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Determinants and the perceived effects of adoption of selected improved food crop technologies by smallholder farmers along the value chain in Nigeria

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Abstract: Adoption of improved agricultural technologies is fundamental to transformation of sustainable farming system, and a driving force for increasing agricultural productivity. This study provides empirical evidence on the determinants, and the perceived effects of adoption of improved food crop technologies in Nigeria. It is a cross-sectional survey of available technologies and 1,663 farm households in Nigeria. Data were analyzed with both descriptive and inferential statistics. The findings revealed very low technology adoption index. Available food crop production technologies used by sampled respondents were assessed as effective, appropriate, readily available, affordable, durable, user and gender friendly, with requisite skill to use them. However, processing technologies such as cabinet dryer were observed as unaffordable, not durable, not gender or users friendly. Packaging machines were also not users or gender friendly; washing machine not affordable, durable and gender friendly. Grain processing technologies like De-stoner, grading, and packaging machines were still not locally available and affordable. While parboilers had a negative impact on product quality, farmers' health and the environment, tomato grinding machines had a positive impact on the quality of the product, health of the users, yield and negatively affect the environment. The main determinants of adoption were the crop types, farm size and locations. Adoption of herbicide and inorganic fertilizer were influenced by travel cost to nearest place of acquisition, while the age of farmer had a positive and significant influence on the adoption of pesticide, water management and cassava harvester. Interestingly, only male farmers exhibited greater likelihood of adopting land preparation, inorganic and organic fertilizer technologies when compared to their female counterpart. Therefore, policy options that consider all users at the development stages, favour reduction of travel cost, increase farm size are recommended to encourage sustainable adoption of improved food cop technologies.

Keywords: Smallholders, modern technology, adoption index, sustainable system, binary choice model, Nigeria

Introduction

One of the major goals of Nigerian agriculture development programs and policies is transition from low productivity subsistence agriculture to a high productivity agro-industrial economy through improved technology adoption. That is, shift from traditional methods of production to new, science-based methods of production which include new technological components and/or even new farming systems (Hassen, 2014). Solving environmental problems in agriculture requires developing and diffusing new technologies (Viatte, 2001). As huge number of the poor lives in rural areas and are engaged in smallholding agriculture, attempt to address the rural poor are often geared toward improving agricultural practices as a means of increasing productivity, efficiency and, finally income. Agricultural technology aims at increasing agricultural productivity by replacing the old method of farming by a modern and more efficient technique of cultivation (Barla, 2013). Adoption of improved agricultural technology is a tool needed to improve sustainable agriculture, a way of reconciling the necessity for sustainable and profitable food production, improve productivity and food security. In Nigeria, National Agricultural Research Institutions such as National Cereals Research Institute (NRCI) Badeji, National Cereals Research Institute (NCRI), Umudike, International Institute of Tropical Agriculture (IITA), Universities and other research institutions are in the forefront of developing and applying new technologies. Farmers are now using a number of modern agriculture technologies (crop production/processing/storage/livestock production) for producing more output all over the country (Meena and Punjabi, 2012) and assessment of the adoption of the technologies have moved from just using dichotomous choice to examining the intensity of adoption, addressing the simultaneity of adoption of different components of a technology package, and contextualizing adoption decisions within social, cultural and institutional environments.

Specifically, this study identified some of the innovative farming practices and value-added products developed by some selected agricultural research organizations in Nigeria; assessed the perceived impact of food crop technologies used by the respondents (farmers and processors) estimated the intensity of adoption of the food crop technology package; and identified factors influencing intensity of adoption of food crop package in the study area.

The outcome of this study fortifies extension staff, rural development institutions, and policymakers with valuable information that can improve the efficiency of communication among them in promoting available technologies. Acquired information from the findings could enhance the efficiency of agricultural research, technology transfer, input provision, and agricultural policy formulation. This study reveals the underlying factors which account for the observed variations in the adoption intensity of improved food crop production and processing package among the users (farmers and processors) in Nigeria. The findings are expected to render very valuable information for further promotion and sustainable production of food crops in Nigeria. Users' perceived technology evaluation would help research organizations at development of technologies which is appropriate to local situation and in line with the users' criteria.

Technology adoption and the determinants

Adoption of technology is defined as the decision to make full use of a new idea as the best course of action available (Akubuilo, 1982). It involves a change in the orientation and behaviour of the users from the time he/she becomes aware of the technology to its use. Rogers (2005) in his own word defined adoption of technologies as a decision to apply innovation/new technology, method, practice by a firm, a farmer or a consumer and continue to use it. Rate of adoption is the relative speed with which an innovation is adopted by members of a social system. A number of theories have been propounded to explain technology adoption. These include the theory of reasoned action, theory of planned behaviour, unified theory of acceptance and use of technology, diffusion innovation theory and technology-organisation-environment framework (Hassen, 2014). Others are: rational expectation theory of technology adoption and agricultural household models. Adopters are divided into five categories, each with its own characteristics. These are: i) innovators, ii) early adopters, iii) early majority, iv) late majority, and v) laggards. Theoretical models of adoption behaviour looked into variables that may explain the decision to adopt or the intensity of adoption (Toborn, 2011). The adoption decision of farmers and intensity of use of improved technologies are determined by many factors. The most often cited factors that have been used to explain the variability in agricultural technology adoption and its patterns of diffusion are those described by Feder (1985). Traditionally, the factors include farming household specific characteristics, farm size, risk exposure and capacity to bear risk, human capital, labour availability, credit constraints, tenure, and access to input and commodity markets. These factors are considered important at the early stages of adoption but may become less significant in later stages.

Empirical studies on agricultural technology adoption in Nigeria for example suggest that factors such as socio-economic characteristics of farmers, access to credit or cash resources and information from extension and other media influence adoption rate of new agricultural technology among farmers (Ayinde *et al.,* 2010; Idrisa *et al.,* 2012). The wide variety of empirical results, interpreted in the context of the theoretical literature, suggests that size of holding is a surrogate for a large number of potentially important factors such as access to credit, capacity to bear risk access to scarce inputs (water, seeds, fertilizers, insecticides), wealth, access to information, to mention just a few.

Methodology

Nature and Sources of Data

Primary data used in the study were obtained mainly from a sample survey. Thus, two sets of structured questionnaires were used: one to elicit information institutions involved in Agricultural Research Systems (NARS) and technologies and the other for farm households who are either involved in production, processing and storage of the selected food crops. The first part of the survey was a cross-sectional survey of the existing production, processing and storage technologies developed and disseminated to farmers by Universities, research institutes, public as well as private institutions in the six selected states across the geopolitical zones of the federation.

The second part of the survey was the cross-sectional household survey, which followed the food value chain analysis approach, in which data production, processing and/or storage of cassava, maize, rice and tomato were collected from the producers and processors. Qualitative and quantitative information were also obtained from relevant government officials and representative of farmers', marketers' and processors' associations in the selected states and Abuja. The selected crops for the study were from the basic food crops that are strategic to meeting the food security objective of the country and the growth enhancement scheme (GES) of the agricultural transformation agenda in Nigeria.

Sampling Procedure

The sampling approach followed a multi-stage sampling procedure. The first stage was the purposive selection of a state in each of the geopolitical zones in Nigeria to ensure equal representation of the entire six geo-political zones, putting into consideration the agro-ecological divisions (Table 1). The second stage was the purposive selection of locations noted for the production of the selected food crops while the third stage

Table 1 - Selected states for farm household and technology use survey

Geo-political zone	Selected State	Agro-ecological zone
North Central	Benue	Guinea Savannah
North East	Taraba	Guinea Savannah
North West	Sokoto	Sudan Savannah
South East	Ebonyi	Humid Forest
South-South	Cross-river	Mangrove forest
South West	Ogun	Rain Forest and Derived Savannah

Source: Field survey, 2012

involved the selection of 1,800 farm households (300 per selected state) although a total of 1,663 was found useful for the analysis.

Model Specification

The analytical tools employed in this study were both descriptive and inferential statistics. The descriptive statistical tools used were frequency counts, percentages and means, while the inferential statistical tools used include: the analysis of variance and perception index.

Before analyzing the determinants of adoption index, it is important to assess the rate of the adoption for each farm household. This study focuses on individual or farm household improved technology adoption. The rate of adoption is defined as the proportion of farmers who have adopted a new technology. The extent of adoption is the percentage of farmers using a technology at a specific point in time (that is, the percentage of farmers using improved forage technologies). The intensity of adoption is defined as the aggregate level of use of a given technology.

Farmers were at four different adoption stages. That is "Not aware of", "Aware but never tried", "tried but not yet adopted" and "Adopted". The first three classes make up the non-adopters while the last constitute the adopters.

Estimation of the Adoption index

Adoption index score was calculated by adding up the adoption quotient of each practice and dividing it by number of adopted practices of each respondent. The adoption quotient of each practice was also calculated by taking the ratio of actual rate applied to the recommended rate.

In this study, the adoption index following Mihiretu (2008), Ayalew (2011) was used to measures the extent of adoption at the time of the survey for multiple practices (package), which shows to what extent the respondent has adopted the most set of package.

$$Al_i = \sum \frac{\left[\frac{AH_i}{AT_i} + \frac{SRA_i}{SRR} + \frac{FA_i}{FR} + ----------N\right]}{NP} \quad (1)$$

Where: AI_i = Adoption index i

AH = area under improved variety of the selected food crop of the ith farmer.

AT_i = Total area allocated for the selected crop production (improved variety+ local, if any) of the ith farmer.

SRA_i = Seeding rate applied per unit of area in the production of improved variety of the selected crop of ith farmer.

SRR = Seeding rate recommended for application per unit of area.

FA_i = amount of fertilizer applied per unit of area in the cultivation of improved variety of the selected crop by ith farmer,
FR_i = Amount of fertilizer recommended for application per unit of area in the cultivation of improved variety of selected crop,
NP = Number of practices

Perceived Impact

Negative impact was rated (1), normal (2) and positive (3). The score for each impact factor was further used to generate the index. Values greater than the average score (0.5) indicated positive impact while values below 0.5 were rated as having a negative impact on the concerned factor and those of 0.5 indicate that the technology were considered as normal.

Determinants of adoption and intensity of adoption of technology by farm households

Different studies used different models for analyzing the determinant of technology adoption. In principle, the decisions on whether to adopt and how much to adopt can be made jointly or separately (Berhanu and Swinton, 2003). Adoption studies based up on dichotomous regression model have attempted to explain only the probability of adoption versus non-adoption rather than the extent and intensity of adoption. A strictly dichotomous variable often is not sufficient for examining the extent and intensity of adoption (Feder *et al.,* 1985). We therefore use a Tobit regression model to analyse the determinants of adoption index of various specific technology by the respondents. Tobit model is appropriate because respondents may adopt only some part of the recommended package and may also do this on 1% or 100% level. The Tobit model has both discrete and continuous part and it handles both the probability and intensity of adoption at the same time (Augustine and Mulugeta, 2005). In the model, the adoption index was used as the dependent variable (Equation 2). The technologies under study are land clearing, land preparation, improved varieties, herbicide, inorganic fertilizer, organic fertilizer, pesticides, water management, animal tillage and harvester.
The Tobit model applied is specified thus:

$$Al_i^* = \beta_0 + \beta_i X_i + U_i \quad (2)$$

$$Al_i = Al_i^* \; if \; \beta_0 + \beta_i X_i + U_i > 0 \quad (3)$$

$$Al_i = 0 \; if \; \beta_0 + \beta_i X_i + U_i \leq 0 \quad (4)$$

Where:
Al_i^*= is the latent variable and the solution to utility maximization problem of

intensity of adoption subjected to a set of constraints per household and conditional on being above certain limit.

Al_i = is adoption index for ith farmer

X_i = Vector of factors affecting adoption. These include Travel cost (TRACOST), household size (HHDSIZ), maize dummy (MAIZEDUM) rice dummy (RICEDUM), tomato dummy (TOMDUM), age of household head (HHAGE), non-farm income (NFINC), years of schooling (SCHYR), effective area cropped (FARMSIZ), Benue dummy (BENDUM), Ebonyi dummy (EBDUM), Cross River (CRVDUM), Sokoto dummy (SKTDUM), Taraba dummy (TRBDUM), no other secondary occupation (NONEDUM), male dummy (MALEDUM.

β_i = Vector of unknown parameters, and

U_i = is the error term which is normally distributed with mean 0 and variance σ^2

Results and Discussion

Innovative farming practices and value-added products development

Evidence from the NARS survey shows that at least 57 cassava, 54 maize, 65 rice, and 11 tomato varieties have been released by the relevant local and international research institutes in Nigeria. Some of the innovative practices and value added products for the selected crops in Nigeria are revealed in Tables 2 and 3 have

Table 2 - Available innovative farm practices

Crop	Method	Organization name
Cassava	Optimum Spacing	Ebonyi State Agric Development Programme
Maize	Soy-corn Milk Production	IAR&T in Ibadan, Oyo State
Rice	Line Planting	Ebonyi State Agric Development Programme
Rice	Mulching	National Cereals Research Institute, Umudike, Abia State
Rice	Scooped Holes	National Cereals Research Institute
Rice	Spatial Arrangement	National Cereals Research Institute
Rice	Zero Tillage	Ebonyi State Agric Development Programme
Tomato	Lime Use in Preservation	Benue Agric and Rural Development Authority.
Tomato	Tomato Juice Production	Benue Agric and Rural Development Authority.

IAR & T = Institute of Agricultural Research and Training

Source: Field survey, 2012

Awareness and adoption of food crop technologies in Nigeria

Technology with the highest level of adoption was the post-planting technologies such as the inorganic fertilizer (75.5%), herbicides (73.3%), organic fertilizer (66.1%)

Table 3 - Available value added products from selected crops

Crop	Value added Code	Organization name
Cassava	Cassava Bread	IAR&T in Ibadan, Oyo State
Cassava	Cassava Cake	IAR&T in Ibadan, Oyo State
Cassava	Cassava Chips	Nigerian Stored Products Research Institute in Ilorin, Kwara State
Cassava	Cassava Flour	Ebonyi State Agric Development Programme
Cassava	Cassava Flour	Nigerian Stored Products Research Institute
Cassava	Fufu Flour	FUNAAB (Cassava: Adding Value for Africa)
Cassava	Fufu Flour	NRCRI in Umudike, Abia State
Cassava	High Quality Cassava Wet Cake	FUNAAB (AMREC) at Abeokuta
Cassava	High Quality Cassava Flour	FUNAAB (Cassava: Adding Value for Africa)
Cassava	Odourless Fufu	FUNAAB (Cassava: Adding Value for Africa)
Cassava	Pea Snacks	IAR&T in Ibadan, Oyo State
Cassava	Soy Garri	IAR&T in Ibadan, Oyo State
Cassava	Wet Fufu Cake	FUNAAB (AMREC) in Abeokuta
Maize	Dry maize drink	IAR&T in Ibadan, Oyo State
Maize	Flavoured Pap	Nigerian Stored Products Research Institute
Maize	Maize Flour	Ebonyi State Agric Development Programme
Maize	Soy Ogi	IAR&T in Ibadan, Oyo State
Rice	Ground Rice	Nigerian Stored Products Research Institute
Tomato	Tomato Paste	Nigerian Stored Products Research Institute

IAR & T = Institute of Agricultural Research and Training, NCRI = National Cereal Research Institute
FUNAAB (AMREC) = Federal University of Agriculture, Abeokuta (Agricultural Media Resources and Extension Centre)

Source: Field survey, 2012

and knapsack/boom sprayer (66.1%) while harvesting technologies such as grain harvester (0.73%), cassava harvester (1.83%) were very low (Table 4). However, the high level of unawareness associated with most of these technologies and the general low level of adoption of the technologies among the respondents suggest inadequate and poor exposure of farmers to improved agricultural technologies. Hydraulic press (67.2%) and motorized grater (61.5%) were found the most widely adopted cassava processing technologies (Table 5) while milling machine had the highest (71.4%) adoption rate for grain processing technology (Table 6). About 33.3% respondents adopted grinding machine as the only improved technology used for tomatoes processing (Table 6). An average adoption technology adoption index of 0.190 in the study area implies that only 19% of the entire food crop technologies are adopted in Nigeria

Table 4 - Awareness and adoption of crop production technologies

TECHNOLOGY	NOT AWARE OF	AWARE BUT NEVER TRIED	TRIED BUT NOT YET ADOPTED	ADOPTED
Land Preparation				
Animal pulled implement (tillage)	28.06	57.19	1.60	13.14
Tractor pulled implement (tillage)	15.40	48.92	5.18	30.50
D7 Bulldozer for Bush Clearing	35.94	56.87	1.28	5.91
Planting				
Seed Broadcaster	33.40	63.34	0.61	2.65
Seed of improved Rice/Maize/Tomato	4.35	26.98	4.60	64.07
Seed Planter(Rice, Maize, Tomato)	32.10	59.78	0.92	7.20
Stem cutting for Hybrid Cassava	9.92	25.82	4.35	59.92
Maintenance /Post Planting				
Herbicides	2.68	22.49	1.52	73.31
Inorganic Fertilizer	2.24	18.16	4.06	75.53
Knapsack/Boom Sprayer	4.43	26.99	2.48	66.10
Organic Fertilizer	6.08	26.80	1.80	65.33
Pest Scaring Devices	38.89	33.33	5.36	22.42
Pesticides(Mammal, Insect, Aves, etc)	10.34	38.22	4.31	47.13
Water Management/Irrigation Equipment	37.13	38.70	0.59	23.58
Harvesting				
Cassava Harvester	57.11	40.26	0.79	1.84
Grain Harvester	52.20	46.83	0.24	0.73
Average	**19.03**	**37.13**	**2.70**	**41.14**

Source: Computed from the field Survey data, 2012

Farmers' Perception of available food crop technologies in Nigeria

Results from the study indicate that all the crop production technologies such as: tractor pulled implement, herbicide, knapsack sprayer, improved seed and inorganic fertilizer were perceived as effective (0.74), appropriate (0.81), readily available in the localities (0.70), affordable (0.70), durable (0.80), user friendly (0.74) and gender friendly (0.70) and the farmers also had the requisite skills to use them (0.72) (Obayelu et al., 2015). Similarly, the users of the available crop production technologies adjudged them as having positive impact on product quality, farmer's health, the environment and yield. The use of cabinet dryer in cassava processing was not affordable (0.33), durable (0.33), user-friendly (0.33) and gender-friendly (0.00) with

Table 5 - Awareness and adoption of cassava processing technology

TECHNOLOGY	NOT AWARE OF	AWARE BUT NEVER TRIED	TRIED BUT NOT YET ADOPTED	ADOPTED
Cabinet Dryer	46.94	51.02	0.00	2.04
Chipping Machine	30.30	69.70	0.00	0.00
Fermentation Tank	20.00	58.67	0.00	21.33
Flash Dryer	41.82	58.18	0.00	0.00
Garri Fryer	11.88	30.69	2.97	54.46
Hammer Mill	23.88	43.28	1.49	31.34
Homogenizer	52.94	47.06	0.00	0.00
Hydraulic Press	8.21	21.64	2.99	67.16
Motorized Grater	6.99	31.47	0.00	61.54
Packaging Machine	29.23	58.46	0.00	12.31
Peeling Machine	21.25	73.75	0.00	5.00
Rotary Dryer	35.29	52.94	0.00	11.76
Sifter	24.62	44.62	0.00	30.77
Washing Machine	22.67	74.67	0.00	2.67
Average	22.66	47.73	0.74	28.88

Source: Computed from the field Survey data, 2012

Table 6 - Awareness and adoption of grain processing technology

TECHNOLOGY	NOT AWARE OF	AWARE BUT NEVER TRIED	TRIED BUT NOT YET ADOPTED	ADOPTED
De-stoner	19.49	57.63	0.00	22.88
Grading Machine	25.86	63.79	0.00	10.34
Milling Machine	0.00	27.53	1.12	71.35
Packaging Machine	28.45	60.34	0.00	11.21
Parboiler	28.46	60.77	0.00	10.77
Polisher	29.00	69.00	0.00	2.00
Rice Cleaner	27.27	60.91	0.00	11.82
Rotary Dryer	44.09	55.91	0.00	0.00
Shelling Machine	38.18	58.18	0.00	3.64
Steamer	38.37	59.30	0.00	2.33
Average	25.76	55.57	0.17	18.50

Source: Computed from the field Survey data, 2012

Table 7 - Awareness and adoption of tomato processing technology.

Technology	Aware but never tried	Adopted
Canning Machine	100.00	0.00
Drying Machine	100.00	0.00
flexible machine	100.00	0.00
Grinding Machine	66.67	33.33
Sealing Machine	100.00	0.00
Slicing Machine	100.00	0.00
Sorting Machine	100.00	0.00
Washing Machine	100.00	0.00
Average	94.12	5.88

Source: Computed from the field Survey data, 2012

a lot of requisite skill required (0.33). Packaging and washing machines also had similar attributes. All the processing technologies had positive impact on product quality, farmer's health, the environment and yield. Grain processing technologies such as de-stoners were not available (0.43) and not affordable (0.46). Grading machines were likewise not available locally (0.48), not easy to operate as requisite skills were needed (0.48) and not available (0.43). Respondents had a similar assessment of both packaging and grading machines. Rice cleaners were not affordable (0.41) and par boilers were not gender-friendly (0.43). The available grain processing technologies such as milling, shelling machines, and rice cleaners in the study area except par-boilers had positive impact on product quality, farmer's health, the environment and yield. The only tomato processing technology in use in the country was the grinding machine and the result of its assessment indicated that it was 100% effective, appropriate, available, easy to operate as the requisite skill for operating it was readily available and affordable. The impact assessment of tomato grinding machine revealed it had 100% positive impact on quality (1.00) of the processed tomato, farmer's health (1.00) and yield (1.00) but it had a negative effect on the environment (0.33).

Factors influencing the intensity of adoption of crop production technologies

The intensity of production technology adoption was conceptualized as an index of crop production technologies in use. These are technologies available and in use in the country according to the National Agricultural Research System (NARS). The result presented in Table 8 shows that intensity of adoption of all the food crop

Table 8 - Factors influencing the intensity of adoption of specific crop production technologies

Variables	Land Clearing	Land Preparation	Improved variety	Herbicide	Inorganic fertilizer	Organic fertilizer	Pesticide	Water Management	Animal tillage	Cassava harvester	Grain harvester
TRACOST	0.000	0.000	0.000	3.67e-04**	5.34e-04***	0.000	-0.000	0.000	0.000	0.000	0.000
HHDSIZ	0.003	0.014**	0.010	0.008	-0.000	0.004	0.007	0.007	0.012	0.003	0.009
MAIZEDUM	0.229**	0.353***	0.211**	0.497***	0.360***	0.358***	0.351***	0.348***	0.193***	0.226**	0.231**
RICEDUM	0.081	0.073	-0.391***	0.105	0.017	-0.256***	0.027	-0.066	0.259***	-0.165**	-0.085
TOMDUM	0.725***	0.648***	0.278**	0.394***	0.546***	0.689***	0.735***	0.507***	0.472***	0.121	0.140
HHAGE	0.003	-0.005	-0.001	-0.002	-0.003	-0.005	-0.007**	-0.007**	0.003	-0.007**	-0.006
NFINC	0.000	0.000	0.000	-0.000	-0.000	0.000	0.000*	0.000	0.000	0.000	0.000
SCHYR	0.005	0.005	0.003	-0.004	-0.003	0.003	-0.013**	-0.004	-0.001	-0.010	-0.005
FARMSIZ	0.039***	0.071***	0.100***	0.101***	0.162***	0.071***	0.068***	0.059***	0.058***	0.037***	0.041***
BENDUM	0.473***	0.380***	0.288**	0.484***	1.030***	0.403***	0.440***	0.561***	1.023***	0.572***	0.800***
EBDUM	1.191***	0.891***	0.879***	1.156***	1.418***	1.593***	1.344***	1.485***	1.921***	1.558***	1.607***
CRVDUM	1.361***	0.780***	-0.289**	1.019***	0.755***	0.908***	0.903***	1.130***	1.414***	1.091***	1.187***
SKTDUM	0.466***	0.395***	-0.192	0.340**	0.652***	1.097***	0.693***	1.389***	1.710***	0.580***	0.674***
TRBDUM	1.800***	1.530***	1.077***	1.346***	1.302***	1.157***	1.189***	1.515***	2.602***	1.728***	1.711***
NONEDUM	0.368***	0.271***	0.612***	0.413***	0.526***	0.398***	0.253***	0.174**	0.321***	0.270***	0.248***
MALEDUM	0.163	0.187**	0.146	0.212**	0.189**	0.067	0.142	0.027	0.060	-0.054	-0.052
CONSTANT	-2.255***	-1.656***	-1.133***	-1.707***	-1.785***	-1.555****	-1.350***	-1.857***	-2.809***	-1.757***	-1.953***

Source: Computed from the field survey data, 2012

production technology was influenced by travel cost to nearest town, household size, crop type, farm size and location. Other variables that influenced the intensity of adoption were secondary occupation and gender. Adoption of herbicide and inorganic fertilizer only were influenced by travel cost to the nearest urban area where they can be easily accessed. This is because these items are usually sourced outside villages. All crop technologies (land clearing, land preparation, improved varieties, herbicide, inorganic fertilizer, organic fertilizer, pesticides, water management, animal tillage and harvester) were influenced by crop types as maize and tomato farmers had a greater likelihood to adopt them when compared with a typical cassava farmer. However, rice farmers had a greater likelihood of adopting improved varieties but their adoption of organic fertilizer was significantly lesser when compared with cassava farmers. Furthermore, the age of household head had a positive and significant relationship on the likelihood of crop farmers adopting the use of pesticides, water management and cassava harvester while increase in non-farm income and years of schooling improved the likelihood of pesticide adoption. Other factors that had influence on adoption of technologies were farm size, agro-ecological zones, secondary occupation and gender. Increase in farm size positively encourages the adoption of all crop production technologies. Farmers with large farms can choose to apply a given technology widely and there by reap economies of size (Langyintuo and Mungoma, 2008). This finding is in line with Yirga (2006), who observed in Ethiopia that the farm size positively and significantly affected both the likelihood of adoption and intensity of technology use. Also, farmers with no other secondary occupation were more likely to adopt all crop production technologies except land clearing. This is because the time available after the usual harvesting period are usually devoted to clearing as rural farmers are primarily engaged in agriculture. Interestingly, only the male farmers exhibited greater likelihood of adopting land preparation, inorganic and organic fertilizer technologies.

Factors influencing the intensity of cassava processing technologies adoption

The result of factors that influence adoption of specific cassava processing technologies in Table 9 showed that the likelihood of adopting peeling, washing and motorized grating machines were higher with increasing the quantity of fresh cassava tubers to be processed, suggesting that processors who processed large quantity of cassava tubers were more likely to adopt the use of these processing technologies than those who processed small quantities. Also, female cassava processors were more likely to use the peeling and washing machine only when compared with the male processors. Furthermore, the Northcentral (Benue), Southeast (Ebonyi), Southsouth (Cross River) and Northeast (Taraba) had a greater likelihood of adopting the use of peeling and washing machine when compared with the processors in the Southwest.

Table 9 - Factor influencing the adoption of cassava processing technologies

DEP /INDEP[a] VARIABLES	PEELING MACHINE COEFFICIENTS	WASHING MACHINE	MOTORIZED GRATER	FERMENTATION TANK	HYDRAULIC PRESS	GARRI FRYER	PACKAGING MACHINE	OVERALL ADOPTION INDEX
TRACOST	0.000	0.000	-0.000	0.000	0.000	0.000	0.000	0.000
HHDSIZE	-0.007	0.016	-0.082***	-0.005	-0.071**	-0.058	0.036	-0.015
HHAGE	-0.015	-0.011	-0.022	-0.024	-0.016	-0.017	-0.004	-0.006
EXP	0.004	-0.030	0.018	0.003	0.001	-0.003	-0.013	0.001
NFINC	0.000	0.000	-0.000	0.000	-0.000	-0.000	-0.000	-0.000
SCHYR	0.042	0.033	0.009	0.016	0.028	-0.022	0.055**	0.010
PRODWORTH	4.30e-06**	5.42e-06**	7.66e-06**	0.000	4.65e-06**	0.000	4.82e-06**	1.17e-06**
BENDUM	1.281***	1.889***	1.180***	0.371	0.535	1.760***	1.506***	0.362***
EBDUM	1.073**	1.620***	1.186***	0.928**	0.878**	1.250***	1.335**	0.400***
CRVDUM	2.059***	2.686***	0.848	1.332**	0.312		1.829***	0.656***
TRBDUM	1.813***	2.381***	0.484	1.326***	0.130	1.154***	2.227***	0.377***
NONEDUM	-0.288	-0.290	0.272	-0.094	-0.165	0.176	0.094	0.051
FEMDUM	0.707**	0.629**	0.204	0.036	0.288	-0.274	0.385	-0.113
CONSTANT	-1.896***	-2.123***	0.567	-0.412	0.868	0.267	-2.668***	0.371**

Note: a = dependent variable (adoption status of the various technologies in row and independent variables in column)

Source: Computed from the field survey data, 2012

The probability of a processor using the motorized grater in the Southsouth and Northeast was however not significantly different from that of a processor in the Southwest. Factors that exert negative influence on adoption were age and household size in the case of motorized grater and hydraulic press. Thus, older processors and processors with large household members were less likely to use motorized grater and hydraulic press respectively. Increasing the quantity of fresh cassava tubers for processing significantly increased the likelihood of adopting the use of all the cassava processing technologies being investigated in this research with only two exceptions: fermentation tank and garri fryer which may be connected with the non-popularity fact of these two technologies. In this light, location was the only factor influencing the adoption of the fermentation tank and garri fryer.

Adoption of hydraulic press was negatively affected by age as earlier mentioned but processor who processes larger quantity of cassava would likely use hydraulic press. The use of packaging machine was favoured by increasing years of schooling as well as location in addition to the quantity of cassava to be processed.

Factors influencing the adoption of rice processing technologies

Rice processing technologies captured in this study are milling machine, Parboiler, de-stoner, polisher and cleaner. The result in Table 10 shows various factors that determined the intensity of adoption of rice processing technologies.

The results of the Tobit regression shows that experience and non-farm income negatively impact the likelihood of adopting the use of milling machine, Parboiler, de stoner, polisher and cleaner combined.

Travel cost had a positive effect on the probability of adopting de-stoner and polisher only while increasing years of experience in rice processing negatively influenced the likelihood of adopting de-stoner, polisher and cleaner owing to the mastery of skills involved in carrying out these processing operations. This same negative effect on likelihood of adoption is exerted by non-farm income on milling machine, de stoner and polisher while having no secondary occupation reduced the adoption of de stoner and polisher. Expectedly, increase in the number of schooling years raises the probability of adopting use of milling machine, Parboiler, de stoner and polisher while the processors in Northcentral (Benue), Southeast (Ebonyi) and Northwest (Sokoto) are more likely to use these technologies than their Southwestern (Ogun) counterparts.

The probability of a processor in Northeastern (Taraba) part of Nigeria to adopt the technologies was found to be lesser than that of their counterparts in the Southwest. Gender-wise comparison however shows that the female processors were more likely to adopt the use of de stoner, polisher and cleaner.

Table 10 - Factor influencing the adoption intensity of rice processing technologies

DEP /INDEP [a] VARIABLES	MILLING MACHINE COEFFICIENTS	PARBOILER	DE-STONER	POLISHER	RICE CLEANER	OVERALL ADOPTION INDEX
TRACOST	0.001	0.001	0.002*	0.002*	0.001	0.000
HHDSIZE	0.001	0.033	-0.004	0.017	-0.009	0.010
HHAGE	0.001	-0.010	0.015	0.004	-0.005	0.001
EXP	-0.010	-0.019	-0.031**	-0.024*	-0.027**	-0.009*
NFINC	-1.0e05**	-0.000	-1.36e-05**	-1.64e-05*	-0.000	-5.84e06**
SCHYR	0.067***	0.038*	0.058**	0.060**	0.038	0.028***
PADDYWORTH	-0.000	-0.000	-0.000	-0.000	0.000	-0.000
BENDUM	0.145	0.124	5.698	5.459	5.060	0.485**
EBDUM	0.200	0.090	5.531	5.097	5.427	0.473**
OGDUM	-0.689	------	------	4.604	------	0.221
SKTDUM	-0.697	0.178	5.111	5.108	4.690	0.594**
TRBDUM	0.228	0.713	5.585	5.704	5.682	-0.231*
NONEDUM	-0.389	-0.340	-0.645**	-0.652**	-0.391	0.113
FEMDUM	0.396	0.251	0.536*	0.456*	0.457*	-0.100
CONSTANT	0.215	-0.048	-6.008	-5.765	-4.887	195

Note: a = dependent variable (adoption status of the various technologies in row and independent variables in column)

Source: Computed from the field survey data, 2012

Conclusion and Recommendations

Results showed that only about 19% of the entire improved food crop technologies had been adopted by the stakeholders (producers and processors) in Nigeria, suggesting inadequate exposure of farmers to improved agricultural technologies. The study concluded that farm size positively and significantly affected both the likelihood of adoption and intensity of technology use for food crops production in Nigeria. While the adoption of cassava processing techniques was positively influenced by the quantity of cassava tuber processed, this was not true in the case of rice processing techniques. The inventory of some developed food crop technologies; the perceived effects of the technologies by users; and the determinants of the adoption can help the policy making process in moving towards sustainable agriculture. The findings in the study revealed that in order to ensure sustainable agricultural production, the farmers and processors need to have access to the right knowledge and technology.

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