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Awareness and adoption of improved cassava varieties and processing technologies in Nigeria

Abdoulaye T.*, Abass A., Maziya-Dixon B., Tarawali G., Okechukwu R., Rusike J., Alene A., Manyong V. and Ayedun B.

International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

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Development of high yielding and disease resistant cassava varieties, coupled with the promotion of efficient processing technologies, was the principal intervention aimed at changing the cassava sub-sector in Nigeria. National research and extension programs in Nigeria and IITA have been spearheading efforts to disseminate these varieties alongside improving farmer's access to processing machineries. Several Research-for-Development (R4D) projects were implemented to this effect between early 1980 to date. This paper investigated the effects of improved cassava varieties and processing technologies on adopting households. It also attempts to test and establish the link between adoption of improved cassava varieties and access to processing technologies. The data used in this paper come from a sample household survey of 952 households conducted in four regions of Nigeria. The results showed that in all the study sites farmers grow mixture of improved and local cassava varieties. They process cassava at home using small processing machines and also using services of commercial processors. The most common processed cassava products were found to be garri and fufu. Adopters of improved cassava varieties have higher cassava yield of 16 tons/ha compared to 11 ton/ha for non-adopters. There was also significant yield variation between villages that participated (15 tons/ha) in research for development (R4D) training and those which did not (13 tons/ha). The bivariate probit model estimates showed a strong relationship between adoption of improved cassava varieties and farmers' access to grating machines. Moreover, farmers that were members of either community organizations or cooperative organizations had a higher tendency of using improved varieties than others, suggesting that the introduction of new cassava varieties would be enhanced by farmers' access to processing facilities and services. Moreover, training of farmers and processors through R4D programs has led to increased use of improved technologies.

Key words: Cassava, improved varieties, processing, bivariate probit.

INTRODUCTION

Cassava is an important regional food source for 200 million people – nearly one-third of the population of sub-Saharan Africa. In Nigeria, it is one of the most important food crop. It is the most widely cultivated crop that provides food and income to over 30 million farmers and large numbers of processors and traders. However, in Nigeria, Cassava Mosaic Disease (CMD) poses a serious threat (Alabi et al., 2011). The most vulnerable areas are the South-South and South-East States including the Niger Delta Region (Ogbe et al., 2006; Nweke et al.,

*Corresponding author. E-mail: t.abdoulaye@cgiar.org.

2002). Several initiatives were enacted to address the critical threat of a CMD outbreak in Nigeria and West Africa and to revitalize Nigeria's agricultural economy[1]. Among those efforts was that of IITA and national partners which developed and disseminated high yielding and CMD resistant cassava varieties. Between 2002 and 2010, IITA implemented a research for development (R4D) project called Integrated Cassava Project (ICP) to support the presidential initiative (PI) for cassava launched in 2002 to boost cassava production and processing. Through this project, IITA successfully introduced and promoted cassava varieties via the National Agricultural Research Services (NARs) and Agricultural Development Programs (ADPs). These efforts were complemented with promotion of cassava processing machineries especially for graters. Participants in the project from all major cassava producing regions of Nigeria, were also trained on crop management (density, weed management, fertilizer application etc). In addition, cassava processing centers were established along with introduction of small grating machines. Through these efforts, more than 40 cassava varieties were successfully introduced and promoted to farmers in Nigeria and the establishment of many processing centers and fabricating enterprises was facilitated between 2002 and 2010. It is important to note that local fabricators were trained in producing and maintaining the processing machines.

There is need to understand whether farmers are aware of the improved cassava varieties and processing machines? Also, what is the adoption status of these technologies? Are there any relationship between adoption of improved varieties and processing machines? Similarly, the introduced improved varieties were expected to give higher yields through better varieties with enhanced resistance to biotic stresses. What is the extent of the realization of such yield potentials in farmers' fields?

A number of studies have been carried out on the adoption of improved technologies singly and independently (Shiferaw and Holden, 1998; Zeller et al., 1998; Alene et al., 2000; Oluoch-Kosura et al., 2001; Abdoulaye and Sanders, 2002; Bamire et al., 2002; Akinola et al., 2010). According to von Braun (1988), agricultural growth via technological transformation leads to an expanded food supply which presupposes relationship between production and processing operations in agriculture. Greene (2000) and Maddala (1983) posited that 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. However, a single equation estimation model could be threatened by bias, inconsistency and inefficiency in estimates. The problem might become worse in decision where simultaneity is detected or observed heterogeneities are correlated. In such situations, possible relationship and synergies in adoption decision are overlooked. Simultaneous estimation makes it possible to establish relationship that can be useful in adoption decisions. Improved cassava varieties and grating machines were often jointly deployed in most areas, but in some cases improved varieties were first demonstrated. Increase in cassava production through better and higher yielding varieties could stimulate more cassava processing and consumption (Braun, 1988). On the other hand, enhanced cassava processing could also lead to increased demand for raw cassava products thereby necessitating greater production. Therefore, a joint estimation method is expected to provide better estimates of the contribution of key variables to either adoption of improved cassava varieties or use of grating machines.

This study was carried out to provide empirical evidence of the state of awareness and adoption of improved cassava varieties and grating machines in Nigeria. Moreover, it attempted to establish likely relationship between the production and processing activities among the Nigeria's farming households.

[1] For details see Nigerian cassava presidential initiative, Integrated Cassava Project of IITA, RTEP program of the federal government.

METHODOLOGY

Study area, sampling method and data collection

The survey was carried out in 4 geopolitical zones in Nigeria known for cassava production. These zones were the South-West (SW), South-South (SS), South-East (SE) and North Central (NC). A total of 952 respondents were selected comprising of 38% who participated in project R4D interventions (participants) and 62% who did not (non-participants). The participants were selected based on their initial participation in the project. These included 160 respondents from the SW, 96 respondents from the SS, 70 respondents from the SE and 35 respondents from the NC. The non-participants were selected randomly from non-participating communities in the regions. They included 262 from SW, 157 from SS, 114 from SE and 58 from NC (Figure 1).

Data analysis

Descriptive statistics and econometric modelling were used in this study. As stated earlier, the joint estimation of adoption of varieties and processing technologies is preferred. The use of joint estimation is expected to reduce the most serious problem in modeling this type of decisions, of variables being endogenous at least for the 2 main variables in the model (use of improved varieties and use of processing machine). Therefore, a Bivariate Probit is used. The model is expressed as follows:

$$Y_{1i}* = X_{1i}\beta_1 + \mu_{1i}$$

$Y_{1i} = 1$ if $Y_{1i}* > 0$

$Y_{1i} = 0$ Otherwise (1)

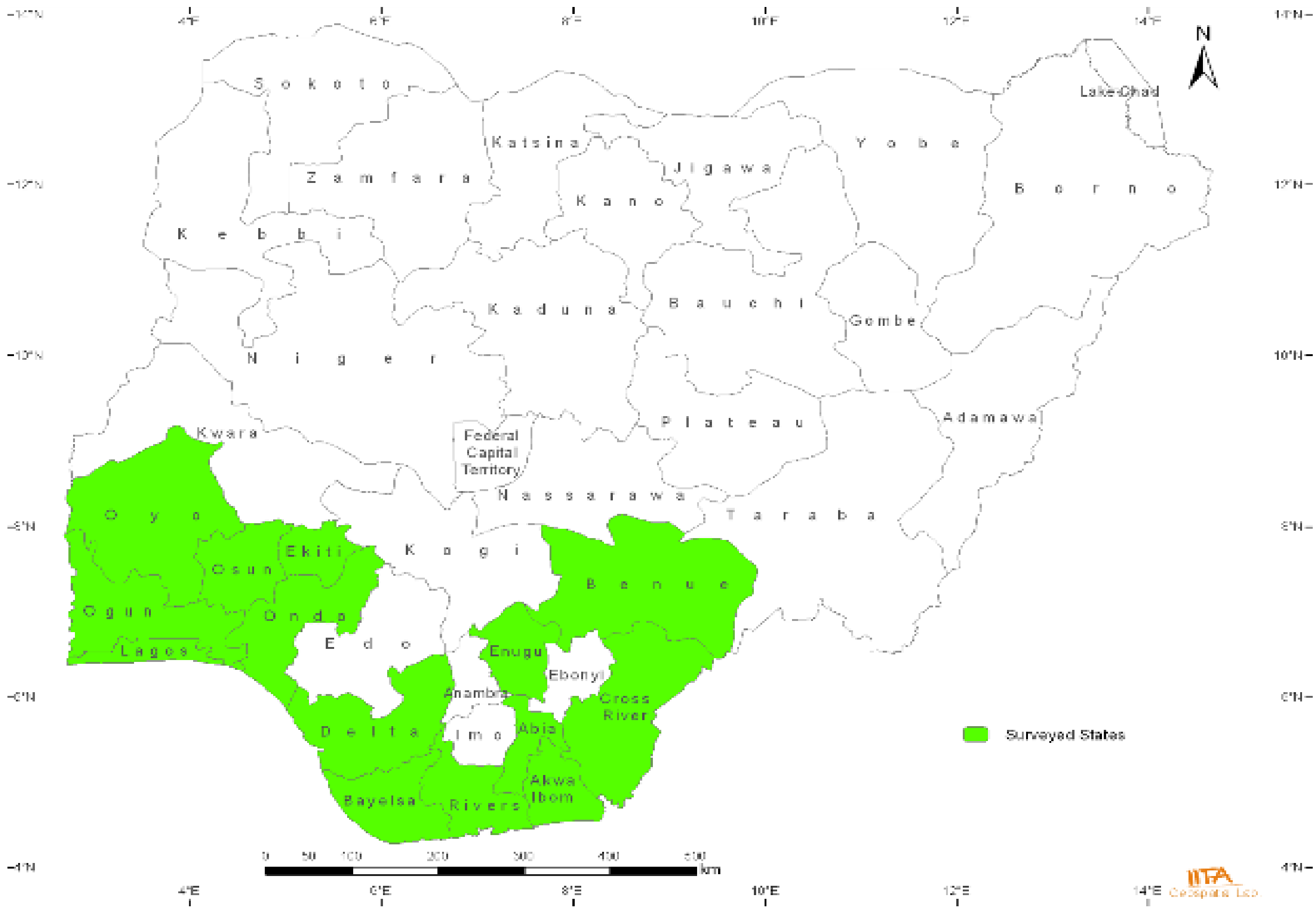

Figure 1. Map of the study area.

$$Y_{2i}* = X_{2i}\beta_2 + \mu_{2i}$$
Y_{2i} = 1 Y_{2i} *>0
Y_{2i} = 0 otherwise (2)

Where Y_i is the decision to use any of the technology; the two latent variables are decision to use improved cassava varieties and decision to use cassava grating machines. The coefficients β_1 and β_2 are vectors of explanatory variables influencing decision to use improved cassava varieties and grater machines, respectively; and μ_{1i} and μ_{2i} are error terms which are normally distributed but related.

The empirical model of the bi-variate model and each for the single estimation is explicitly stated as follows:

$$Y_1 = \beta_0 + \beta_2 GENDER + \beta_2 AGE + \beta_3 EDUCATION + \beta_4 HHSIZE + \beta_5 CASH + CMSOKAL + COSOKAL + VARAWARE + TRAINING + GRATER + \mu_1$$

And

$$Y_2 = \beta_0 + \beta_2 AGE + \beta_3 CASH + \beta_4 CMSOKAL + \beta_5 COSOKAL + \beta_6 ARLAND + EXTENSION + TRAINING + VARIETY + \mu_2$$

The independent variables included farmer, farm and institutional factors postulated to influence technology adoption. These variables were sex (gender) of the household head, age (age) of the household head in years, the household size (HHsize), measure of social interaction resulting from membership in farmers' organization and cooperative societies (CMSOCKAP and COSOCKAP), cash available at hand measured in dummy, education of household head (education) measured by farmers' ability to read and write, effective extension contacts (extension) measured in dummies by the regularity of visits by extension agents, size of arable land (ARland). Other variables included were the percentage of land planted improved cassava varieties (variety) and proportion of cassava grated by grating machine (grater) as well as farmers' awareness of existence and benefits of improved cassava varieties.

The rationale for inclusion of these factors was based on a priori expectation of agricultural technology adoption literature. The effect of age on technological adoption decisions may be negative or positive. Younger farmers have been found to be more knowledgeable about new practices and may be more willing to bear risk and adopt new technology because of their longer planning horizons. The older the farmers, the less likely they are to adopt new practices as they place confidence in their old ways and methods. On the other hand, older farmers may have more experience, resources, or authority that may give them more possibilities for trying a new technology. Thus, for this study, there

Table 1. Description of variables.

Variable	Description	Unit
Gender	Gender of the respondent (Male = 1, Female = 0)	
Age	Age of respondent in years	Years
Education	A measure of ability to read and write. Ability to read and write = 1, 0 otherwise	
HHsize	Number of people living under the same roof and taking joint decision about their welfare	Number
Cash	Cash saving: 1 = if having saving in cash form, 0 = Otherwise	
CMSOCKAP	Membership of community association, 1 = member, 0 = non-member	
COSOCKAP	Membership of cooperative society, (1 = member, 0 = non-member)	
Varaware	Respondent's awareness of improved cassava varieties, 1 if aware, 0 = non aware.	
Training	Respondent's participation in either training on improved cassava varieties or use of grating machines	
Grater	% of tuber grated by grater machine	%
Arland	Household arable land	ha
Extension	Contact with extension services on the use of improved varieties and grading machines, 1 = access, 0 = non access	
Variety	% of land cultivated to improved cassava	%

is no agreement on the sign of this variable as the direction of the effect is location-or technology-specific (Feder et al., 1985; Nkonya et al., 1997; Oluoch-Kosura et al., 2001; Bekele and Drake, 2003). Education was hypothesized to influence the adoption of decisions positively since, as farmers acquire more, their ability to obtain, process, and use new information improves and they are likely to adopt. Education increases the ability of farmers to use their resources efficiently and that will enhance their ability to obtain, analyse and interpret information. Several studies reviewed by Feder et al. (1985) indicate positive relationship between education and technology adoption (Alene et al., 2000; Nkonya et al., 1997; Oluoch-Kosura et al., 2001).

Institutional factors of social capitals and farmers' awareness of the benefits derivable from improved cassava varieties, participation in R4D programs (training*)* and extension contact were hypothesized to influence the adoption positively as these support services facilitate the uptake of new technologies. Membership in associations (CMSOCKAP), such as cooperative societies (COSOCKAP), has been found to enhance the interaction and cross-fertilization of ideas among farmers (Bamire et al., 2002). Farmers who are not members of associations are expected to have lower probabilities of adoption and a lower level of use of either improved cassava varieties or grating machine. The extension contact variable incorporates the information that the farmers obtain on their production activities on the importance and application of innovations through counselling and demonstrations by extension agents on a regular basis. It is hypothesized that the respondents who are not frequently visited by extension agents have lower possibilities of adoption than those frequently visited (Adesina and Zinnah, 1993; Shiferaw and Holden, 1998; Oluoch-Kosura et al., 2001; Bamire et al., 2002). The variable was measured as dichotomous with respondents 'contact during the period scoring one, and zero for no extension contact on the use of the technologies (Table 1).

Measures of wealth such as off-farm income and income from other sources apart from processing were also hypothesized to influence adoption positively. They are generally considered to be capital that could be used either in the production process or be exchanged for cash or other productive assets. They are expected to influence the adoption of the technologies positively (Shiferaw and Holden, 1998; Zeller et al., 1998; Negatu and Parikh, 1999). To the extent that liquidity is a constraint to adoption, off-farm income and income from other sources will have a positive effect on adoption. The level of off-farm income, however, may not be exogenous but be affected by the profitability of the farming operation that in turn depends on technology adoption decisions. Thus, the adoption of the technologies and the level of off-farm income may be determined simultaneously. This arises due to the labor allocation decisions of the households about farm and non-farm activities. However, the off-farm income of the household surveyed is mostly derived from the remittances of family members in non-farm business activities and from employment in non-farm sector. As the skill requirements for these jobs are likely to be different from those of farming, the farm and non-farm employment may be considered as non-competitive activities. In this situation, the level of non-farm income would be largely exogenous to the adoption decision (Lapar and Pandey, 1999).

Household size, which includes all people living under the same roof and who eats from the same pot as the household head, has been identified to have either a positive or a negative influence on adoption (Manyong and Houndekon, 1997; Zeller et al., 1998; Oluoch-Kosura et al., 2001; Bamire et al., 2002; Bekele and Drake, 2003). Larger family size is generally associated with greater labor force availability for the timely operation of farm activities. The negative relationship of the variable with adoption has been linked to the increased consumption pressure associable with a large family. It is therefore difficult to predict 'a priori' the sign for this variable in this study. In addition, percentage of improved cassava varieties was expected to be positively related to the percentage of cassava grated and vice versa. The size of arable land is also expected to be positively related to technology adoption.

RESULTS AND DISCUSSION

Socioeconomic characteristics of the sample households

Demographic and socioeconomic characteristics of our sampled households are summarized in Table 2. These characteristics play important role in understanding the

Table 2. Socioeconomic characteristics of the sample households.

Variables	Values
N	**952**
Region (%)	
South-South(SS)	27
South-East (SE)	19
South-West (SW)	44
North-Central (NC)	10
Gender (%)	
Male	89
Female	11
Marital status (%)	
Single	3
Married	89
Divorced	1
Separated	1
Widowed	7
Age of household heads	
<20	1
21-40	26
41-60	61
61-80	12
>80	1
Age of household heads (average)	49
Years of farming experience (%)	
1 – 10	18
11- 20	32
21-30	24
31-40	17
>40	9
Farming experience (average)	24
Farming experience in cassava production (average)	22
Cassava processing experience (average)	19
Years of processing experience (%)	
1-20	66
21-40	29
41-60	4
>60	1
Household size (average)	8
Dependency ratio (average)	1.5
Main decision maker (%)	
HH head	69
Spouse	2
Children	0.1
HH head and spouse	24
HH head and kids	3
Spouse and kids	1
All members	2
Level of education (%)	
Educated	77
Year of education	
1-5	6
6-10	35
11-15	51
16-20	8
>20	0.1
Average number of years of education	10
Association	
Cooperative association (%)	27.4
Processing association (%)	9.9
Growers associations (%)	20.4
Marketers association (%)	4.9
Transporter association (%)	1.1
Total association group (%)	63.7
Cooperative (average years)	22
Processing association (average years)	8
growers associations (average years)	6
marketers association (average years)	6
Transporter association (average years)	7
Intervention village	38
Counterfactual village	62

Source: Data analysis (2012).

differences among households and hence explaining their behaviour regarding technological change. The major characteristics of households covered in the survey included are those related to the relative frequency distribution of heads of the households by gender, age, years of formal education, marital status. Also included were household asset ownership structures, distribution of household farms, land tenure types, sources of farm credit, and household consumption patterns. The sampled household heads were 81% men and 89% of them were married having family responsibility. Family responsibility presupposes their willingness to get involved in productive activities to meet family demands. The average family size of 8 suggested availability of family labour on the farm. In addition, the dependency ratio of 1.5 which showed that there were more number of dependants (children below 15 years old and adult above 64 years old) compared to working population (> = 15 years and < = 64 years old) in all the zones. Education level of the respondents was high with an average of 10 years of formal education and with 77% of respondents responding to be having formal education.

Average farming experience was 22 years indicating that study sample was composed of experienced farmers (Table 2). Most of the respondents belong to grower and cooperative groups among others. These groups normally encourage their members sometimes with moral

Table 3. Percentage of household making different products from cassava.

Products	Pooled	Percentage of total	Intervention	Non-intervention	Participation	Non-participation
N	**952**		**358**	**594**	**145**	**807**
Garri	82	52	75	85	90	80
Fufu making	48	30	39	53	55	45
Flour making	10	6	10	10	15	9
Starch	2	1	3	2	10	1
Abacha	10	6	16	6	0	0
Lafun	6	4	15	1	0	0

Source: Data analysis (2012).

and sometimes financial support (credit) for adopting technologies.

Agricultural production in the study area

The main land tenure system was by inheritance (53%) followed by one being rented (29%) among others. Majority of the respondents cultivated farm size of 2 ha or less (80%). This is an indication that they were mainly small scale farmers. The respondents were engaging in cultivation of many crops including roots and tuber, cereals, legumes among others. When arable crops were ranked according to most important crop grown, 70% of the respondents indicated that cassava was their most preferred crop, followed by yam, maize and plantain among others. Percentages of area of land cultivated for different crops also indicated that cassava had the biggest area and occupied the largest percentage of land used for cropping by the farmers irrespective of village types considered.

Household cassava processing

Cassava tubers are processed by households into different cassava products. Almost all the products were previously known to farmers, the work done by change agents was just to improve their processing activities, thus adding value to it and increasing market value. Looking at Table 5, the products increased over the years. However, by disaggregating by village groups, it can be seen that the control villages is better than intervention ones. There were higher percentages of participants processing all these products than non-participants. This same trend is observed when considering alternative ways of utilizing cassava at home. Garri and fufu (foufou) were the most common products made by households constituting 52 and 30%, respectively, while the remaining percentage was shared by other products like cassava flour and starch (Table 3).

Technological awareness and use of technologies

Awareness and use of cassava production technology

Awareness and knowledge of a technology is a prerequisite for its use. Information on level of awareness and use of production technologies is presented in Table 4. The level of use for improved cassava was relatively high (68%) than other production technologies like fertilizer. The results suggest that awareness and use of improved variety of cassava was skewed towards intervention villages which have higher percentages for both variables compared to non-intervention villages.

Increased in awareness and use of improved technologies as shown in the table increased with how closer the respondents were to the change agents with participating farmers having highest awareness and use levels, followed by non-participating farmers from intervention villages and then farmers from non-intervention villages.

Awareness and use of cassava processing technology

The study found that among the promoted innovation, awareness of grating and pressing was the highest. Farmers with first-hand information from research and extension agent (participating respondents) have higher awareness and use in all introduced technologies. Table 5 shows that the spread of information about the technologies was a collective effort by many stakeholders. Results indicate that farmers to farmers' technological diffusion played the greatest role in dissemination of the technologies. Also, it is expected that with better use of production and processing technologies by farming households from intervention villages and participating respondents, these farmers would have positive impact on their farm output and productivity.

Table 4. Awareness and use of inputs used in cassava production.

Variable input	Pooled		Intervention		Non-intervention		Participation		Non-articipation	
	Aware (%)	Use (%)	Aware (%)	Use (%)	Aware (%)	Use (%)	Aware (%)	Use (%)	Aware (%)	Use (%)
Improved planting materials	75	68	88	74	67	65	100	94	70	64
Basal (NPK)	45	25	45	30	44	23	61	50	42	21
Topdress_Urea	27	7	25	8	29	6	39	17	25	5
Herbicides	37	17	33	14	40	19	46	26	35	16
Insecticides	30	8	29	10	31	7	36	16	29	7
Manure	33	13	30	14	35	12	36	15	33	12

Source: Survey data (2012).

Table 5. Sources of information about different technologies (% of respondents).

Technology/source	N	IITA (%)	NGO (%)	Farmer (%)	Media (%)	Ext. agent (NARS) (%)	Agro-dealer (%)	Others (%)
Improved planting materials	629	16	1	28	3	46	3	4
Peeling	153	8	3	44	7	28	9	1
Washing	121	7	3	46	3	33	9	1
Grating	360	10	1	59	2	22	5	2
Chipping	42	12	2	17	12	43	12	2
Extracting	289	8	1	61	5	19	4	2.3
Pressing	71	13	3	56	3	20	4	1
Sifting	70	6	1	43	9	23	13	6
Drying	36	8	-	31	11	33	14	3
Boiling	8	25	-	25	-	38	-	13
Distilling	45	7	-	31	9	42	9	2
Fermenting	164	15	1	51	2	23	7	2
Frying	10	20	-	10	-	50	10	10
Pelletizing	123	7	2	53	3	24	6	5
Grinding	78	10	3	37	15	23	5	6
Milling	39	5	3	44	13	28	3	6

Source: Data analysis (2012).

Table 6. Average reported cassava yields among farmers.

Variable	Adopter	Non-adopter	Difference	Participating villages	Non-participating villages	Difference
Yield (ton/ha)	16.1±4	11±5	4.9** (114)	15.0±4	13.0±8	2** (5.2)

Figures in the bracket are t-values; ***, ** means significant at 1 and 5%, respectively. Source: Survey data (2012).

Cassava productivity

It is expected that investment in inputs such as improved cassava cuttings along with complementary agronomic practices would lead to higher yields for adopting farmers. Survey results indicate that the cassava tuber was higher for adopting households compared to non-adopting ones. The difference between the two groups was also found to be statistically significant (Table 6). Also, as expected, yields were higher in villages that participated in R4D programs compared to on-participating ones. This might be related to the higher use of improved cassava varieties and the trainings received by farmers in those villages.

Determinants of adoption of improved cassava varieties and grating machines

Both single equation and joint estimation results are presented in Table 7. Results from single probit

Table 7. Probit and Bivariate Probit model estimates of the determinants of adoption of improved cassava varieties and grating machines.

Determinants	Single equation estimation				Joint estimation			
	Probit model: Adoption of improved cassava varieties		Probit model: Use of cassava grating machines		Y1 = Decision to use improved cassava variety		Y2 = Decision to use cassava grating machine	
	Estimates	P>|z|	Estimates	P>|z|	Estimates	P>|z|	Estimates	P>|z|
Gender	0.236	0.351			0.139	0.179		
Age	0.011	0.500	0.004	0.575	0.002	0.738	-0.003	0.479
Education	0.151***	0.000			-0.076	0.431		
HHsize	0.071	0.015			0.017	0.100		
Cash	0.408	0.046	0.322*	0.040	0.127	0.220	0.091	0.328
CMSOCKAP	0.286	0.193	-1.311***	0.000	0.275*	0.015	-0.521***	0.000
CPSOCKAP	0.834***	0.000	0.811***	0.000	0.206*	0.059	0.067	0.513
Varaware	6.330***	0.000			1.462***	0.000		
Training	0.115	0.672	0.761***	0.001	0.050	0.716	0.096	0.475
Grater	0.452**	0.048			1.411***	0.000		
Arland			0.014	0.199			-0.002*	0.057
Extension			0.410***	0.001			0.009*	0.059
Variety			0.205	0.195			1.196***	0.000
Constant	-8.614	0.001	0.511	0.121	-2.787	0.000	-0.019	0.925
Athrho					12.694			
Rho					1.000			
Chi^2	368.00		105		206.338			
$Prob>chi^2$	0.000		0.000		0.000			
Pseudo R^2	0.384		0.091					
Log likelihood	295.27		-532.44					

***, **, * Significant at 1, 5 and 10%, respectively. Source: Data analysis (2012).

estimations for both varieties and machines are shown to help understand the joint relationship between adoption of improved varieties and access to cassava grating machines. The joint estimation results are emphasized and preferred for interpretation because both use of improved cassava varieties and use of grating machines have shown positive effects on each other in the single equation estimation. Results from joint estimation using bivariate probit regression showed that different variables affected the probability of adoption of improved cassava varieties and probability of use of grating machines. For the first equation on use of improved cassava varieties, significant variables that affected probability of such use included membership in community organizations, membership in cooperatives organizations, awareness of the benefits associated with the adoption of the improved varieties, and the proportion of cassava grated. Farmers that were members of either community organizations or cooperative organizations had a higher tendency of using improved varieties than others. Membership in community organization showed a positive effect in increasing the probability of adopting improved cassava varieties by 0.28. Also, membership in cooperative societies increased the probability of adoption of improved cassava varieties by about 0.21. In addition, greater increase in the probability of adoption of improved cassava varieties is indicated by model results for awareness of the importance and benefits associated with the use as well as the proportion of cassava grated using grating machines in the household. As expected, those farmers who were made aware of the potential of improved cassava varieties were more likely to adopt them. Awareness about the benefits of improved cassava varieties had a positive coefficient of 1.46, while the coefficient on the proportion of cassava grated using machines was slightly lower at 1.41 (Table 7). This underscores again the importance of giving farmers opportunity to experience and learn about new technologies in the adoption process. Also, since the majority of households (about 82%) use mainly small grating machines at home, these results indicate that promotion of such small scale processing would have great impact in increasing adoption of improved cassava varieties.

For the second equation, model estimation results indicate that the most significant variable influencing the use of grating machine was the proportion of land planted to improved cassava varieties. A 10% increase in the proportion of land planted to cassava varieties increased the probability of using grating machine by 12%. Frequency of access to extension services showed a positive effect on the probability of adopting grating machine by about 1 percentage point. Farmers with smaller farm showed higher tendency of using grating machines. This was expected as farmers with smaller farms would likely have more time for processing activities than others. Membership in community organization was negative but significant in influencing the use of grating machine. This result might be related to the availability of small individual grating machines that most farmers are using instead of relying on big community level processing centres.

Conclusion

Awareness and adoption of improved cassava varieties was relatively high. Adopting farmers have high cassava yield of 16 tons/ha compared to non-adopters (11 ton/ha). However, yields are still low when compared to potential yield of 30 to 40 tons/ha from research trial plots. Introduction of smaller grating machines has helped increase awareness and use of cassava grating and pressing machines by households. However, there is a need to mechanize peeling of cassava roots in order to address the increasing labor constraints in rural areas. Mechanizing peeling is the next big leap that is needed for cassava industry to continue to grow in Nigeria. The results of bivariate probit regression showed that adoption of improved cassava varieties had an effect on farmers' access to grating machine and vice versa. That is, the most significant variable influencing the use of grating machine was the adoption of improved cassava varieties.

The results confirm the strong complementarity between improved cassava varieties and processing machines. Since the use of grating machines is having greater effect on adoption of improved cassava varieties, introduction of processing machine should precede that of improved cassava varieties. Also, the introduction of new technologies should be backed up by training and provision of complementary services. Finally, promotion of processing should also include small processing machines as their availability in the study areas has been an important factor explaining the observed differences in adoption.

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