidence of poverty of 61.1 % among the non-adopters was however higher than those of the adopters' of 55.9 %. These results are consistent with other related studies on the impact of agricultural technologies on poverty (Kassie *et al*., 2011; Asfaw 2010; Diagne et al., 2009; Awotide *et al.,* 2012; Mendola, 2007). From all the analyses, it appears that the adopters were better-off than the non-adopters even though these comparisons did not adjust for the effects of other characteristics of the farmers that could influence the outcome.

Determinants of adoption of improved cassava varieties

The factors that influenced the adoption of improved cassava varieties were examined using the binary logistic regression model. Farmers that had planted at least one improved variety over the last one year were classified as adopters and those that have engaged in the cultivation of traditional cassava varieties or have adopted briefly and discontinued adoption as at the time of the survey were classified as non-adopters. The results from the logit model used in examining the factors that affect the adoption of improved cassava varieties were obtained using maximum likelihood estimation technique and are presented in Table 6. An additional insight was also provided by analyzing the marginal effects, which was calculated as the partial derivatives of the non-linear probability function, evaluated at each variable sample mean in line with Greene (2008). The likelihood estimates of the logit model indicated that the Chi-square statistic of 91.39 was highly significant ($p < 0.001$) suggesting that the model has a strong explanatory power. The pseudo coefficient of multiple determination (R^2) shows that 28 % of the variation in farmers' decision to adopt improved cassava varieties in the study area was collectively explained by the independent variables. This conforms to the result of Omonona et al. (2006). The decision to adopt improved cassava varieties by the farmers was significantly influenced by some socioeconomic factors. Among these were: marital status, years of farming experience, availability of improved cassava cutting within the village and access to radio.

The marital status of the respondents had a positive coefficient which was significant at $p < 0.05$, on the decision to adopt improved cassava varieties in the study area. The

Table 6 Determinants of adoption of improved cassava varieties

Variable	Coefficient.	Standard error	P > |z|	Marginal effect
Gender	0.1056	0.4003	0.7920	0.0123
Marital status	0.0302**	0.0137	0.0280	0.0035
Main occupation	−1.6883***	0.5188	0.001	−.01964
Farming experience	0.0244*	0.0142	0.0850	0.0028
Contact with Extension Agent	0.5212	0.3945	0.1860	−0.0052
Access to credit	−0.0443	0.3831	0.9080	0.0606
Price of improved cassava cutting	−0.0001	0.0005	0.8170	−0.000014
Farm size	0.0017	0.0154	0.9120	0.0002
Years of education	−0.0053	0.0408	0.8970	−0.0006
Ownership of land	0.1909	0.0408	0.2870	0.0222
Membership of association	0.2631	0.3753	0.483	0.0306
Access to improved cassava cutting within village	2.4053***	0.3636	0.0000	0.2798
High level of knowledge of traditional cassava varieties	−0.3917	0.4238	0.3550	−0.0456
Use of radio	1.3916**	0.6589	0.0350	0.1619
Annual total income	0.0000125	0.0000208	0.5480	1.45e-06
Constant	−2.9688**	1.1938	0.0130	
Number	312			
LR Chi^2(18)	91.3900			
Prob > Chi2	0.0000			
Log-Likelihood	−117.8852			
Pseudo R-Square	0.2793			

Note: *** = (P < 0.01) Significant at 1 %, ** = (p < 0.05) Significant at 5 %, * = (p < 0.1) Significant at 10 %
Source: Field survey data, 2013

positive sign and significance of the estimated coefficient of marital status suggests that married farmers are more likely to adopt than unmarried farmers. As farmers get married, the likelihood of adoption of improved cassava varieties increases by 0.35 %. The empirical finding however contradicts a study by Amao and Awoyemi (2008) on adoption of improved cassava varieties by farmers in Osogbo, Osun State of Nigeria which indicated that marital status is not a significant determinant of adoption of improved cassava varieties. The increase in the probability of adopting improved cassava varieties by marital status may be due to the fact that marriage increases a farmer's concern for household welfare and food security which is therefore likely to have a positive effect on their decision to adopt improved agricultural technology (Johnson et al. 2006; Adeoye et al. 2012; Nnadi and Akwiwu, 2008). Also, the significant positive coefficient of access to improved cassava cutting ($p < 0.1$) attests to its influence on the adoption of improved cassava varieties by farmers. This also is established by the work of Diagne and Demont (2007). It contributes to an increase in the probability of adoption of the new varieties by farmers, since, awareness, availability of information and planting material positively influence adoption.

Although farming as a major occupation had a significant ($p < 0.01$) influence on the adoption of improved cassava varieties, the effect is however negative on the probability of adoption of improved cassava varieties in the study area. The results of the marginal effect showed that those whose primary occupation is farming has a likelihood of not adopting improved cassava varieties 1.96 % times than others who are not exposed. This position was supported by the work of Diagne and Demont (2007) and could be as a result of the farmers missing out on information about improved cassava varieties since they do not attend meetings/trainings, and full time farmers spend more time on farm, thereby not availing themselves the opportunity of knowing about the improved cassava varieties. The year of farming experience significantly and positively influenced the adoption of improved cassava varieties by rural households. The likelihood of adoption by farmers increases by 0.28 % for every additional increase in year of farming experience. This result was not consistence with past empirical studies such as Adesina and Baidu-Forson (1995); Ojo and Ogunyemi (2014) who found the years of farming experience as a significant factor in adoption model. Our result could be due to the fact that farmers had learnt from experience of growing the traditional varieties and need to adopt a new innovation for a change. Information about the improved variety increases awareness—a farmer cannot adopt a technology without being aware of it (Diagne and Demont, 2007). A unit increase in access to improved cassava cutting within the villages has a likelihood of increasing farmers' adoption of improved cassava varieties by 28 %. Use of radio can create awareness and hence increase the probability of adoption. Through the use of radio communication, information can be passed to the farmers on available sources of inputs and prices. Further, information can also be passed from one farmer to the other. This has been found to positively and significantly (at $p < 0.05$) influence adoption of improved cassava varieties in the study area. Farmers who use radio have a likelihood of increasing adoption of improved cassava varieties by 16.19 % in the study area.

Conclusion and policy recommendations

This study assessed the impact of adoption of improved cassava varieties on the welfare of cassava producing households in two states in the SW Nigeria. TME 419 was the most widely adopted variety among the introduced improved cassava varieties in the states with 60.2 % of the farmers adopting the variety. The results also showed that adoption of improved cassava varieties in the study area increases annual income and annual consumption expenditures of cassava farming households thus increasing their welfare. Adoption of improved cassava varieties is therefore pro-poor in nature with the adopters having a lower poverty rate than the non-adopters. A significant relationship was found between farmers' marital status, farming as a major occupation, farming experience, access to improved cassava cutting within the villages, use of radio and adoption of improved cassava varieties.

Policy recommendations

There are a number of policy related issues that have been raised by this research. The government has to put in place a number of policies in order to improve the adoption of cassava technology to promote rural households welfare in SW Nigeria. In particular, is the implementation of some policies to address the following issues:

i. Rural households welfare in the SW Nigeria through adoption of improved cassava varieties requires giving rural farmers more access to improved cassava cuttings within the villages where they are resident;
ii. In as much as adoption leads to improvement in farming households' welfare, the quest to eradicate poverty among the rural dwellers in Nigeria should incorporate strategy of educating farmers through the use of radio programme on the need to adopt improved cassava technologies. Battery should be made available for their radios since poor power supply hinders innovation dissemination;
iii. There is need for readily available markets for the tubers through good linkage of farmers to processors to prevent commodity glut and the likelihood of offering unattractive price to the farmers . Small-holder cassava farmers should be linked to large-scale producers of high quality cassava flour, starch and industrial alcohol. The potential for sun-dried chips use in livestock and aquaculture feeds should be explored and promoted;
iv. Suggestion for future studies is recommended in areas beyond access to credit to actual volume of credit use in production given the low level of the income of the farmers in order to ensure that fund limitation does not curtail production.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
All authors were involved in the design of the study, and participated in field data collection. CA conceived the idea of the study and participated in the coordination and critical revision of the manuscript. AE performed the statistical analysis, involved in the preparation of the draft of the manuscript, interpretation of data and results, and participated in the critical revision of the manuscript for important intellectual content. IO participated in the conception and designing of the study, acquisition of data and relevant literature. All authors read and approved the final manuscript. Nigeria.

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