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Extension support for cassava (*Manihot esculenta*) production and processing in Nigeria: Effects on farm practice adoption

Oluchi L. Otubo, Joseph J. Molnar*

Department of Agricultural Economics and Rural Sociology, College of Agriculture, Auburn University, Alabama 36849-5406, USA.

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Cassava (*Manihot esculenta*) is an important regional food source, providing food and income to over 30 million farmers, processors, and traders in Nigeria. Extension programs support awareness and interest in new technologies; they facilitate the adoption and adaptation of new approaches to crop production, post-harvest processing, and marketing. Extension can be understood as an intermediary or catalyst in the dissemination of information to rural farmers. This study analyzed the effect of cassava farmers' exposure to extension on a broad measure of cassava technology adoption, while considering the influence of some individual and farm characteristics as control variables. Data were obtained from personal interviews with sample of 952 households conducted in southern Nigeria. Results show a relationship between extension exposure and technology adoption. Farmer-to-farmer interaction played the greatest role in diffusion of the technologies. Interactions with extension agents were low, suggesting that adoption of improved technologies could be enhanced by improved regular contact with extension information. The results underscore the importance of farmer-to-farmer interaction processes that often overshadow extension assistance in supporting and guiding the use of production technology. The conclusions consider some implications for 21st century extension.

Key words: Extension exposure, technology adoption, cassava production.

INTRODUCTION

Agriculture occupies a key position in the Nigerian economy judging by its critical role of providing food security, provision of employment, revenue generation and provision of raw materials for industrial development (Ajala et al., 2013). Cassava (*Manihot esculenta)* an important regional food source, providing food and income to over 30 million farmers, as well as a large number of processors and traders in the cassava value chain (Abdoulaye et al., 2014). Nigeria's average yield per hectare is 10.6 t ha^{-1}, but over 20 t ha^{-1} might be regularly possible with proper varieties, practices, fertilizer, and irrigation (Nweke, 2005; Akinwumiju et al., 2020). The low average yield of cassava can be ascribed to inadequate knowledge of the crop's inherent benefits, poor on-farm management (such as tilling, spacing, and weeding), and low soil fertility (Akinwumiju et al., 2020).

*Corresponding author. E-mail: molnajj@auburn.edu, ozo0012@auburn.edu.

Almost every household in rural Nigeria grows cassava on small farms as one of the staple food crops to feed families and supply the local markets (Aderinto et al., 2017). Cassava tends to serve as a relief crop to food insecurity because of its copious consumption in various forms by people. It has the ability to give appreciable yields on soils where many other crops fail to perform, thus has endeared its cultivation by many smallholder farmers (Anaglo et al., 2020). Cassava has become a very popular crop and is fast replacing other traditional local staples in the country (Anyaegbunam, et al., 2015; Zie et al., 2019).

Nigeria has dedicated extension offices in each of its 36 states, along with a large number of agricultural research institutions and extension training programs. The Research-Extension-Farmer-Input Linkage System (REFILS) connects farmers to the network through a body of 7,000 extension agents (28% female). After an initial surge of World Bank funding in the 1980s, the Nigerian Agricultural Knowledge and Information System (AKIS) has since suffered from a severe lack of funding and coordination in times of both economic growth and recession (Agbontale and Issa, 2011; Huber et al., 2017).

Extension supports awareness and interest in new technologies and facilitates the adoption and adaptation of new approaches to crop production, post-harvest processing, and marketing (Davis, 2009). Extension can be understood as an intermediary or catalyst in the dissemination of information to rural farmers. Ideally, extension should be more a participatory process, rather than a top-down, supply-driven, technically weak program, catering mainly to so-called progressive farmers (Qamar, 2002).

Traditional extension has often provided insufficient coverage of the small-scale farmers, who are the producers of the bulk of food crops in Nigeria (Hamisu et al., 2017). Thus, many technologies that might underlay higher productivity and food security do not regularly reach small-scale farmers. Consequently, most obtain information from the sources that most immediately and conveniently present themselves such as other farmers, inputs dealers, produce buyers, and nongovernmental organizations (NGOs) (Agbelemoge, 2009). The uneven and irregular nature of information flows in a nation's AKIS is a distinct obstacle to the advancement of food production and the livelihoods of African farmers (Ekele, 2015). Some suggest that Nigeria extension should move toward a demand-driven (private) extension service to supplement traditional extension, which has often been seen as part of the social services rendered by government for the farming populace (Hamisu et al., 2017).

A stream of studies have addressed the adoption of improved technologies singly and independently (Abdoulaye et al., 2014; Alene et al., 2000; Oluoch-Kosura et al., 2004; Abdoulaye and Sanders, 2002; Bamire et al., 2002). Agricultural growth via technological transformation leads to an expanded food supply which presupposes relationship between production and processing operations in agriculture (Von Braun, 1988). Most studies on adoption have reflected farmers, farm, institutional, and technology-specific factors based on analysis that identified and estimated separately in a single equation model (Greene, 2003). Inadequate adoption of contemporary innovations and technology have constrained cassava yields in sub-Saharan Africa including Nigeria (Ajibefun, 2015). The call to increase yield, resilience, and nutritional value has again come to the fore as the demand for cassava is increasingly gaining momentum. Communicating these possibilities to farmers and supporting their decisions falls to extension.

Even though considerable work has been done on the impact of extension service delivery among cassava farmers in Nigeria, more research still needs to be done to show how, specifically, cassava farmers' exposure to extension services affects the adoption of improved technologies in Nigeria, and the extent of their role in enhancing production. The aim of this study is to analyze the effect of farmers' exposure to extension on the awareness and adoption of improved cassava technologies. The influence of individual and farm characteristics on awareness and use of selected recommended production practices and approaches were also considered.

METHODOLOGY

Description of the study area

Nigeria is the most populous country in Africa, with a population of over 212 million and over 250 ethnic groups. Nigeria has 36 states and a Federal Capital Territory (FCT) located in Abuja. The target study areas in southern Nigeria where cassava is significant are shown in Figure 1.

Sample

Data were drawn from a survey carried out in selected cassava production areas conducted by International Institute of Tropical Agriculture (IITA) in 2010 (Abdoulaye et al, 2014). A total of 952 respondents were interviewed. To ensure a sub-nationally representative sample of communities and households, a three-stage stratified random sampling procedure was adopted, whereby states were used as strata to improve sampling efficiency. Rural Local Government Areas were used as primary sampling units (PSUs). Enumeration areas (EAs), defined as a cluster of housing units, were used as secondary sampling units (SSUs). The rural smallholder farming households were used as the final sampling units. LGAs were selected from each state based on probability proportional to size, where size is measured in terms of the number of EAs. The EAs that formed the sampling frame were obtained from the Nigerian Bureau of Statistics (NBS), which uses the 2003/2004 master sample frame of the National Integrated Survey of Households (NISH).

Using EAs as approximately equal in size sampling units ensured that all farmers had an equal probability of being selected. Within each LGA, four EAs were selected at random from a sampling

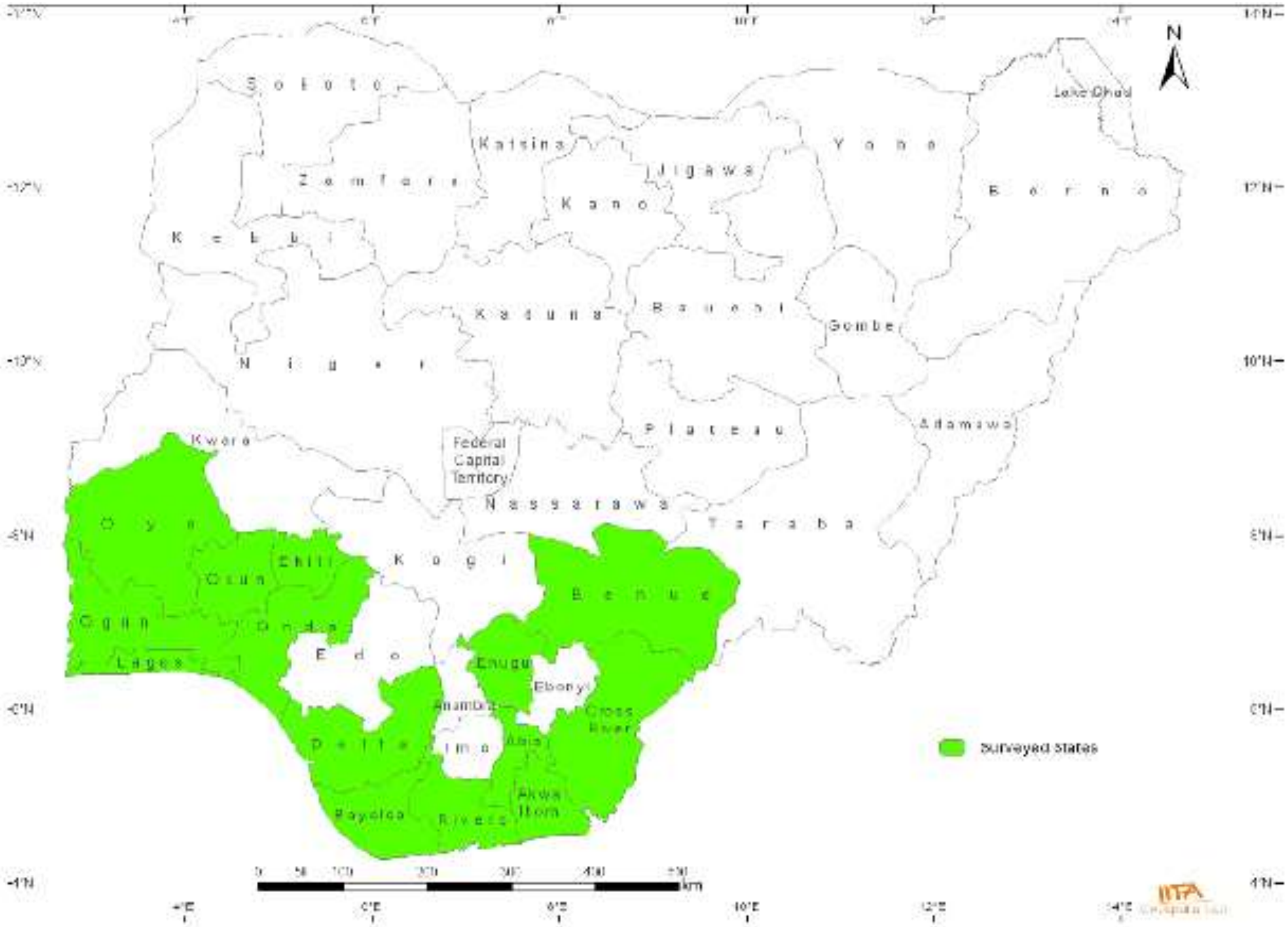

Figure 1. Map of the study districts in Nigeria.

frame of EAs classified as rural or semi-urban, giving a total of 80 EAs or villages. Finally, a list of households was developed for the selected EAs, and a sample of at least ten farming households was selected randomly in each of the sampled EAs. Trained enumerators administered community and household questionnaires under the field supervision of a senior agricultural economist and the direction of IITA's economist. The data was collected using a structured questionnaire administered by trained interviewers knowledgeable of local languages (Abdoulaye, 2018).

Dependent variables

Extension exposure index

These were measured to explain the number of times a farmer was able to interact with either an extension agent, an agricultural extension worker, or was able to attend extension training on production and processing of cassava. The measure counts the number of non-zero responses to the items and ranges from 0 to 4.

(1) How many times did you interact with extension agent on cassava processing?
(2) How many times did you interact with agricultural extension workers on cassava production?
(3) How many times did you interact with agricultural extension workers on cassava processing?
(4) How many times did you attend cassava processing training last session?

Technology awareness index

The measure reflects the respondent is cognizant of cassava production and processing technologies. It counts *yes* responses to “Are you aware of this technology” for each of the seventeen technologies listed in Table 3. The number of *yes* responses was counted to reflect an overall level of cassava technology awareness.

Technology adoption index

The measure reflects whether the respondent actually used a cassava production and processing technology. It counts *yes* responses to the adoption question, “Have you ever used this technology” for the seventeen technology topics listed in Table 3. The number of yes responses was counted in order to create a new

Table 1. Description of variables used in the study.

Variable	Description of variable
Dependent	
Extension exposure	Number of cassava topic interactions with extension services
Technology awareness	Number of noted cassava technologies
Technology adoption	Number of cassava technologies actually used
Independent	
Gender	Gender of respondents (0=female, 1=male)
Age	Age of respondent in years
Marital status	Indicates a person who is married, single or otherwise
Education	Reported years of schooling
Household size	Number of people living under the same roof and taking joint decision about their welfare
Farming experience	Total number of years engaged in farming
Years of growing cassava	Total number of years engaged in cassava farming
Years processing cassava	The number of years a farmer has been processing cassava
Farm size	Total hectares of land owned by cassava farmers
Cassava area (ha)	Total hectares of land dedicated to cassava farming

variable that reflects the total number of technologies adopted.

Independent variables

Farm characteristics

The farm size and cassava areas cultivated were measured by the total number of hectares owned by the farmers and the total size of lands dedicated to cassava production.

Individual characteristics

The individual characteristics indices are age, education, household size, gender, marital status, farming experience, years of growing cassava and years of processing. The rationale for inclusion of these factors was based on a priori expectation of agricultural technology adoption literature (Table 1).

Multiple regression

OLS regression was used to analyze the impact of cassava farmers' exposure to extension on the adoption of improved technologies. Multiple regression was used to determine the relationship between the dependent and independent variables which estimates the extent to which extension exposure, technology awareness and technology adoption were correlated with the individual and farm characteristics of the respondents. Pearson correlation matrix was also constructed to examine the association among study variables.

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6,\ldots X_n)$

The explicit form of the model is represented thus:

$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \ldots + \beta_nX_n + et$

where β_1- β_n = estimated parameters, β_0 = autonomous level of adoption known as the constant, and et = error term. Thus, the regression models are:

(1) Extension exposure (Y_1) = $\beta 0$ + β_1Gender + β_2Age + β_3Marital status + β_4Education + β_5Household size + β_6Farming experience + β_7Years of growing cassava + β_8Years of processing + β_9Farm size + β_{10}Cassava area

(2) Technology awareness (Y_2) = $\beta 0$ + β_1Extension exposure + β_2Gender + β_3Age + β_4Marital status + β_5Education + β_6Household size + β_7Farming experience + β_8Years of growing cassava + β_9Years of processing + β_{10}Farm size + β_{11}Cassava area

(3) Technology adoption (Y_3) = $\beta 0$ + β_1Technology awareness + β_2Extension exposure + β_3Gender + β_4Age + β_5Marital status + β_6Education + β_7Household size + β_8Farming experience + β_9Years of growing cassava + β_{10}Years of processing + β_{11}Farm size + β_{12}Cassava area

Hypotheses

H_{01}: There is no significant effect of cassava farmers' individual and farm characteristics on extension exposure.

H_{02}: There is no significant effect of farmers' individual characteristics, farm characteristics and extension exposure on the awareness of technology.

H_{03}: There is no significant effect of farmers' individual characteristics, farm characteristics, extension exposure and technology awareness on the adoption of technology.

These further imply that all regression coefficients are equal to zero.

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$

RESULTS

Descriptive statistics

Table 2 summarizes the study variables in the Nigeria

Table 2. Descriptive statistics of variables used in analysis, Nigeria cassava farmers, 2010.

Variable	Valid	Missing	Mean	Mode	Range	Min	Max	Response
Dependent								
Extension exposure	952	0	0.24	0	4	0	4	
Technology awareness	952	0	4.66	2	17	0	17	
Technology adoption	952	0	2.69	0	17	0	17	
Independent								
Gender	952	0	0.77	1	1	0	1	0 = female, 1 = male
Age	938	14	49.08	50	82	18	100	
Marital status	952	0	0.13	0	1	0	1	0 = married, 1 = others
Education	952	0	10.11	10	20	1	21	
Household size	946	6	2.00	2	4	1	5	1=1-5, 2=6-10, 3=11-15, 4=16-20, 5=21 and above
Farming experience	925	27	2.66	2	4	1	5	1=1-10, 2=11-20, 3=21-30, 4=31-40, 5=41 and above
Years of growing cassava	926	26	2.44	2	4	1	5	1=1-10, 2=11-20, 3=21-30, 4=31-40, 5=41 and above
Years of processing cassava	952	0	2.20	1	4	1	5	1=1-10, 2=11-20, 3=21-30, 4=31-40, 5=41 and above
Farm size	952	0	1.40	1	3	1	4	1=under 5, 2=6-10, 3=11-15, 4 = 16 and above
Cassava area (ha)	952	0	1.09	1	3	1	4	1=under 5, 2=6-10, 3=11-15, 4 = 16 and above

cassava farmer sample. From the sampled households, result shows that the average age of the respondents was 49 and the oldest among them was 100 years which means that most of the farmers are in their productive stage of the lifecycle. Age is also considered to be a primary latent characteristic in adoption decisions. Most respondents were men, a greater percentage of those who are engaged in cassava production in the sampled states. About 87% were married, family responsibility suggesting a willingness to get involved in productive activities. Most households reported 6-10 members (58%), which suggest availability of family labor. Education level of the respondents was high with an average of 10 years of formal education which indicates that the respondents are literate and are expected to be more receptive to improved farming techniques and improved technologies.

Most people reported that they have been growing cassava for about 11 to 20 years. Likewise, majority of (Technology adoption) around its mean is explained by the regression model, and F-value of 46.9, $p<0.001$. The results of the regression analysis show a positive coefficient for technology awareness, extension exposure, and age, which are all statistically significant at 1%, while household size, years of farming experience, and farm size were negative and statistically significant at 1%. Interpreting the standardized beta coefficients, we get that one standard deviation increase in technology awareness, extension exposure and age results in a 0.551, 0.126 and 0.099 standard deviation increase in technology adoption, respectively. Also, one standard the respondents had between 11 and 20 years' experience in farming while experience in processing was between 1 and 10 years. Experienced farmers, most owned farms less than 5 hectares, mainly dedicated to cassava farming. Most were small scale farmers.

Sources of information

Respondents were asked whether a series of information source had been consulted as a source of cassava technology. Table 3 suggests that extension officers are the major sources of information for cassava producers in Nigeria on six topics. *Other farmer* was the most cited source

Table 3. Sources of cassava technology information by topic, Nigeria 2010

Topic	Percent identified as information source by cassava farmers						
	Extension	Gov't	NGO	Farmer	Media	Agro Dealer	Others
Pelleting	50.0	-	-	10.0	-	10.0	10.0
Improved varieties	46.3	3.7	0.8	28.0	2.9	2.5	0.3
Chipping	42.9	-	2.4	16.7	11.9	11.9	2.4
Fermentation	42.2	-	-	31.1	8.9	8.9	2.2
Management	39.7	2.0	0.7	47.1	1.8	1.1	0.2
Distilling	37.5	-	-	25.0	-	-	12.5
Boiling	33.3	-	-	30.6	11.1	13.9	2.8
Washing	33.1	-	2.5	45.5	2.5	9.1	0.8
Extracting	28.2	2.6	2.6	43.6	12.8	2.6	2.6
Peeling	28.1	-	3.3	44.4	6.5	9.2	0.7
Grinding	24.4	1.6	2.4	52.8	3.3	5.7	3.3
Milling	23.1	1.3	2.6	37.2	15.4	5.1	5.1
Drying	22.9	2.9	1.4	42.9	8.6	12.9	2.9
Frying	22.6	-	1.8	50.6	1.8	7.3	1.2
Grating	22.2	1.1	1.4	59.2	1.7	4.7	-
Sifting	19.7	-	2.8	56.3	4.2	4.2	-
Pressing	19.0	1.0	1.4	60.9	4.5	3.8	0.7
Number	*952*						

of information for eleven topics. More farmers rated extension as their top source of information for pelleting, improved varieties, and several processing steps. Farmers were rated as the top source of overall management information. Overall, farmer-to farmer technological diffusion played the greatest role in dissemination of the technologies. Over half the cassava farmers indicated that their peers were their main source of information for four topics. Fifty percent said that extension was their main source for pelleting, the highest proportion of any topic. Sixty-one percent said that peers were the main source of guidance on pressing (the highest rating for any source on any topic), but only 19% cited extension.

Farmer-to-farmer contact is very important in technology dissemination especially in small-scale farming system (Grisley, 1994). This is similar to the findings of Sanginga et al. (1999) who stated that friends/neighbors contact and extension contact from the principal sources of information seemed to be more effective.

Correlations

Table 4 presents correlations between the dependent variables and the independent variables. Overall correlation between extension exposure, technology awareness, technology adoption and the independent variables were low. The highest degree of correlation (0.577) was observed between technology awareness and technology adoption. The associations are more fully examined in the regression analysis.

Multiple regression

Table 5 presents standardized beta coefficients for the regression analysis between the individual characteristics, farm characteristics, extension exposure, technology awareness and technology adoption. The regression analysis showed that different variables had an effect on technology adoption, technology awareness and extension exposure. A positive sign on a parameter indicates that a standard deviation increase in independent variable will result to a standard deviation increase on the dependent variable.

Impact on extension exposure

The results show that 5.1% of the variation of the response variable (Extension Exposure) around its mean is explained by the regression model. The positive coefficient for household size is statistically significant at 1%, while years of processing cassava, and farm size are negative and statistically significant at 5 and 1%, respectively.

Interpreting the standardized beta coefficients, a one standard deviation increase in household size results in a 0.151 standard deviation increase in exposure to extension, a one standard deviation increase in farm size results in a 0.164 standard deviation decrease in

Table 4. Pearson correlation matrix of study variables, Nigeria cassava farmers 2010.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
Extension exposure	--											
Technology awareness	0.125**	--										
Technology adoption	0.187**	0.577**	--									
Gender	-0.050	0.010	-0.085**	--								
Age	0.020	0.057	0.054	0.125**	--							
Marital status	0.036	-0.014	0.059	-0.308**	0.011	--						
Education	0.010	0.029	0.014	0.062	-0.076*	-0.077*	--					
Household size	0.134**	0.042	-0.062	0.125**	0.200**	-0.097**	0.049	--				
Years of farming	0.070*	-0.053	-0.129**	0.196**	0.474**	-0.007	-0.123**	0.302**	--			
Years growing cassava	0.053	-0.093**	-0.104**	0.161**	0.453**	0.006	-0.130**	0.256**	0.891**	--		
Years of processing	0.010	-0.134**	-0.103**	0.123**	0.363**	0.026	-0.135**	0.148**	0.763**	0.851**	--	
Farm size	-0.102**	-0.008	-0.155**	0.114**	0.087**	-0.084**	-0.033	0.249**	0.157**	0.111**	0.019	--
Cassava area	-0.004	-0.021	-0.077*	-0.001	0.066*	-0.020	-0.082*	0.090**	0.094**	0.098**	0.073*	0.295**
Number	*902*											

*p < 0.05; **p < 0.01.

exposure to extension, and a one standard deviation increase in years of processing results in a 0.136 standard deviation decrease in exposure to extension. This is not consistent with the a priori expectation because one would think that the larger the farm size, the more likely a farmer is to have more exposure to extension. For years of processing cassava, this implies that the more time spent in processing cassava, the less the interaction with extension agents. The result also contradicts a priori expectation because the longer a farmer is engaged in processing, the more it is expected that he would make extension contact as well as gain more knowledge and information of different techniques in processing.

Impact on technology awareness

The results show an R^2 value of 0.050 which implies that 5% of the variation of the response variable (Technology awareness) around its mean is explained by the regression model, and F-value of 3.199**. The results of the regression analysis show a positive coefficient for extension exposure and age which are both statistically significant at 1%, while years of processing cassava is negative and statistically significant at 1%.

Interpreting the standardized beta coefficients, we get that one standard deviation increase in extension exposure and age results in a 0.126 and 0.116 standard deviation increase in technology awareness, respectively. Also, one standard deviation increase in years of processing results in a 0.175 standard deviation decrease in technology awareness. For years of processing cassava, this implies that the more time spent in processing cassava, the less the farmers' awareness of new technologies. The result is not in line with a priori expectation because it is expected that the more a farmer is engaged in processing, the more he would be aware of new technologies.

Impact on technology adoption

The results showed an R^2 value of 0.388 which implies that 38.8% of the variation of the response variable deviation increase in household size, years of farming and farm size results in a 0.058, 0.237, and 0.099 standard deviation decrease in technology adoption, respectively.

The result of respondents' exposure to extension and adoption shows a positive impact and this is due to the fact that for adoption to take place there must be adequate information about the technology, which the extension agents have to do frequently with the farmers.

For age, it implies that any increase in age is to

Table 5. Regression of extension exposure, awareness, and technology adoption on selected farm and individual characteristics, Nigeria cassava farmers 2010.

Variable	Standardized beta coefficients					
	Extension exposure		Technology awareness		Technology adoption	
	(1)	(2)	(3)	(4)	(5)	(6)
Technology awareness	--	--	--	--	--	0.551**
Extension exposure	--	--	0.126**	--	0.196**	0.126**
Gender of respondent	-0.068	0.011	0.020	-0.052	-0.039	-0.050
Age of respondent	-0.019	0.114**	0.116**	0.160**	0.164**	0.099**
Marital status	0.023	0.001	-0.002	0.031	0.026	0.027
Education	-0.006	0.009	0.010	-0.006	-0.005	-0.010
Household size	0.151**	0.042	0.023	-0.016	-0.046	-0.058**
Years of farming	0.135	0.063	0.046	-0.185*	-0.211**	-0.237**
Years growing cassava	0.035	-0.043	-0.047	0.110	0.104	0.130
Years of processing cassava	-0.136*	-0.192**	-0.175**	-0.104	-0.077	0.019
Farm size	-0.164**	-0.025	-0.004	-0.133*	-0.101**	-0.099**
Cassava area	0.037	-0.005	-0.010	-0.017	-0.024	-0.019
R^2	0.051	0.035	0.050	0.063	0.099	0.388
Adjusted R^2	0.040	0.024	0.038	0.052	0.088	0.380
N	902	902	902	902	902	902
F-value	4.801**	3.199**	4.242**	5.970**	8.899**	46.936**

*p < 0.05; **p < 0.01.

advance without regular patterned connections to farmer communities. It is expected that farmers' interaction with extension agents will bring about their awareness of technology, hence, leading to adoption of technologies, and increase in farm output and productivity. The findings suggest that major reconciliations are needed between past practices, institutional constraints, and the pressing need for production advances in a growing Africa.

Farmer-to-farmer technological diffusion played the greatest role in dissemination of the technologies whereas interaction with extension agents were low, suggesting that adoption of improved technologies would be enhanced by farmers' exposure to extension. Mobile technologies and a broader set of actors in the AKIS should be recognized as resources for extension and not competition. The findings point to the limits of extension but also suggest a powerful potential for leveraged impact and partnership to counter funding and policy constraints that often limit the potential of extension to reach and support the broad population of small farmers.

The study has also shown that socio-economic characteristics of farmers play a major role in adoption of new technologies. Some of the findings would appear to contradict with some previous findings, the negative influence of farm size and years of processing on adoption appears at odds with Ayayi and Solomon (2010) observing that farm size and years of farming experience had positive influence on adoption. The larger and more experienced Nigerian farmers seem to have committed grip on their current practices and seemed less interested in new approaches.

The demand for extension support reflects the felt needs of farmers as they confront the immediate problems of pest, disease, and market uncertainties. The supply of extension services is often highly variable, limited by variations in the capability and preparation of extension staff and the availability research-based recommendations that fit local conditions. Extension must also address the unfelt needs of farmers, that is the performance gaps and new possibilities that are not perceived or well-understood. 21st century extension support for cassava farmers will need training, technical support, and proper supervision in the context of the broader agricultural knowledge and information system to advance farmer livelihoods and win food security for the broader population.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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