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Determinants of Adoption of Improved Cassava Varieties among Farming Households in Oyo, Benue, and Akwa Ibom States of Nigeria

Abdoulaye Tahirou[1], A. S. Bamire[2], Adewale Oparinde[3], and A. A. Akinola[2]

ABSTRACT

Biofortified pro-vitamin A cassava varieties are being developed and deployed in Nigeria and other countries. Understanding the adoption pathways of already released non-biofortified improved cassava varieties can inform decision makers on how best to disseminate the newly developed varieties. This paper empirically investigated factors influencing adoption of the improved cassava varieties in Akwa Ibom, Benue, and Oyo states in Nigeria.

A multi-stage sampling technique was used to select a sample of 1,609 farming households. Data were analyzed using descriptive statistics and the Probit regression model. The results* showed that Oyo State had the highest reported rate of improved cassava use (69 percent of farmers surveyed), followed by Benue (52 percent), with the lowest in Akwa Ibom (38 percent). The variables that significantly influenced adoption of improved cassava varieties include education ($p<0.01$), livestock ownership ($p<0.05$), access to extension services ($p<0.01$), farmers' organizations ($p<0.05$), participation in demonstration trials, and location-specific variables ($p<0.01$). The positive influence of the location-specific variable in favor of Oyo compared with Benue could be linked to proximity to, and the activities of, international and national research institutes. Within states, regression analysis reveals significant differences across agricultural extension zones. This suggests the need to develop localized strategies that account for applicable socioeconomic and institutional conditions. To increase adoption, an intensive program for farmers' participation in on-farm demonstration trials should be considered. This can be achieved by facilitating group formation to encourage increased knowledge sharing among members, thereby promoting uptake of newly developed pro-vitamin A cassava varieties.

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* These adoption rates were based on the percentage of respondents who have planted some improved cassava on part or all of their farms. However, these estimates could be biased due to the problem of identification of improved varieties based on farmers' and experts' opinions, because of different names given to the same varieties in different locations. Future work would benefit from using DNA fingerprinting to improve estimates.

CONTENTS

1. INTRODUCTION

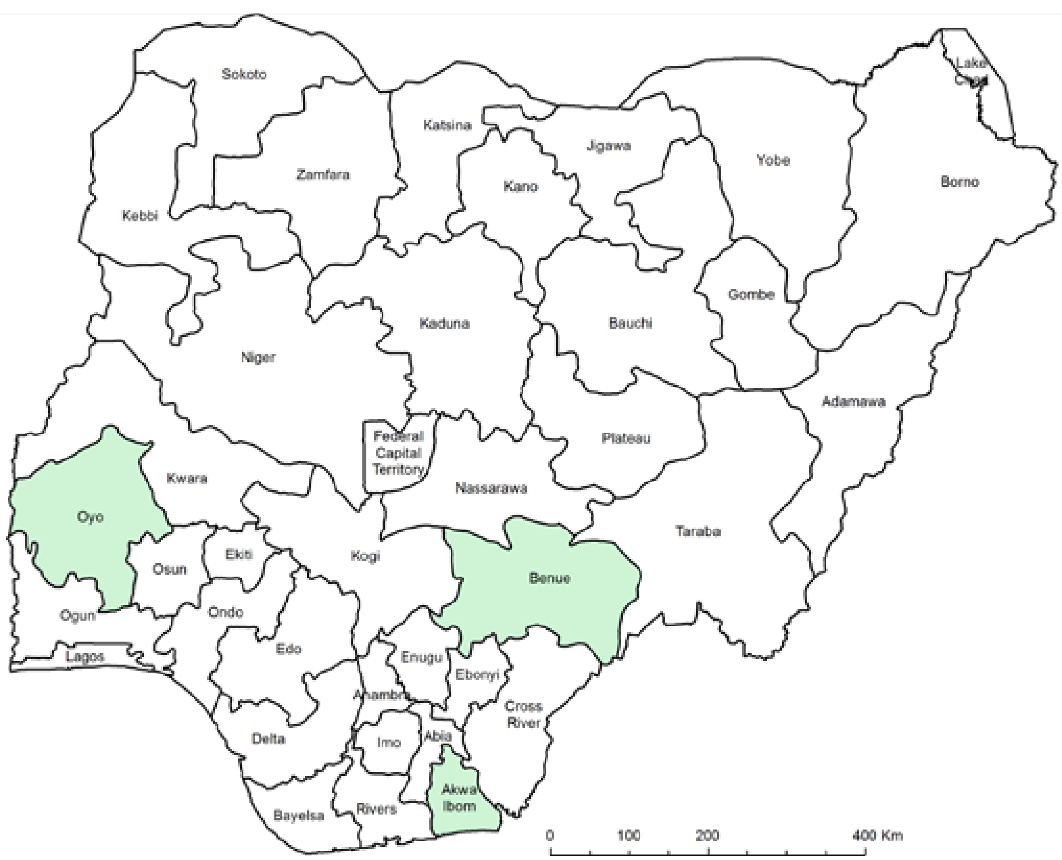
The importance of cassava to resource-poor farmers in Nigeria cannot be overemphasized. Currently, Nigeria is the world's largest producer of cassava. The total area harvested in 2009 was 3.13 million hectares (ha), with production estimated at 36.8 million metric tons and average yield at 11.7 tons/ha–1 (FAOSTAT 2010). Cassava has a special capacity to bridge the gap in food security, poverty alleviation, and environmental protection (Clair and Etukudo 2000). But, while cassava roots are rich in energy, containing mainly starch and soluble carbohydrates, its nutritive value is low (Okigbo 1980).

The HarvestPlus program was initiated to improve the vitamin A status of resource-poor farming households, especially women and children in developing countries such as Nigeria. The project facilitated breeding and delivery activities for micronutrient-dense cassava varieties, which are suitable for many agroecological conditions (Oparinde et al. 2014). These varieties are expected to be adopted by farmers to improve their uptake of vitamin A.

The definition of adoption varies across studies, and the appropriateness of each approach depends on the particular context. Bekele et al. (2000) used a simple dichotomous approach and defined a farmer as an adopter if he or she was found to be growing any improved materials. Thus, a farmer may be classified as an adopter and may still grow some local materials. This approach is most appropriate when farmers typically grow either local varieties or improved varieties. Where farmers are increasingly devoting more land to improved varieties while still growing some local varieties, a continuous measure of adoption is more appropriate. Many other studies used measures of the proportion of land allocated to improved varieties as the measure of adoption. According to An (2013), adoption of a technology could be slow in the beginning of the process, and some farmers never adopt even after the technology matures. Also, limited use of some improved cassava varieties previously developed by research institutions in Nigeria has been noted (Nweke et al. 2002).

Several factors could drive the adoption process. Low or non-adoption could be conditioned by institutional and structural factors, such as social networks and the market structure of seed systems (Akinola et al. 2010). However, there is no general consensus on the magnitude and direction of factors influencing rapid adoption of a specific improved variety (Alene, Poonyth, and Hassan

Figure 1. Map of Nigeria showing Akwa Ibom, Benue, and Oyo States



Source: IITA (2014)

2000; Oluoch-Kosura, Marenya, and Nzuma 2004). The factors are as varied as technologies and context (Shiferaw and Holden 1998; Zeller, Daigne, and Mataya 1998; Alene, Poonyth, and Hassan 2000; Oluoch-Kosura, Marenya, and Nzuma 2004; Abdoulaye and Sanders 2005; Bamire, Fabiyi, and Manyong 2002; Akinola et al. 2010). Learning about the adoption of improved cassava varieties in general becomes imperative in order to understand the pathways to adoption. This information can, in turn, be used to inform policy decisions about the potential adoption and consumption of vitamin A cassava. This paper, therefore, aims to assess the drivers of adoption of improved cassava varieties among farming households.

Specifically, the objective to determine the rate of, and factors influencing, adoption of improved cassava varieties in three states (Oyo, Benue, and Akwa Ibom) of Nigeria. This will be important in defining adoption pathways for rapid uptake, and will serve as a guide for future research programs aimed at developing and disseminating improved cassava varieties in Nigeria. A number of studies on adoption of improved technologies already exist (Bekele et al. 2000; Bamire, Fabiyi, and Manyong 2002; Akinola et al. 2010; Mazvimavi and Twomlow 2009). However, this paper utilizes a robust dataset of cassava farmers in three states across geopolitical zones in Nigeria: South-West (Oyo), South-South (Akwa-Ibom), and North-Central (Benue). The paper also draws lessons based on the determinants of adoption to inform the dissemination and promotion strategies for biofortified pro-vitamin A cassava. It addresses the following research questions: what are the socioeconomic aspects and the farm- and farmer-related characteristics that influence the adoption decision, and what are the other drivers of adoption of improved cassava varieties? The remainder of this paper describes the research methodology, presents and discusses the results of data analysis, and draws some conclusions and implications from the study.

2. METHODOLOGY

This section discusses the study area, sampling procedure and data collection methods, and theoretical model used. The description of study variables is also presented.

2.1 Study Area, Sampling, & Data Collection

The study was conducted in the rural areas of three states (Akwa Ibom, Benue, and Oyo) in Nigeria where cassava cultivation is predominant (Figure 1). Cassava-producing households constituted the study population in each state. A two-stage cluster sample design was used in which enumeration areas (EAs) were systematically selected using probability-proportional-to-size (PPS) sampling from the Nigeria National Bureau of Statistics 2008 household listing data in the first stage, and simple random sampling of households within EAs in the second stage. This involved an implicit stratification of EAs based on intensity of cassava production (or the proportion of cassava-producing households in each EA). Sample sizes of 500, 524, and 585 farming households were selected in Akwa Ibom, Benue, and Oyo states, respectively, for a total of 1,609 households used in the study.

The survey was conducted on a representative number of farming households that can be generalized to the greater population of rural cassava-growing households in each of the states. It was conducted toward the end of the dry season, when farmers typically have harvested most of their cassava (among other crops) and till their land in preparation for the next cropping (rainy) season. Thus, information was obtained on cassava cultivation from April to November 2012 for both rainy and dry cropping seasons. Data were collected on cassava varieties cultivated, household characteristics, assets, access to information and extension services, and farm input uses, among others, using a computer-assisted personal interviewing method. The data were then analyzed using descriptive statistics and the Probit regression model. Although it is now common knowledge that adoption is beyond a dichotomous estimation approach (Oparinde et al. 2015), the choice of the Probit model in this study is based on the nature of data available.

2.2 Model Specification

2.2.1 Theoretical Model

Small-scale farmers' decisions to adopt improved cassava varieties could be explained using a utility model. A typical smallholder-farming household will adopt improved cassava varieties in order to maximize a multidimensional objective function, while at the same time minimizing risks (Strauss, Bednar, and Mees 1989). When there is a change in the benefits accruing from adoption of improved varieties, the central question is related to how much compensation would make the decision maker uninterested about the change. Therefore, the change in gains associated with this development could provide a platform for the economic valuation process. When an individual farmer faces a change in a measurable attribute, for example expected gain or loss from using improved varieties (p), then p changes from p_0 to p_1 (with $p_1 > p_0$). The indirect utility function, U, after the change becomes higher than the status quo. The status quo can be represented econometrically as in equation (1):

$$u_{1j} = u_{\mathrm{i}} (y_i, z_j, p_0, \varepsilon_{0j}) \quad (1)$$

On the other hand, the change or final state due to adoption of improved cassava varieties is expressed in equation (2):

$$u_{2j} = u_i\,(y_i, z_j, p_1, \varepsilon_{ij}) \quad (2)$$

Where,

p_1 is the gain or benefit related to adoption of improved cassava varieties.

y_i, refers to household expected tangible gain; z_j is a vector of the farm-, farmer-, and improved varieties-related factors; and ε_j is the stochastic error term representing other unobserved utility components.

The farmer would decide to adopt on the following condition expressed in equation (3):

$$u_i\,(y_i - p_i, z_j, \varepsilon_{ij}) > u_0\,(y_i, z_j, \varepsilon_{0j}) \quad (3)$$

Since the random components of the preferences are not known with certainty, it is possible only to make probabilistic statements about expected outcomes. Thus, the decision by households to adopt improved cassava varieties is the probability that they will be better off if adoption improves their welfare. This is represented in equation (4):

$$Prob\,(Yes_i) = Prob\,[u_i\,(y_i - p_i, z_j, \varepsilon_{ij}) > u_0\,(y_i, z_j, \varepsilon_{0j})] \quad (4)$$

Since the above utility functions are expressed generally, it becomes critical to specify the utility function as additively separable in deterministic and stochastic preferences. Using this argument, the function becomes as shown in equation (5):

$$u_i\,(y_i, z_j, \varepsilon_{ij}) = u_i\,(y_i, z_j) + \varepsilon_{ij} \quad (5)$$

Where:

The first part of the right-hand side is deterministic, and the second part is stochastic. The assumptions that ε_{ij} are independently and identically distributed with mean zero describe most widely used distributions.

The two estimating techniques most frequently used are (i) the maximum likelihood estimator (MLE) and (ii) the minimum $\chi 2$ estimator. The MLE can be used in the case of few or many observations per cell, but the minimum $\chi 2$ estimator can only be effectively used when there are many observations per cell (Gujarati 2006). Though the linear probability model (LPM) has been found to be computationally and conceptually simpler than others, an inherent deficiency of the model is its heteroscedastic disturbance term, the presence of which results in a loss of efficiency but does not in itself result in either biased or inconsistent parameter estimates. Therefore, its specifications create estimation problems with the application of ordinary least-squares regression (Amemiya 1981; Capps and Kramer 1985; Akinola 1987). While the use of monotonic transformations can transform the model to obtain homoscedastic disturbances, the efficiency of the weighted (transformed) least-squares estimates depends on the condition that $0 < Xi, ß < 1$, which may be violated (Goldberger 1964; Amemiya 1981; Gujarati 2006). Additionally, the non-normality of the disturbance terms makes the use of traditional tests of significance (the t-test and F-test) inappropriate. Since the LPM involves the interpretation of predicted values of Y as probabilities, it presents a serious weakness and problem when the predicted value lies outside the (0, 1) range. This is because even if the true linear probability model is correct, it is certainly possible that a given sample value of X will lie outside the interval (Pindyck and Rubinfield 1997; Gujarati 2006).

To overcome the difficulty arising from the LPM, its constrained form can be used by involving some notion of probability as the basis of transformation. According to Tobin (1958) and Amemiya (1984), this transformation (called monotonic transformation) can be effected with the cumulative probability function. Among possible alternative cumulative probability functions are the logistic (Logit) and the normal (comprising Probit and Tobit) models. The logistic and Probit formulations are quite similar, with the only difference being that the logistic distribution has slightly fatter tails. Though the Probit model is computationally more difficult, it is more flexible and, unlike the Logit model, does not result in any violation of the basic assumptions if some of the alternatives from which a choice is to be made are close substitutes. Therefore, Probit models are operationalized in this paper.

2.2.2 Probit Empirical Model

The general form of the univariate dichotomous choice model can be expressed as in equation (6):

$$P_i = P(y_i = 1) = G(X_i, \Theta),\ i = 1,\ldots n \quad (6)$$

With the assumption that the random variables yi are independently distributed, equation (6) states that the probability that the ith farmer will adopt a given technology, such as improved cassava varieties $P_i(y_i = 1)$, is a function of the vector of explanatory variables, Xi, and the unknown parameter vector, Θ (Amemiya 1981; Gujarati 2009).

The empirical model of the Probit model employed can be expressed as in equation (7):

$$Y_i = \beta_0 + \beta_1 SEX + \beta_2 HHEDU + \beta_3 HHAGE + \beta_4 HHSIZE + \beta_5 FARMSIZE + \beta_6 POCCUPA + \beta_7 AMOUNT + \beta_8 OFFINCOM + \beta_9 LIVESTOCK + \beta_{10} INFOACESS + \beta_{11} FGROUP + \beta_{12} DEMONSTRAT\,N\,\beta_{13} AKWADUMY + \beta_{14} OYODUMY + \mu \quad (7)$$

Where:

The dependent variable (Y_i) is a dummy variable where an adopter of improved cassava varieties is scored 1, and non-adopters are scored 0. The explanatory variables include farmer, farm, and institutional factors postulated to influence adoption of technologies.

The rationale for the inclusion of specific variables is explained in the paragraphs that follow. These variables include the sex of the household head (*SEX*); the age of the household head (*HHAGE*); and the type of farming activities engaged in by household heads, measured based on whether farming is the primary occupation (1) or is not (0). Other variables included the education of the household head (*HHEDU*), measured based on the ability to write and read (1) or otherwise (0); the number of people in the household (*HHSIZE*); and livestock ownership by households (*LIVESTOCK*) (proxied by the Tropical Livestock Unit). Livestock were chosen because cassava by-products are commonly used as livestock feed in the study area, and information access (*INFOACCESS*) was measured by access to information on improved cassava varieties through extension agents. Further, the following variables are included: active membership in farmers' groups or organizations (*FGROUP*), and participation in demonstration trials organized by the International Institute of Tropical Agriculture (IITA), National Agricultural Research System (NARS), and other collaborators. Moreover, variations associated with the state of cassava agro-processing and level of influence of international and national research institutes, such as IITA, were captured by state dummy variables—*AKWADUMY*, *BENUDUMY*, and *OYODUMY* (Table 1).

Education (*HHEDU*) has been found to have a positive and direct influence on adoption of technologies (Nkonya, Schroeder, and Norman 1997; Alene, Poonyth, and Hassan 2000; Oluoch-Kosura, Marenya, and Nzuma 2004). In other words, education could increase the ability of farmers to use their resources efficiently, while giving them a leverage on effective information diagnosis, analysis, and interpretation. Therefore, it is expected to positively influence adoption of improved cassava varieties.

Previous studies have shown that the effect of household size on technology adoption could be positive or negative (Manyong and Houndekon 1997; Zeller, Daigne, and Mataya 1998; Oluoch-Kosura, Marenya, and Nzuma 2004; Bamire, Fabiyi, and Manyong 2002; Bekele and Drake 2003). On the positive side, larger family size is generally

Table 1. Description of Variables

Variable	Variable description	Units
SEX	Gender of the household head: 1 if male, 0 otherwise	
HHHHAGE	Age of the household head	Years
HHEDU	Measure of literacy level: 1 if the household can read or write, 0 otherwise	
HHSIZE	Number of people living together under the same roof and eating from the same pot	
FARMSIZE	Size of household farmland	Ha
POCCUPA	Primary occupation of household head: 1 if farming, 0 otherwise	
AMOUNT	Amount spent on purchase of cassava stems	Naira
LIVESTOCK	Livestock holdings of the households	TLU
EXTENSN	Access to information on improved cassava varieties through extension agents: 1 if there is access, 0 otherwise	
DEMONSTN	Participation in demonstration trials organized: 1 if participation, 0 otherwise	
FGROUP	Membership in farmers' group or organization: 1 if yes, 0 otherwise	
AKWADUMY	Dummy for Akwa Ibom State: 1 if the state is Akwa Ibom, 0 otherwise	
OYODUMY	Dummy for Oyo State: 1 if the state is Oyo, 0 otherwise	
BENUEDUMY	Dummy for Benue State: 1 if state is Benue, 0 otherwise	

associated with a greater labor force being available to the household for the timely operation of farm activities, including activities relating to improved cassava varieties. More labor hours are likely be spent on the use of improved technologies during labor-slack seasons because of the low opportunity cost of labor in rural areas. The study hypothesized that increased household size could favor adoption of improved cassava varieties by the farming households. The negative relationship of this variable may be due to the increased consumption pressure associated with larger family size. It is therefore difficult to a priori predict the direction of influence of this variable on adoption.

Institutional factors, such as access to extension services and participation in demonstration trials, are expected to positively influence cassava variety adoption. These factors entail knowledge acquired on the importance and application of innovations through counselling and demonstrations by extension agents on a regular basis. This study posits that households with access to extension services who frequently receive training and participate in demonstration trials will have a higher probability of adopting improved cassava varieties than others (Adesina and Zinnah 1993; Bamire, Fabiyi, and Manyong 2002; Mazvimavi and Twomlow 2009).

2.2.3 Measures of Wealth

Livestock ownership (*LIVESTOCK*) is hypothesized to influence adoption of improved cassava varieties positively (Zeller, Daigne, and Mataya 1998; Negatu and Parikh 1999; Akinola et al. 2010). It is generally considered to be capital that could be either used in the production process or exchanged for cash or other productive assets. Engagement in farming as a primary occupation by the household head is expected to have a positive relationship with adoption of improved cassava varieties. It is measured as a dummy variable, with farming scored 1 and other occupation scored 0.

Social capital, captured as active membership of a farming organization (*FGROUP*), was also hypothesized to be positively linked with the adoption of improved technologies. The role of social capital in boosting positive adoption decisions has been linked with providing an effective platform for interaction and cross-fertilization of ideas on farming-related activities (Bamire, Fabiyi, and Manyong 2002). Farmers who are not members of associations are expected to have lower probabilities of adoption.

Technology adoption is expected to be influenced by the presence and activities of research institutes and the state of value-chain or agro-processing development of the area, as well as by socioeconomic pressures, such as population density, that characterize some states more than others. For instance, adoption of improved varieties could be higher in places close to IITA, because of greater exposure and access that farmers in those areas might have to the activities relating to production and deployment of improved varieties. Similarly, adoption is expected to be higher in states with enhanced processing activities than in other states. Therefore, in this study, adoption is expected to be highest in Oyo, followed by Benue, and then Akwa Ibom, because of a higher presence of research institutions, such as IITA, and processing centers.

The effect of age (*AGE*) on the adoption of improved cassava varieties could be negative or positive. The age of farmers could contribute to how new ideas are perceived and could thereby influence adoption (Bekele and Drake 2003). Younger farmers may be more willing to bear the risks associated with early adoption of innovation. On the one hand, as farmers grow older they may become more conservative, with a greater tendency to stick to old practices and methods. On the other hand, old age can be an indicator of better experience, greater resources, and enhanced authority that may influence adoption of new varieties positively.

3. RESULTS & DISCUSSION

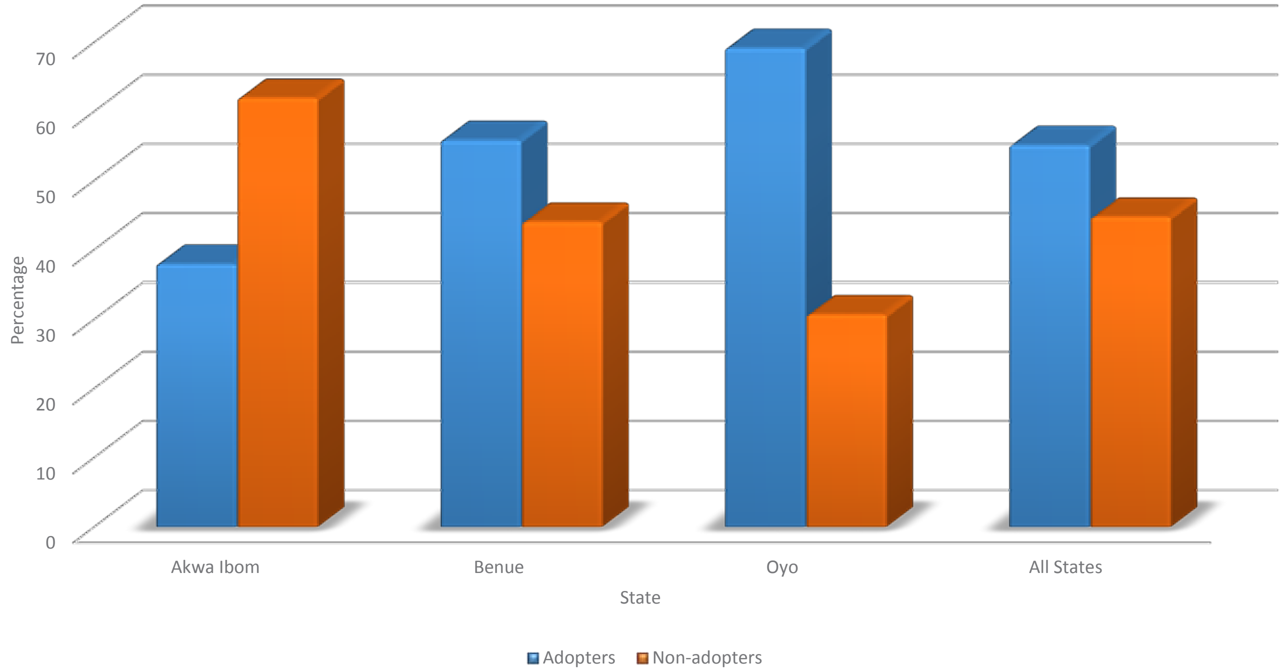
This section presents the results of data analysis and their interpretation. It describes farming households' socioeconomic characteristics, and cassava production and farm input use levels. It also reports the adoption and non-adoption of improved cassava varieties as well as the determinants of adoption in each state and the study area as a whole.

3.1 Adoption of Improved Cassava Varieties

The adoption rate of improved cassava varieties is shown in Figure 2. Adoption here is defined with a dichotomous variable (adopt/not adopt) based on the general frequency of use or non-use of improved cassava varieties. About 58 percent of the interviewed households have planted at least one improved cassava variety in the study area. It is important to note here that this adoption rate does not reflect any information on the intensity of use of improved cassava varieties. Another issue here is the correct identification of cassava varieties. Due to lack of a formal seed system and varietal naming, farmers and even cassava experts (extension agents and breeders) have trouble distinguishing varieties in the fields. As a result, improved varieties can be tagged local and vice-versa.

At the state level, based on the above definition of adoption, Oyo had the highest adoption rate (69 percent), followed by Benue (52 percent), and Akwa Ibom (38 percent).

Figure 2. Rate of Adoption of Improved Cassava Varieties



Source: HarvestPlus cassava varietal adoption survey (2012)

However, we recognize the shortcoming of the reported adoption rate since (1) the figures were not verified objectively through a DNA fingerprinting technique, which is the state-of-the-art technology for varietal identification (Oparinde et al. 2015); (2) farmer's knowledge is not sufficient for the identification process, since one local name can refer to different varieties within the same village and even within the same cassava field (Oparinde et al. 2012); and (3) varietal identification requires expertise, funding, and access to a complete DNA database for all varieties; however, the database of landrace varieties is still incomplete in Nigeria. These shortcomings limit the possibility for an objective identification of varieties, which is why this study depends on the available dataset.

The high adoption rate reported in Oyo may be due to the state's proximity to IITA and the relatively higher dissemination efforts from NARS working with IITA in increasing the adoption of improved technologies. On the other hand, Benue had the highest proportion of cassava farmers in Nigeria. This could encourage more rapid farmer-to-farmer diffusion of information on improved cassava varieties than in other states. The low adoption rate in Akwa Ibom may be traced to limited extension efforts in the area. The average rate of adoption for the study area in general was about 52 percent. This implies that there is still room for improvement in the uptake of improved cassava varieties in the area and, therefore, justifies the goals and investments of HarvestPlus.

3.2 Household Characteristics

3.2.1 Socioeconomic characteristics of respondents

Most of the households (>80 percent) were headed by males (Table 2). A high percentage of the farmers (88 percent) could either read or write, which is expected to boost the probability of their adoption of improved cassava varieties. For both adopters and non-adopters, more than 60 percent of respondents reported farming to be their main occupation. Irrespective of the category of adoption, all household heads are still in their economically active age (about 50 years), and have been engaged in farming for more than 20 years.

The extent of land available to the farming households for cultivation is an important asset for their agricultural and livelihood activities. On average, there was a significant difference ($p<0.05$) between the total farm size of adopters (4.1 ha) and non-adopters (3.4 ha) of improved cassava varieties. This suggests that adopters of the technology generally had a larger farm than non-adopters. At the state level, farmers in Benue state had the highest average farm size, of about 5 ha, followed by Oyo with about 4.1 ha for non-adopters and 4.5 ha for adopters, and Akwa Ibom with about 1.4 ha. The farm size follows the land mass in each state (see Figure 1). Of the total farm size owned by households, an average adopter cultivated 2 ha, about half (48.8 percent) of the available farmland with improved cassava varieties. At the state level, an average adopter

Table 2. Socioeconomic Characteristics of Respondents

Socioeconomic characteristics	All states			State								
				Akwa Ibom			Benue			Oyo		
	Non-adopters (n=721)	Adopters (n=888)	t-value	Non-adopters (n=310)	Adopters (n=190)	t-value	Non-adopters (n=231)	Adopters (n=293)	t-value	Non-adopters (n=180)	Adopters (n=405)	t-value
Male (%)	87.9	92	9.2	83.5	86.3	1.0	89.6	93.1	3.1**	93.3	94	0.18
HH head literacy level (%)	87.9	86.5	0.0	98.1	99.5	1.6	95.2	96.6	7.8***	61.1	72.8	10.1***
Farming as primary occupation (%)	85.8	81.5	16.5***	60.8	57.9	0.4	98.3	95.6	0.3	95.6	91.9	4.4**
Mean age (years)	53.4 (14.7)	52.2 (15.2)	2.4	55.5 (13.1)	53.6 (13.6)	2.6	51.5 (14)	49.5 (14.7)	2.7*	51.8 (17)	53.7 (16.1)	0.94
HH size (#)	5.6 (3.1)	6.0 (3.1)	1.0	5.7 (3.5)	5.5 (1.8)	0.3	5.7 (2.4)	6.5 (3.8)	0.9	5.5 (2.9)	5.7 (1.1)	8.23***
Farming experience (years)	29.5 (17.3)	26.9 (17.5)	8.6***	35.4 (15.3)	35.8 (16)	0.2	29.2 (15)	27.2 (13.7)	1.7	21.7 (18)	21.8 (19)	0.81
Farm size (ha)	3.4 (4.9)	4.1 (6.4)	6.3***	1.4 (2.6)	1.38 (1.67)	0.0	5.38 (6.4)	5.23 (5.66)	0.0	4.06 (4.8)	4.52 (7.68)	1.70
Land cultivated to improved cassava varieties	0	2.0 (3.8)	0	0	0.77 (1.28)	0	0	1.5 (2.93)		0	1.75 (3.14)	-
Farm size/HH (ha)	0.7 (1.0)	0.9 (2.2)	5.7***	0.27 (0.44)	0.26 (0.29)	0.0	0.99 (1.2)	0.96 (1.35)	0.0	0.98 (1.3)	1.08 (2.95)	0.56

Note: *** = significant at 1%; ** = significant at 5%; * = significant at 10%

Source: HarvestPlus cassava varietal adoption survey (2012).

Table 3. Household Ownership of Physical Assets

Socioeconomic characteristics	All states			State: Akwa Ibom			State: Benue			State: Oyo		
	Non-adopters (n=721)	Adopters (n=888)	t-value	Non-adopters (n=310)	Adopters (n=190)	t-value	Non-adopters (n=231)	Adopters (n=293)	t-value	Non-adopters (n=180)	Adopters (n=405)	t-value
House (%)	82.9	76.3	10.1***	89.7	86.8	1.1	87.3	90.7	2.7	65.6	60.5	1.5
House (#)	1.0 (1.2)	1.0 (1.3)	1.5	1.0 (0.6)	1.0 (0.6)	0.1	0.9 (1.4)	1.0 (1.5)	0.1	1.1 (1.3)	0.9 (1.3)	4.2***
Car (%)	5.7	9.6	7.7***	6.8	12.1	4.5***	3.5	5.3	0.4	6.7	11.4	3.2***
Car (#)	0.1 (0.5)	0.1 (0.5)	4.8***	0.1 (0.3)	0.2 (0.6)	6.9***	0.1 (0.4)	0.1 (0.4)	6.5	0.1 (0.7)	0.1 (0.5)	0.8
Bicycle (%)	24.8	16.7	14.3***	37.4	46.8	5.1***	25.9	15.7	6.9	1.7	2.6	0.5
Bicycle (#)	0.4 (0.9)	0.3 (0.8)	6.6***	0.6 (1.1)	0.8 (1.2)	5.4***	0.4 (0.9)	0.2 (0.7)	4.6	0.0 (0.1)	0.0 (0.2)	1.1
Motorcycle (%)	50.8	52.9	0.9	48.9	60.5	6.6***	50.4	51.6	0.1	54.4	50.0	0.8
Motorcycle (#)	0.6 (0.8)	0.7 (0.9)	3.1***	0.6 (0.8)	0.8 (0.9)	4.6	0.7 (0.9)	0.8 (1.1)	2.5	0.7 (0.8)	0.6 (0.7)	0.1
Cellphone (%)	63.1	69.8	8.7***	67.4	74.7	3.3**	50.9	64.4	10.7	71.1	71.2	0.1
Cellphone (#)	7.5 (6.2)	4.0 (5.0)	2.5**	1.6 (1.9)	1.6 (15.0)	0.1	1.2 (1.6)	1.5 (1.9)	7.2	1.5 (1.5)	1.5 (1.7)	0.4
Radio (%)	67.5	78.7	26.6***	71.8	85.8	12.6***	58.3	69.0	6.5	71.7	82.3	9.4***
Radio (#)	0.9 (0.9)	1.2 (1.0)	4.4***	0.9 (0.8)	1.3 (1.1)	19.1***	0.8 (0.9)	1.0 (1.0)	7.6	1.0 (0.9)	1.1 (1.0)	1.2
Television (%)	31.2	37.0	5.7***	51.9	72.1	21.1***	14.0	20.6	2.8	17.2	31.6	13.5***
Television (#)	0.4 (0.7)	0.5 (0.7)	4.0**	0.7 (0.9)	1.0 (0.9)	11.1***	0.2 (0.4)	0.2 (0.5)	3.1	0.2 (0.5)	0.4 (0.6)	14.6***

Note: *** = significant at 1%; ** = significant at 5%

Source: HarvestPlus cassava varietal adoption survey (2012) in Akwa Ibom, Benue, and Oyo cultivated of the total farmland about 0.8 ha (55.8 percent), 1.5 ha (28.7 percent), and about 1.8 ha (38.7 percent), respectively, of the total farmland with improved cassava varieties. It is important to note that non-adopters allocated none of their farmland to any improved cassava variety.

3.2.1 Household ownership of assets

This section discusses the three main categories of assets owned by households in the study area: physical assets, livestock assets, and institutional and social capital networks.

Physical Assets

Household physical assets can be sources of liquidity to the household in critical times by providing resources for the adoption of improved technologies (Negatu and Parikh 1999). Such assets include houses, cars, motorcycles, cell phones, radios, and television sets (Table 3).

Of the physical assets in Table 3, those owned by more than 50 percent of households include house (about 83 percent for non-adopters and 76 percent for adopters), motorcycle (about 51 percent for non-adopters and 53 percent for adopters), cell phone (about 63 percent for non-adopters and 70 percent for adopters), and radio (about 68 percent for non-adopters and 79 percent for adopters). A greater proportion of adopters of improved cassava varieties owned motorcycles, bicycles, cell phones, and radios, especially in Benue and Akwa Ibom. As expected, cars were the least owned physical asset. This trend was replicated at the state level.

Livestock Assets

Livestock ownership can increase the availability of financial capital, which makes investment in adoption of innovation possible (Zeller, Daigne, and Mataya 1998). A large number of households owned livestock (Table 4).

The highest proportion of households that own livestock was in Benue, followed by Akwa Ibom and Oyo. The most common livestock assets were goats and poultry (>40 percent). An average of 52 percent of adopters of improved cassava varieties owned goats in all the states, versus 48 percent of non-adopters. Similarly, in nearly all the states, adopters of improved cassava varieties owned more livestock than their non-adopting counterparts. About 73 percent of the adopting households owned poultry in Benue, 46 percent in Akwa Ibom, and 36 percent in Oyo.

In terms of the number of livestock assets, an average non-adopting household owned about six poultry and two goats, while an adopter owned about ten poultry and three goats. The number of poultry, pigs, and goats owned was highest in Benue and among adopters of improved cassava varieties.

Table 4. Household Ownership of Livestock Assets

Socioeconomic characteristics	All states			Akwa Ibom			Benue			Oyo		
	Non-adopters (n=721)	Adopters (n=888)	t-value	Non-adopters (n=310)	Adopters (n=190)	t-value	Non-adopters (n=231)	Adopters (n=293)	t-value	Non-adopters (n=180)	Adopters (n=405)	t-value
Poultry (%)	44.1	50.4	8.6***	37.7	46.3	4.2**	57.2	72.5	15.7***	38.0	36.0	0.15
Poultry (#)	6.3	10.4	3.4**	5.1	7.4	27.8***	9.3	18.7	6.7***	5.5	5.0	0.10
	(21.4)	(4.16)		(29.1)		(0.9)	(15.0)	(61.5)		(12.1)	(22)	
Goats (%)	48.0	51.8	3.3**	46.8	54.2	1.3	52.8	59.3	4.50**	43.8	45.1	0.64
Goats (#)	2.4	2.8	4.0**	1.8	2.1	1.4	3.0	3.9	4.5**	2.9	2.2	0.70
	(4.1)	(4.9)		(2.5)	(2.6)		(4.7)	(6.3)		(5.3)	(4.3)	
Pigs (%)	4.5	6.5	10.5**	3.2	7.4	4.6***	7.9	12.9	3.8**	2.4	1.3	0.71
Pigs (#)	0.3	0.5	0.0	0.3	0.7	1.6	0.3	0.8	5.5***	0.2	0.1	0.20
	(1.7)	(3.5)		(2.1)	(5.4)		(1.0)	(3.9)		(1.5)	(1.3)	

Note: *** = significant at 1%; ** = significant at 5%

Source: HarvestPlus cassava varietal adoption survey (2012)

Table 5. Awareness of Vitamin A and Institutional and Social Capital

Socioeconomic characteristics	All states			State								
				Akwa Ibom			Benue			Oyo		
	Non-adopters (n=721)	Adopters (n=888)	t-value	Non-adopters (n=310)	Adopters (n=190)	t-value	Non-adopters (n=231)	Adopters (n=293)	t-value	Non-adopters (n=180)	Adopters (n=405)	t-value
Knowledge of Vitamin A (%)	35.7	38.2	1.0	39.0	47.4	3.3**	43.9	43.8	0.1	19.1	29.5	7.3***
Access to extension services (%)	67.3	77.7	47.9***	68.4	87.9	24.6***	56.7	65.2	9.5***	78.9	82.0	15.4***
Membership in Farmers' group (%)	12.1	20.8	3.2**	4.5	7.9	2.6*	14.3	20.1	0.1	22.2	27.4	1.4
Participation in on-farm demonstrations (%)	5.0	7.3	5.5***	9.7	22.1	15.5***	0.0	0.0	0.0	3.3	5.7	2.4*

Note: *** = significant at 1%; ** = significant at 5%

Source: HarvestPlus cassava varietal adoption survey (2012)

Institutional & Social Assets

Institutional and social capital could aid adoption of new technologies. Among such capital accessible to and used by farmers in the study area are extension facilities, participation in on-farm demonstrations and trials, as well as membership in farmers' groups or organizations (Table 5).

From Table 5, access to information through extension agents was highly prevalent in all of the states. On average, about 78 percent of adopters of improved cassava varieties and 67 percent of non-adopters had access to extension services. "Access to extension services was particularly high (>80 percent) in Oyo and Akwa Ibom among adopters of improved cassava varieties. However, among adopters in the three states taken together, membership in farmers' organizations was low (about 21 percent), and was particularly low (5 percent) among non-adopters in Akwa Ibom. Likewise, few farmers attended demonstration trials conducted by IITA or NARS: about 7 percent of adopters and 5 percent of non-adopters attended in the three states. The highest attendance was recorded among adopters in Akwa Ibom. In Benue, farmers did not participate in research demonstration trials, probably due to the unavailability of research institutes in the area.

3.3 Inputs Used in Cassava Production

The level of farm input use indicates the extent of intensification of the agricultural system, and often signals a tendency to use improved varieties (Ellis 2000). In the study areas, farmers used inputs such as herbicides, pesticides, and fertilizer (Table 6). Use of these inputs was lowest among farmers in Akwa Ibom. Farmers in Benue used herbicides and fertilizers more than farmers in Akwa Ibom and Oyo. This may be associated with the higher cost of fertilizers in Akwa Ibom compared with any other state.

Table 6 shows that a non-adopter incurred about ₦2,000 on cassava stem cuttings, while an adopter incurred an average of ₦9,000. Real and/or opportunity cost outlay on cassava stem cuttings was highest compared with other cost items. High variability in standard deviations was due to the fact that some of the respondents had large cassava farms that necessitated a large quantity of planting materials. Adopters of improved cassava varieties in Oyo incurred the highest costs on improved cassava varieties. The cost incurred for fertilizers was highest in Akwa Ibom among adopters of improved technologies.

Table 6. Household Use of Farm Inputs

Input use	State: All states Non-adopters (n=721)	Adopters (n=888)	t-value	Akwa Ibom Non-adopters (n=310)	Adopters (n=190)	t-value	Benue Non-adopters (n=231)	Adopters (n=293)	t-value	Oyo Non-adopters (n=180)	Adopters (n=405)	t-value
Input: Use %												
Herbicide	24.5	44.0	6.8	1.0	1.6	0.4	49.8	56.9	2.4	32.8	55.4	27.55
Pesticide	18.0	34.4	5.8	1.3	2.6	1.3	22.9	18.1	1.8	40.7	62.1	25.40
Fertilizer	18.6	23.8	8.3	14.2	22.6	6.3	32.9	38.6	2.1	7.8	13.6	6.47
Expenditure on inputs (₦'000):												
Cassava stem	2.2 (9.8)	9.0 (8.0)	1.9	2.16 (9.9)	2.65 (7.8)	0.4	6.25 (5.99)	3.3 (2.06)	1.9	2.0 (0.0)	10.67 (35.0)	0.1
Pesticides	10.1 (12.9)	11.0 (12.0)	0.6	5.4 (0.5)	10.1 (12.0)	0.6	0.0 (0.0)	0.0 (0.0)	0.0	14.3 (13.5)	13.2 (13.0)	2.9
Fertilizer	2.2 (8.1)	5.0 (7.0)	11.3	1.97 (9.3)	3.92 (13.0)	4.0	0.0 (0.0)	0.0 (0.0)	0.0	1.16 (5.46)	3.29 (11.0)	7.7

Source: HarvestPlus cassava varietal adoption survey (2012)

3.4 Determinants of the Use of Improved Cassava Varieties

This section presents the results of Probit models estimated to determine the factors that influence adoption of improved cassava varieties in the study area. The models were estimated for the study area as a whole, comprising the three states (Akwa Ibom, Benue, and Oyo), and then for each of the states in order to allow for comparison. The dependent variable is the adoption (scored 1) or non-adoption (scored 0) of improved cassava varieties, while independent variables comprise demographic and socioeconomic, as well as location-specific factors.

3.4.1 Determinants of adoption in the study area

The results of Probit models for the three states when pooled are shown in Table 7. The log-likelihood function of –1020 for the Probit model and the chi-squared value of 167 show that the model is a good fit for explaining the relationship between explanatory variables and dependent variables.

Based on the Probit model in Table 7, the significant variables influencing adoption of improved cassava varieties were education, livestock, access to extension services, participation in demonstration trials,[1] and location-specific variables for Akwa Ibom and Oyo. With the exception of the Akwa Ibom location variable, which had a negative influence on the probability of adoption, all the other four significant variables had a positive influence on adoption. A one-unit change in education increased the probability of adopting improved cassava varieties by about 0.014, suggesting that better-educated households had more adopters of the improved cassava varieties. This is consistent with the finding of Manyong and Houndekon (1997). A one-unit increase in livestock ownership increased the probability of adoption by about 0.002, an indication that better-endowed farmers adopted the improved cassava varieties more than others. This is not surprising, since access to livestock income can enhance input affordability for farmers.

This result is also similar to the results of existing improved cassava adoption studies (Akinola et al. 2010; Shiferaw and Holden 1998; Zeller, Daigne, Mataya 1998; Negatu and Parikh 1999). Access to extension programs showed a strong relationship to adoption of improved cassava varieties. A one-unit increase in access to extension services increases the probability of adoption by about 0.02. Bamire, Fabiyi, and Manyong (2002) and Mazvimavi

[1] Multicollinerity checks were conducted using the variance inflation factor, and these variables are not correlated.

Table 7. Determinants of Adoption of Improved Cassava Varieties in the Study Area

Variable	Probit	
	Estimates	Marginal effects
CONSTANT	-0.482 (-2.489)	-0.022
SEX	0.007(0.062)	-0.003
EDU	0.315(2. 859)**	0.014
AGE	-0.002(0. 594)	-0.001
HHSIZE	0.015(1.318)	0.075
POCCUPA	0.003(0.412)	0. 001
TLU	0.047(1.901)*	0.002*
EXTENSN	0.374(4.799)***	0.017***
FGROUP1	0.008(0.084)	0.001
DEMONSTN	0.479(3.396)***	0.021***
AKWADUMY	-0.518(5.998)***	-0.023
OYODUMY	0.384(4.376)***	0.103***
Number of observations	1,609	
Log-likelihood function	-1020.09	
Restricted log-likelihood	-1112.10	
Chi-squared	184.01	

***, **, and * are significant at 1%, 5 %, and 10%, respectively.

Source: HarvestPlus cassava varietal adoption survey (2012).

Notes: Figures in parentheses represent t-statistics.

and Twomlow (2009) also found that the validity of extension activities is a key factor in promoting the uptake of new technologies. A one-unit increase in farmers' participation in demonstration trials also increased the probability of adoption by 0.02. This may be a result of increased knowledge sharing about the benefits of the cassava varieties available through demonstration trials.

The location-specific variable had a positive influence on technology adoption in Oyo State, and a negative influence in Akwa Ibom. This is likely the result of proximity to agricultural research centers in the case of Oyo. For Akwa Ibom, cassava's lesser role in the livelihood of farmers due to the availability of options in the oil and gas industry may explain the lower adoption rate compared with Benue. Being located in Akwa Ibom State decreases the probability of adoption of improved cassava varieties by about 0.23; however, location in Oyo State increases the probability of adoption by about 0.10. These results should be interpreted bearing in mind the caveat concerning varietal identification (see footnote on Abstract page).

3.4.2 Determinants of adoption in the study area

To capture specific variables that could be responsible for driving adoption at different zones of respective states, attempts were made to include zones in the state-level regression. The states and their respective zones are shown in Table 8.

The Probit estimates at the state level are shown in Table 9. The Probit model has a log-likelihood of –283 and a chi-squared value of 42.08. This suggests that the model is of good fit. However, based on higher figures of log-likelihood estimate and chi-squared (better fit of the model) and the number of significant variables, we preferred regression for the pooled data over individual state regression. We report these state-level regression results because they provide further insight on determinants of adoption.

From Table 9, it is evident that access to extension services, participation in demonstration trials organized by IITA and national scientists, and zone-specific attributes associated

Table 8. Administrative Zones Based on Local Government Areas in Benue, Akwa Ibom, and Oyo States

Benue			Akwa Ibom						Oyo			
Zone A	Zone B	Zone C	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Ibadan-Ibarapa	Saki	Oyo	Ogbomoso
Ushongo	Buruku	Ado	Abak	Ikot Ekpene	Uyo	Oron	Etinan	Eket	Akinyele	Atsibo	Afijio	Orire
Katsina-Ala	Gboko	Agatu	Ukanafun	Essien Udium	Itu	Urueoffong Oruko	Ibeskpo Asutan	Ikot Abasi	Ibarapa	Irepo	Atiba	Surulere
Kwande	Makurdi	Apa	Orok Anam	Obot Akara	Ibiono Ibom	Okobo	Nsit Atai	Eastern Obolo	Ido	Iwajowa	Iseyin	
Vandeikya	Guma	Otukpo	Etim Ekpo	Ikono	Uruan	Mbo	Nsit Ibom	Mkpat Enin	Lagelu	Kajola	Itesiwaj	
Ukum	Gwer	Ogbadibo	Ika	Ini		Udung Uko	Nsit Ubium	Esit Eket	Oluyole	Olorunso	Oyo-East	
Konshisha	Gwer-West	Ohimini						Ibiono		Orelope	Oyo-West	
Logo	Tarka	Okpokwu						Onna		Saki East	Ogo Oluwa	
		Oju								Saki West		
		Obi										

Source: Consultation with ADP (Oyo, Benue, and Akwa-Ibom states) in 2012.

Table 9. Determinants of Adoption of Improved Cassava Varieties at the State Level

Variable	Akwa Ibom		Benue		Oyo	
	Probit estimate	Probit marginal effect	Probit estimate	Probit marginal effect	Probit estimate	Probit marginal effect
CONSTANT	-0.820 (1.186)	-0.296	0.468 (0.970)	0.184	0.212 (0.613)	0.072
SEX	-0.183 (0.970)	-0.067	-0.003 (0.361)	-0.001	-0.002 (0.085)	-0.001
EDU	0.273 (0.430)	0.099	0.638** (1.738)	0.251	-0.005 (0.085)	-0.002
AGE	-0.003 (0.529)	-0.001	-0.004 (1.089)	-0.002	0.002 (0.681)	0.001
HHSIZE	0.008 (0.302)	0.003	0.051*** (2.320)	0.0212	0.029** (1.53)	0.012
POCCUPA	0.003 (0.426)	0.001	-0.920** (2.330)	0.360	-0.057 (0.214)	-0.019
LIVESTOCK	0.014 (0.778)	0.005	0.043 (1.341)	0.0173	0.001 (0.011)	-0.001
EXTENSN	0.579*** (3.397)	0.211	0.016 (0.13)	0.017	0.194 (1.332)	0.066
FGROUP1	0.317 (1.207)	0.116	0.110 (0.713)	0.043	0.187 (1.388)	0.064
DEMONSTN	0.490*** (2.703)	0.179	-0.007 (0.024)	-0.007	0.349 (1.259)	0.118
AKWAZONE2DUMY	0.303 (1.391)	0.113	-	-	-	-
AKWAZONE3DUMY	0.031 (0.139)	0.012	-	-	-	-
AKWAZONE4DUMY	-1.307*** (4.799)	-0.477	-	-	-	-
AKWAZONE5DUMY	0.220 (1.123)	0.080	-	-	-	-
AKWAZONE6DUMY	0.064 (0.326)	0.022	-	-	-	-
BENUZONE2	-	-	0.187 (1.190)	0.074	-	-
BENUZONE3	-	-	-0.608*** (4.668)	-0.239	-	-
OYOZONE2	-	-	-	-	-0.668*** (4.169)	-0.227
OYOZONE3	-	-	-	-	0.054 (0.342)	0.018
OYOZONE4	-	-	-	-	-0.127 (0.807)	-0.043
LOG-LIKELIHOOD	-283.402		-329.882		-340.962	
RESTRICTED LOG-LIKELIHOOD	-332.032		-359.532		-361.086	
CHI-SQUARED	97.693		59.301		40.247	
R-SQUARED	-	-	-	-	-	-

Note: Figures in parentheses represent t-statistics; *** = Significant at 1%, ** = Significant at 5%,

Source: HarvestPlus cassava varietal adoption survey (2012).

with respective states significantly ($p<0.01$) influenced the probability of adoption of improved cassava varieties in Akwa Ibom. Both access to extension services and participation in demonstration trials were positively related to the probability of adoption only in Akwa Ibom. A one-unit improvement in access to extension services led to about a 0.21 increase in uptake of improved cassava varieties. Similarly, a one-unit increase in the attendance of demonstration trials led to about a 0.18 increase in the adoption of improved cassava varieties. The results agree with the a priori expectation that extension activities and demonstration trials expose households to benefits inherent in new technologies, thereby enhancing their uptake (Mazvimavi and Tomomlow 2009). The insignificant relationship between adoption and extension services and participation in demonstration trials in Benue and Oyo could be due to little variability among adopters and non-adopters, arising from a higher level of agricultural research and development activities in those states.

In Akwa Ibom, the negative influence of Agricultural Extension (AE) Zone 4 in relation to Zone 1 suggests lesser access to research outputs and activities. This implies that locations close to research institutes and their outputs were more likely to adopt improved cassava varieties than others. Similarly, estimates for AE Zone 3 in Benue State also indicate the lack of proximity to research institutes and their outputs in relation to Zone 1. Likewise, Saki Zone in Oyo reflected less access to research outputs and activities compared with Ibadan-Ibarapa Zone, which is closer to the IITA campus (Table 9). Moreover, in Benue State, farming as a primary occupation was negatively and significantly ($p<0.05$) related to adoption. A one-unit increase in the number of households engaged in farming as a primary occupation decreased the probability of adoption by 0.40 in the state. This may reflect the low level of extension services in the state.

As expected, education was positively and significantly ($p<0.05$) related to adoption. Increasing households' literacy level by one unit increased the probability of adopting improved cassava varieties by 0.25 in the state. This implies that the more educated the households are, the greater the tendency to adopt improved cassava varieties. The variable was only significant in Benue State, which may reflect the fact that nearly all the household heads (>95 percent) in this state could read and write.

Household size was positively and significantly ($p<0.05$) related to adoption of improved cassava varieties in Benue and Oyo. This implies that large households were better adopters of improved cassava varieties in those states. However, household size was not significant in Akwa Ibom, perhaps resulting from the lower variability among adopters and non-adopters, since both had the same standard deviation and average values.

4. CONCLUSIONS & IMPLICATIONS

The use of improved technologies has been proposed as one of several possible solutions to fostering innovation and productivity in agriculture. This study investigated the factors that affect adoption of improved cassava varieties in Akwa Ibom, Benue, and Oyo states of Nigeria using data from 1,609 farming households. The study sought to understand factors that influence adoption, and how they could affect the dissemination and promotion of newly developed biofortified vitamin A cassava varieties.

Most of the cassava-growing households in the study were headed by males, and a sizable proportion of them could read and write. The majority of household heads practiced farming as a primary occupation. Based on morphological identification and farmers' oral accounts only, about 58 percent of farming households adopted improved cassava varieties across the three states. The highest adoption rate was in Oyo State (69 percent), followed by Benue (52 percent), with the lowest in Akwa Ibom (38 percent). In all the states, adopters of improved cassava varieties had more physical and farm-related assets than non-adopters. Cassava stems used for planting represented an important cost item. The cost of stems among adopters was highest in Oyo State, while the cost incurred for fertilizers was highest in Akwa Ibom. Household size, livestock ownership, access to extension services, participation in demonstration trials, and location-specific variables for Akwa Ibom and Oyo significantly influenced farming households' adoption decisions.

All the significant variables in this study should be taken into consideration by HarvestPlus in its efforts to increase the uptake of new cassava varieties. The policy thrust should be directed at strengthening extension agents and their capacity for enhanced productive interaction with farmers on improved cassava varieties. Likewise, farmers' participation in on-farm demonstration trials should be strengthened. Results also show strong locational differences that should be considered when designing future promotion and dissemination activities. Moreover, encouraging literacy among farming households could increase knowledge of vitamin A benefits, which should result in higher rates of adoption. Also worth considering are future studies with more innovative and precise methods (such as DNA fingerprinting) of identifying cassava varieties adopted by farmers in order to ascertain true adoption rates.

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