PATTERNS AND DETERMINANTS OF ADOPTION OF CROP PRODUCTION TECHNOLOGIES AMONG FOOD CROP FARMERS IN NIGERIA

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Abstract
The need to improve agricultural productivity through technological adoption is undoubtedly critical in the drive for economic growth and poverty reduction in Nigeria. This study therefore examines availability, awareness and adoption rates of crop production technologies among farm household in Nigeria as well as the determinants.The study was based on data collected in a National Agricultural Research System (NARS) survey to determine available technologies, and a nationwide Farm Households Technology Use (FHTU) survey to assess awareness, adoption and impacts of the technologies on farm households. The NARS survey was focused on all public, private and multinational Institutions involved in agricultural research, extension and technology goods production and marketing identified across the six geopolitical divisions of Nigeria. The FHTU survey covered 1, 663randomly selected farm households drawn by multistage random sampling across about 240 farming communities/villages in 80 Agricultural Development Project (ADP) cells spread across all block in six states (Benue, Ebonyi, Cross-river, Ogun, Sokoto and Taraba), which were drawn one state per geopolitical division of Nigeria. The data were analysed using descriptive, budgetary and econometric techniques. The NARS survey revealed that a wide range of improved varieties of cassava (57), maize (54), rice (65) and tomato (11) as well as innovative farming practices, equipment and intermediate materials have been developed and released to farmers across the country. However, while the awareness rates of many of the technologies are quite high (above 70%), the adoption rates, defined by the percentage of potential users that have tried and are willing to continue the use of the technology, are generally low, except for cultivation of improved varieties (above 70%),and use of fertilizer (56%), herbicide (52%) and mechanised tillage (43%). The current (2011/2012) use rates were however much lower than the adoption rates due to non-availability of many of these technologies in the local market, and where available, high cost. There are also significant ($p<0.01$) variation in adoption rates of the technologies across the states, with likelihood of adoption generally declining significantly with increase in travel cost to nearest agro-service centre ($p<0.05$)and household size ($p<0.05$), but rising significantly with increase in farm size ($p<0.01$), household wealth ($p<0.01$), and education level of the household head ($p<0.05$). The likelihoods of adoption were also generally and significantly ($p<0.05$) lower among female headed households than among male headed households.

Keywords: Adoption rate, Crop production technologies, Farm households, Nigeria.

Introduction

Agriculture is the major source of income and employment in the world poorest countries (Doss, 2006). In Nigeria, it has been contributing an average of 27.3% ofthe employment of economically active people,33.0% the real Gross Domestic Product (GDP), and remained the fastest growing sector since year 2000 (FAOSTAT data, 2014; CBN, 2014). Yet, agricultural productivity level in the country remains very low (Ibeawuchi *et al*., 2009) with the annual output of an average farmer in Nigeria in 2005 being barely the output of his counterpart in Northern America in barely 5days, less than a quarter of what obtains in other tropical countries like Brazil and Malaysia, and just about half of what obtains even in Côte d'Ivoire and Cape Verde (Shittu, Ashaolu and Phillip, 2010). Consequently, poverty and food insecurity remain very high in Nigeria, with the worst affected being predominantly rural farm households (Ogwumike and Aromolaran; 2000; NBS, 2005, 2012; Olomola, 2013; Shittu, Obayelu and Salman, 2014).

A critical factor in the rather low and declining productivity in Nigerian agriculture is an excessive reliance on crude implements and traditional technologies by the predominantly resource poor and smallholders in the country. Considering, however, the seemingly impossible task of continuously raising agricultural outputs through increased farm areas given other pressing use of land, the need to progressively transform the agricultural sector away from subsistence-oriented production towards an integrated economy fuelled by agricultural productivity growth becomes very germane (Uaiene, 2009). This growth in agricultural productivity as evidenced in all developed economies is generally driven by improved farm technologies through the adoption of mechanization, improved seeds, fertilizer, and water control techniques (Gabre-Madhin and Johnston, 2002;Foster and Rosenzweig, 2010). There therefore arise the needs to critically examine factors contributing to low adoption of improved technologies in Nigeria.

A number of previous studies have examined the adoption of various crop production technologies. Among these is adoption of improved cassava varieties: NR-8082, TME-419 and TMS-980505; in which Udensi *et al*. (2012a) identifiedthe factors that negatively influence adoption as including household size, too small farm size, and unfavourable land tenure system. Similar evidences were provided by Adeniji, *et al*. (2007) who stressed that the main reasons for non-adoption of improved cotton production technologies in Katsina State include inadequate knowledge and non-availability of most of the technologies within the local communities. Udensi *et al*. (2012b) also attributed the low adoption of chemical weed control technology among cassava farmers in south eastern Nigeria to problems relating to lack of training on chemical weed control, low income, and high cost of chemicals. Polson and Spenser (1991) also identified inadequate access to extension services and subsistence nature of agricultural production as a cause of low adoption of improved cassava varieties among subsistent farmers in southwest Nigeria. Similarly, Adesina and Chianu (2002) identified factors influencing adoption of alley farming technology in Nigeria to include farmer characteristics such as gender of the farmer, contact with extension agents, years of experience with agroforestry and tenancy status in the village; and economic factors, proxied by village-level characteristics that condition resource use incentives.

To update these knowledge, there still exists the need for an holistic examination of factors affecting crop production technologies adoption in Nigeria at broad national levels. These leaves considerable gaps in our knowledge of thecrop production technologies that are available in the country that farmers are aware of, the different stages of adoption and the assessment of what they are using. This study will therefore bridge this gap and also provide information on where the technologies are being used and who is using them as these information are crucial for policy making in addition to generating useful background information about technology diffusion. The broad objective of this study was to unravel the factors behind the adoption of crop production technological adoption in Nigeria. Specifically it revealed awareness and perception of these technologies and it further exposes the factors associated with adoption of crop production technologies by major crop (cassava, maize and rice) farmers in Nigeria.

Methodology

This study was based on two different sets of respondents. The first set comprised of institutions / agencies in the National Agricultural Research System (NARS); companies and individuals involved in the production, distribution and marketing of technology-based inputs and services. Here, all universities and research institutes whose mandates cover the selected national strategic crops as well as other key players in the NARS most especially the various state Agricultural Development Programmes (ADPs), Agro-service Corporations, Federal as well as states' Ministries of Agriculture were included in the NARS survey. Snowball sampling was employed in drawing as many companies and private/public institutions involved in the production and distribution of agricultural technologies in each of the six geopolitical divisions into the study samples and the results from this survey subsequently informed the choice of technologies included in the farmer's questionnaire. The second set of respondents consists of rice, cassava and maize farmers. The farmers were visited between July and September 2012.

The sampling process was based on the structure already created by the various States' Agricultural Development Programmes which have grouped farming communities in each states of the Federation into zones, blocks and cells. The first stage of the sampling process was a random selection of 25% of the blocks in each of the agricultural zones of all the states for each geo-political divisions of the country. With each state having 2 - 4 agricultural zones and each zone having eight (8) blocks, at least 40 blocks per geopolitical division were mapped out at this stage across the country. The second and the third stage of the sampling process also randomly selected 25% of the cells and one farming community per cell in each of the selected blocks. This process led to selection of 80 farming communities in each geopolitical division of the country. The final stage of the sampling process also involved the random selection of 10% each of the farmers involved in the production of any or a combination of rice, cassava, maize and tomato in each of the selected farming communities.

On the overall, a total of 1663 food crop farmers were selected across the six geopolitical divisions of the country. The states selected across the six geopolitical zones were Sokoto, Taraba, Benue, Cross River, Ebonyi and Ogun in North West, North East, North Central, South South, South East, and South West respectively.

Various technologies that have been developed by the NARS Farmers were categorised into four different adoption stages i.e. "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**.** The adopters are those who have been using and are currently still using these technologies. Assessment of the technologies in terms of their effectiveness, appropriateness, local availability, possession of requisite skill for use, affordability, durability and user's as well as gender friendliness were done by the adopters. These were rated as low, normal and high on a scale of three in an ascending order respectively. Also, the adopters perception about the impact of these technologies were rated on a scale of three as negative, none noticeable and positive. In either of the cases don't know had a score of zero individual score were then divided by three the highest score possible in each case to generate an index. This was then interpreted as being favourable when it is 0.5 and above with respect to the factor of interest and the converse holds when it was otherwise.

The factors influencing the adoption of specific crop production technologies were investigated in the binary choice – probit model where the framework for analysing adoption was modified following Adegbola and Gardebroek (2007). They opined that farmers can only adopt a technology if they are aware of it. It is after this information threshold is crossed that the adoption decision becomes relevant. Not accounting for awareness leads to selection bias in the estimation of adoption decisions. This was controlled for in this study as adopters here were beyond the awareness stage and were still using the technologies. The decision to adopt a technology is not observable therefore a latent variable associated with this decision is specified.

Formally the model is written as follows:

$$Y_j = \begin{cases} 1 \; if \;\; y_j^{*} = \left(X\beta_j + \varepsilon_j\right) \geq 0 \\ 0 \; if \;\; y_j^{*} = \left(X\beta_j + \varepsilon_j\right) < 0 \end{cases} \qquad \text{j=1, 2, …, m} \qquad (1)$$

Where Y_j is a binary variable that takes on the value one (Y_i=1) on adoption of technology j (j=1, 2, …, m) and zero if otherwise. The latent variabley_i^* is positive when Y_i=1 and is negative if otherwise.$X$is the vector of explanatory variables hypothesized as the determinants of adoption of the technologies, including age of the farmer, availability of family labour captured by the household size, crop type, location, effective area cropped, credit, educational level of farmers etc. While $\varepsilon' = [\varepsilon_1 \; \varepsilon_2 \; ... \; \varepsilon_m]$follows a multivariate normal distribution $MVN(O, \Delta)$ of Δ centred variance-covariance matrix.

The set of dependent variables in this application consists of adoption status in respects of modern technologies being promoted by various States' Agricultural Development Projects (ADPs) in respect ofmechanised land preparation and use of improved crop varieties, herbicide, inorganic fertilizer, organic fertilizer, pesticides, water management, animal tillage and harvester. The independent variables weresocio economic characteristic of the farmer: age, schooling year, educational level, area cropped, farming experience, gender, assets (building ownership captured as dummy) and asset income, nativity (dummy-1 for natives and 0 for non-natives), non-farm income, credit, household composition; household size, dependency ratio, location; Benue, Ebonyi, Sokoto, Taraba dummies, crop type; cassava, maize, rice and tomato dummies, community characteristics: presence of financial institution- microfinance or co-operative society.

Results and Discussion

Household Characteristics :

Decisions on whether or not to adopt a technology may depend on socio-economic characteristics of the farm households, most especially those of the household the heads. Hence, socio-economic characteristics of the heads of the sample farm households were analysed. The results are presented in Table 1. The study found the farm households are mostly (80.3%) headed by males. The modal age group was41-50 years, and the modal crop farming experience of 11 - 20 years. It was also more common to find a non-educated household head among Nigeria crop farmers as the modal group (30.2%) in

terms of highest educational attainment was those who had no formal education. The result of farming household composition showed that about one third (30.6%) of farming household were made up of 4 and 6 individuals.

Adoption of Crop Production Technologies in Nigeria

Table 2 showed that majority (57.19%, 48.92%, and 56.97%) of the farmers are only aware of animal and tractor pulled implement as well as bulldozer for clearing respectively (i.e. land preparation technologies) but have never used them. The adoption rate for D7 bulldozer was 5% while the tractor pulled implement had a better (30.50%) adoption rate with at most one out of every three farmers using the tractor pulled implement for crop production.

Factors Influencing the Adoption of Specific Crop Production Technologies

The influence of various factors such as location, crop type, community characteristics, and socio economic characteristics on the adoption decision is presented on Table 3. The results showed that location had significant effect on the adoption of all the crop production technologies as farmers in Benue, Ebonyi, Sokoto, Taraba were more likely to adopt all technologies (land clearing, land preparation, improved varieties, herbicide, inorganic fertilizer, and organic fertilizer) when compared with farmers in Ogun State. The observed exceptions in this case were land clearing, herbicide, organic fertilizer, pesticides, water management technology and harvesters in Benue. Also, adoption of land clearing technology in Sokoto was not significantly different from that of Ogun state.

The type of crops grown by the farmers also has effect on the adoption of specific technologies. Maize farmers do have a higher probability of adopting the use of improved varieties and herbicides while rice farmers are more likely to adopt use of land preparation technologies, improved varieties, and inorganic fertilizer while their use of animal for tillage is likely to be significantly less when compared with an average cassava farmer. Another result that lends credence to the impact of crop type on technological adoption was that tomato farmers were seen to have a greater chance of adopting the use of land preparation and organic fertilizer technologies as against the cassava farmers. However, the use of specific harvester is not affected by the crop type that it was meant for. The presence of at least a micro finance bank in the farming communities was also very critical and helpful in the adoption of all the technologies while the presence of at least a cooperative society in the locality did not have substantial effect on the likelihood of adopting land clearing, and organic fertilizer.

This may not be untrue as this set of technologies except for harvesters represents the basis that an average farmer may not need credit from co-operative society to purchase. Furthermore, the determinants of adoption on Tables 5&6 revealed that adoption of certain technologies (land preparation, pesticides, improved varieties and inorganic fertilizer) were not gender sensitive i.e. adoption across male and female farmer was not different from those scenarios where gender had implication (land preparation, herbicide, organic fertilizer, water management, animal tillage and harvesters). It was however interesting to note that the females had a higher probability of adopting key technologies. Ownership of building, being a native of a particular community where one is farming confers greater likelihood of adopting the crop production technologies except for improved varieties of which ownership of a building has no effect on and inorganic fertilizer which both building ownership and being a native does not significantly influence. Likewise, increasing farm size (effective area) is instrumental in the adoption of all crop production technologies (land clearing, land preparation, improved varieties, herbicide, inorganic fertilizer and organic fertilizer).Others factors that were instrumental in the adoption of technologies (land clearing, land preparation, inorganic fertilizer, organic fertilizer) were years spent in school and credit (organic fertilizer, water management, animal tillage and harvesters) which exerted a positive influence on their adoption while increasing non-working members (animal tillage) and age of household head (land clearing, land preparation, pesticides, water management, animal tillage and harvester) did not support the probability of adopting some technologies.

Conclusion and Recommendations

The findings from this study revealed that majority of crop farmers (cassava, maize, rice and tomato) were only aware of animal and tractor pulled implement (land preparation technology) as well as bulldozer for clearing. In terms of planting technologies, improved seeds as well as hybrid cassava stem cutting have been greatly adopted but the improved technology associated with them e.g. use of seed broadcaster and planter was abysmally low. Furthermore, a great deal of the farmers were seen to have adopted some maintenance /post planting technologies such as herbicides, inorganic and organic fertilizers and knapsack/boom sprayer but the technologies associated with the control of pest such as pest scaring devices for rice and pesticides as well as the use of irrigation equipment have not been mainly adopted. Majority of the crop farmers are not aware of both the cassava and grain harvesting technologies available in the country and therefore could not adopt them. In totality, less than half of the farmers had adopted and was currently using the crop production

technologies put together. On the overall, the use of all these crop production technologies was highest in Taraba followed by Ebonyi while Ogun state is having the lowest adoption rate.

Location also played a significant role on the likelihood of adoption of all the crop production technologies (land clearing, land preparation, improved varieties, herbicide, inorganic fertilizer, organic fertilizer) with exceptions in land clearing, herbicide, organic fertilizer, pesticides, water management technology and harvesters in Benue. Also land clearing adoption in Sokoto was not significantly different from that of Ogun state. Also, maize farmers had a greater probability of adopting the use of improved varieties and herbicides while rice farmers were more likely to adopt use of land preparation technologies, improved varieties, and inorganic fertilizer with the use of animal for tillage significantly less used when compared with its use by an average cassava farmer. Tomato farmers also had a greater chance of adopting the use of land preparation and organic fertilizer technologies as against cassava farmers. However, the use of specific harvester was not affected by the crop type it was meant for. The presence of at least a micro finance bank in the farming communities also played a significant role in the adoption of all key technologies while having at least a cooperative society did not have a substantial effect on the likelihood of adopting land clearing, organic fertilizer, pesticides, water management and harvesting technologies. Other determinants of adoption on were increasing farm size, years spent in school and credit amount. However, increasing non-working membersand age of household head were discovered to reduce the probability of adopting some technologies. Gender i.e. being a female, ownership of building, being a native of a particular community where one is farming confers greater likelihood of adopting the crop production technologies when compared with their counterparts.

In the light of the above, the study therefore recommends that:

- NARS and other agencies involved in the production, dissemination and marketing of crop production technologies should intensify effort in creating awareness about the technologies particularly in the South Western part of the country.
- The cassava farmers should be strategically targeted and included in the awareness and adoption campaign of the NARS and their allies.
- Government and privately owned micro finances should establish in rural farming communities so as to enhance adoption of crop production technologies.
- In the same manner, credit should be made available to farmers by governments and non-governmental organisation.
- Farmers should be encouraged by extension agents to increase their farm size as this will enhance their adoption chances.
- The design of crop production technologies should be female friendly as they are more likely to use these technologies.

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Table 1: Characteristic of Heads and Farming Households

Description	State						Total
	Benue	C/River	Ebonyi	Ogun	Sokoto	Taraba	
Number of Respondents	**270**	**266**	**270**	**293**	**278**	**286**	**1663**
Sex							
Female	26.3	16.9	7.0	35.8	8.6	23.4	19.7
Male	73.7	83.1	93.0	64.2	91.4	76.6	80.3
Age							
18 – 30	7.0	5.0	1.1	14.7	13.9	10.6	8.7
31 – 40	24.4	20.3	12.2	26.0	29.9	20.4	22.2
41 – 50	28.9	36.4	35.9	24.0	30.3	37.0	32.1
51 – 60	28.2	25.7	33.0	16.5	20.4	24.6	24.7
Above 60	11.5	12.6	17.8	18.8	5.5	7.4	12.3
Farming experience (years)							
1 – 10	19.1	17.0	6.3	24.3	13.7	20.2	16.8
11 – 20	35.2	32.0	29.1	33.9	28.8	34.3	32.2
21 – 30	29.3	34.4	26.4	21.1	28.3	32.2	28.6
Above 30	16.4	16.6	38.2	20.7	29.3	13.4	22.4
Widowed	3.3	4.8	1.5	2.7	2.9	3.9	3.0
Highest Education of household Head							
None formally	22.6	15.8	15.9	33.8	70.1	22.7	30.3
Primary	31.8	22.9	27.0	40.2	17.6	28.0	27.9
Secondary	30.0	44.0	29.3	20.5	11.2	30.4	27.5
Tertiary	15.6	17.3	27.8	5.5	1.1	18.9	14.3
Household Size							
1 – 3	8.3	10.7	6.6	29.3	15.0	8.7	13.1
4 – 6	21.1	42.9	30.4	33.5	25.5	30.4	30.6
7 – 9	27.3	31.3	35.0	26.9	27.1	30.4	29.7
10 or more	43.4	15.2	28.0	10.3	32.4	30.4	26.6
Nativity							
Non-natives	15.2	20.3	5.2	35.8	15.5	24.8	19.5
Natives	84.8	79.7	94.8	64.2	84.5	75.2	80.5
Ownership of Building							
No	16.7	20.7	14.4	52.2	39.6	23.8	27.9
Yes	83.3	79.3	85.6	47.8	60.4	76.2	72.1
Best available Finance Institution							
Commercial Bank	20.4	24.1	10.0	20.8	31.3	43.4	24.9
Microfinance Bank	46.7	44.4	20.4	35.5	42.4	27.6	36.1
Cooperatives	28.1	25.9	63.3	37.2	25.9	27.3	34.4
Esusu/Ajo Group	4.4	5.6	6.3	5.5	0.4	1.7	3.9
None	0.4	0.0	0.0	1.0	0.0	0.0	0.7

Source: Data from Field survey, 2012

Table 2: Awareness and Adoption of Crop Production Technologies

Technology	Not aware of	Aware but never tried	Tried but not yet adopted	Adopted
Land Clearing				
D7 Bulldozer	35.94	56.87	1.28	5.91
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
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: Data from Field survey, 2012

Table 3: Factor Influencing the Adoption of Specific Crop Production Technologies

Explanatory Variables	Mechanised Land clearing	Mechanised Tillage	Improved varieties	Herbicide	Inorganic Fertilizer	Organic Fertilizer
Benue Dummy	-0.174	0.109	0.697***	0.051	0.916***	0.018
Ebonyi Dummy	0.565***	0.663***	1.126***	0.689***	1.105***	1.253***
Sokoto Dummy	0.228	0.503***	0.424***	0.433***	0.961***	1.287***
Taraba Dummy	1.321***	1.416***	1.399***	0.995***	1.010***	0.720***
Maize dummy	-0.145	0.078	0.201**	0.185*	0.095	0.110
Rice Dummy	0.108	0.160*	-0.337***	0.207**	0.228**	-0.192**
Tomato Dummy	0.191	0.285**	-0.040	-0.013	0.130	0.317**
Microfinance Dummy	0.186*	0.254***	0.346***	0.254***	0.314***	0.158*
Cooperative Dummy	0.272***	0.135	0.287***	0.238***	0.409***	0.032
Gender Dummy	-0.316***	-0.161	-0.192	-0.241**	-0.060	-0.204*
Building dummy	0.703***	0.605***	0.129	0.553***	-0.018	0.291***
Nativity dummy	-0.353***	-0.342***	-0.345***	-0.401***	-0.011	-0.116
Effective Area	0.012*	0.037***	0.062***	0.065***	0.121***	0.044***
Years of schooling	0.072**	0.089***	-0.011	0.035	0.077**	0.087***
Households size	-0.001	0.012	0.002	0.007	-0.012	0.000
Dependency Ratio	-0.004	0.004	-0.031	0.017	-0.022	0.000
Head Age	-0.009**	-0.012***	-0.002	-0.006	-0.001	-0.006
Experience	0.005	0.001	-0.000	-0.002	-0.008	-0.001
Non-Farm Income	0.000	0.000	0.000	-0.000	-0.000	0.000
Asset Income	-0.000	0.000*	0.000	0.000	-0.000	-0.000
Credit	0.000	0.000	0.000	0.000	0.000	0.000*
Distance to Agro-service	-0.370**	-0.467***	0.019	-0.180	-0.430**	-0.433***

Source: Data from Field survey, 2012