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FACTORS DETERMINING ADOPTION OF IMPROVED COWPEA VARIETIES AMONG SMALLHOLDER FARMERS IN THE DRY SAVANNAS OF NIGERIA

[1,2]Mohammed, S. B., [2]Pangirayi, B. T., [2]Gracen, V., [2] Dzidzienyo, K. D., [1]Ishiyaku, F. M., [1]Umar, M. L. and [1]Abdulmalik, R. O.
[1]Institute for Agricultural Research Ahmadu Bello University, Zaria, Nigeria.
[2]West Africa Centre for Crop Improvement, University of Ghana, Accra, Ghana.
Corresponding Author's E-mail: bsmohammed@abu.edu.ng **Tel.:** +2348069299881

ABSTRACT
The success of modern-day plant breeding is determined by adoption and use of improved crop varieties. Several improved cowpea varieties have been released in the last few decades in Nigeria. This study thus investigated the extent of use of improved cowpea varieties among smallholder farmers and factors influencing their adoption. To understand the extent and factors influencing adoption of these varieties, we used primary data from 420 households spread across 36 communities of three major cowpea growing states in the north-western part of Nigeria. Data collected on the use and non-use of improved varieties was analyzed using a binary logit regression model. Gender, age, household size, education, years of experience in cowpea cultivation, knowledge of nutrient deficiency, cropping system, attendance of cowpea field-days and contacts with extension agents were considered as independent variables that influence farmers' decision to adopt improved varieties. Four variables: years of cowpea cultivation experience, level of education, cropping system and contacts with extension services, were important in determining farmers' probability of using improved varieties of cowpea. Cowpea breeding programmes should incorporate farmer preferences in planning and designing of new varieties to ensure higher adoption. We recommend enhanced promotion and demonstration of available improved cowpea varieties and other production technologies as contacts with extension agents was among the most important factors influencing the use of improved cowpea varieties among farmers.

Keywords: Adoption, Cowpea varieties, Determinants, Insect pests, Yield.

INTRODUCTION
Cowpea is a major source of protein for millions of people. Nigeria is a leading global producer of grain cowpea with an estimated production of over 2 million tonnes (FAOSTAT, 2016) and consumption of more than 3 million metric tonnes (Boukar *et al.,* 2018). There is a deficit of close to 1 million tonnes that requires cowpea imports from neighboring countries like Niger Republic, Cameron, Mali and other countries in the sub-region. The present data shows an increased deficit over the 500, 000 metric tonnes previously reported (Langyintuo *et al.,* 2003). The huge deficit is partly due to the low yield of prevailing varieties grown by farmers. Most of these varieties are mostly photosensitive and they are cultivated in mixed intercrops with cereals.

The productivity of cowpea is low in West and Central Africa (< 600 kg/ha) when compared to the crop's genetic potential of over 2, 000 kg/ha. The low yield is due to many biotic constraints (insect pests, diseases, parasitic weeds), abiotic constraints (low soil fertility especially phosphorus, drought, heat) (Boukar *et al.,* 2018; ICRISAT, 2017a), sub-optimal agronomic management practices (Pachico, 2014; Persley & Anthony, 2017; Walker and Alwang, 2015), use of traditional low yielding landraces (Horn *et al.,* 2014) and low plant

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density as a result of intercropping and wide intra-plant spacing (Agwu, 2004; Ewansiha *et al.,* 2014).

The popularity of cowpea as a protein source is rapidly increasing across West Africa and in some areas in southern Africa. However, research on varietal adoption, yield gaps, and constraints to adoption of improved varieties has been limited (Pachico, 2014). "Diffusion and Impact of Improved Varieties in Africa (DIIVA, 2015)", a project commissioned by the Consultative Group on International Agricultural Research (CGIAR) targeted varietal adoption for 20 crop species including cowpea in over 30 countries in Africa. It was found that the average adoption rates of over 1,150 released crop varieties by the CGIAR centres and national agricultural research systems (NARS) in the African continent was about 35%, compared to 60% in Asia and 80% in South America (Pachico, 2014; Walker and Alwang, 2015). The adoption rates of cowpea varieties in 18 countries was 27.2% as determined by expert opinion and household survey data (Walker and Alwang, 2015). In a different survey in northeastern Nigeria, low adoption of improved cowpea production technologies such as the use of tractors for land preparation, inorganic fertilizers and recommended spacing have been reported (Agwu, 2004). A recent review revealed a lack of adoption and limited investment for genetic improvement of legumes as reasons responsible for under-representation of agricultural statistics on the global scale for grain legumes (Pachico, 2014).

There are many reasons for low adoption of developed varieties in Africa including failure to consider farmers' needs and preferences in new varieties (Persley & Anthony, 2017), lack of awareness on available improved varieties (on the shelf-technologies), poor farmers' knowledge that new varieties will provide needed yield increase, limited access to seeds of improved varieties, low returns on farm investment, poor extension services, poor access to credit facilities, and gender-based constraints (Horn *et al.,* 2014; Persley & Anthony, 2017). Another important factor responsible for poor adoption of improved technologies among smallholder farmers is fluctuations in prices, such that prices are low at harvest and go up when most farmers have finished selling their stocks (Abate *et al.,* 2012). This discourages farmers from investing in improved technologies.

Cowpeas are grown mostly by smallholder farmers in West and Central Africa using popular local varieties that are low yielding. Most local farmers prefer the local cowpea types over those developed by research organizations, or donor-funded and development partners (Mishili *et al.,* 2007). This is partly due to farmers' preference of large-seeded varieties typical of most local grain cowpeas (Lucas *et al.,* 2013). Knowledge of farmers' and consumers' preferences could drive production towards market-led systems and facilitate uptake of improved cowpea varieties that, would lead to increased income for farmers, grain merchants, and processors (Tipilda *et al.,* 2005). This could potentially transform African agriculture from subsistence farming to market-led systems (Hoffmann *et al.,* 2007; Persley & Anthony, 2017). There are several instances where newly released crop varieties were not adopted due to farmers' needs not considered in the variety design (Persley & Anthony, 2017). Modern cowpea varieties are more likely to be adopted by farmers, if preferred traits such as ease of cooking, seed coat colour and texture, grain size and yield are incorporated in such varieties.

Adoption of varieties has been measured using expert opinion, the volume of seeds sold, secondary data from international organizations like FAO, national statistics, and reviews of past studies (Persley & Anthony, 2017). Expert opinion, supported by household surveys, was used in a study of adoption of some grain legumes across several African countries (Walker & Alwang, 2015). The use of expert opinion is popular because it is less expensive compared to household surveys and does not involve challenges faced in sourcing primary data for adoption studies using surveys. It is subjective compared to more objective approaches like

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surveys and volume of seed sales (Persley & Anthony, 2017). Other approaches such as the use of interviews and focus group discussions with crop value chain actors have been used to study the adoption of technologies in eastern and central Africa countries (Odame *et al.,* 2013).

Recent studies have indicated that, in the last four decades beginning in the late 1960s, several improved cowpea varieties have been released across the continent, but there has been inadequate documentation of these varieties and their impacts on the livelihood of the intended beneficiaries (Monyo & Varshney, 2016; Pachico, 2014). Since the early 1970s, the Institute for Agricultural Research of Nigeria (one of the NARS in Nigeria) and the International Institute of Tropical Agriculture in partnership with other research institutions and universities under a scheme called nationally coordinated trials have developed, evaluated and released over twenty improved cowpea varieties for various agro-ecologies in Nigeria. These improved varieties can transform the productivity of African farmers, by increasing yield for home consumption and providing surplus grains for markets. There has been little documentation of the spread of improved cowpea varieties in major producing countries like Nigeria. Such documentation is needed to guide policy decisions on research investment and provide feedback to breeding programmes on whether improved varieties are being used by farmers. Where varieties are not being adopted, the barriers to adoption of new improved varieties must be identified, but there have been little efforts at assessing adoption of these varieties and how they have impacted livelihoods of the target end-users (Agwu, 2004; Huynh *et al*., 2013; Ojiewo *et al.,* 2018). Therefore, the objectives of this study were to assess extent of adoption of improved cowpea varieties determine the factors that influence the adoption.

MATERIALS AND METHODS

The Study Area

The study was carried out across 36 communities in 12 local government areas (LGA) in the dry savannah areas including Kano, Kaduna, and Katsina states in northwestern Nigeria. The states were chosen because the cowpea research and diffusion efforts by IAR, Zaria and IITA Kano-station have focused on these savannah agro-ecologies for the past few decades and significant cowpea production has been previously reported in these areas (NAERLS *et al.,* 2017). The informed consent of the respondents was obtained prior to conducting the surveys and the survey interviews were conducted in person using the Hausa language.

Method of Data Collection and Analysis

Semi-structured questionnaires and focus group discussions (FGD) were used to measure the adoption of improved cowpea varieties in the study areas. A two-step sampling procedure was undertaken to select cowpea farmers for the study. The first step was the identification of three major cowpea producing areas in Nigeria and the second step was selection of 420 cowpea farmers across 36 selected communities with the help of local extension agents for the various local government areas (LGA).

Four communities were chosen from each LGA of the three states and questionnaires were administered to an average of 35 farmers in each LGA. The surveys collected data on socio-economic characteristics of the farmers, years of experience in cowpea production, and use of improved cowpea varieties. Information obtained from the surveys was validated via FGD with key informants and personal observations during the discussion sessions. The FGD sessions were held across the study areas, with about 8-10 participants per session. The scope of discussions ranged from desired seed types, the source of seeds, production constraints and desired traits in cowpea varieties.

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The use of improved varieties was modeled as a dependent variable with a binary choice of 1, if the farmer uses improved varieties, and 0 if not. Several explanatory variables were identified and used in the model, see Table 1. The empirical model for estimating the probability of farmers' using improved varieties is as described (Verbeek, 2004).

$$\ln\left[\frac{P_x}{1-P_x}\right] = \beta_o + \sum \beta i \; Xi \qquad \ldots (1)$$

where;

P_x is the probability of a farmer using an improved variety (1) and 0 is otherwise; β_o is a constant term; β_i is a coefficient associated with the independent variate x_i.

The information from the research was coded and analyzed using descriptive statistics with SPSS 20.0 and a logit regression model was used to predict the determinants of farmers' use of improved cowpea varieties using Nlogit 4.0 software.

Table 1: List and Description of Variables used for Binary Logit Regression Model

Variable	Description	Type	Units
Dependent variable			
Used improved variety	Farmers' use of improved cowpea variety	Dummy	1 = yes, 0 = no
Independent variables			
Gender	Sex of the farmer	Dummy	1= male, 0 = female
Status	Marital status of farmer	Dummy	1= married, 0 = single
Age	Age of the farmer	Years	Continuous
Household	Size of farmers' household	Persons	Continuous
		Dummy	1=formal, 0 = informal
Education	Formal education of farmer		
Experience	Experience in cowpea cultivation	Years	Continuous
Def-Symptoms	Knowledge of nutrient deficiency symptoms	Dummy	1 = yes, 0 = no
Cropping	Cowpea cropping System in use by farmer	Dummy	1 = sole, 0 = mixed
Field-day	Attendance of cowpea field day	Dummy	1 = yes, 0 = no
Extension contact	Farmers access to production information from extension agents	Dummy	1 = yes, 0 = no

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

The 420 sample size employed in the study was adequate, as established by Field (2009) who reported that over 300 respondents were adequate for analysis of sampled respondents. Men (84.8%) were more involved than women (15%) in cowpea production (Table 2) in this region. This is probably due to the influence of religion and cultural norms, as women's activities were mostly limited to non-farm operations like threshing and winnowing of cowpea after harvest. Little involvement of women in farm operations in northern Nigeria has earlier been reported (Umar *et al.,* 2014). The age group of the respondents varied widely. The majority of cowpea farmers interviewed were within 30 - 40 years (Table 2).

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The farmers' level of formal education (primary, secondary and tertiary) was low in the study area as the results shows that 37% had no formal of education. Although, most of them had Qur'anic (grouped as informal) education and could read literature written in *Ajami* (Hausa language written in Arabic alphabets). The *Ajami* system in northern Nigeria is a popular style of written literature (Dobronravine & Philips, 2004). The majority of the respondents had no formal education, which agrees with Akpalu *et al*. (2014), who found that over half (57%) of cowpea farmers in northern Ghana had no formal education. The low level of formal education could be one of the main factors limiting the use of improved technologies. In some areas, the FGD revealed that farmers had very little awareness on improved cowpea production practices; hence, their cultivation style has remained traditional in approach. This underscores the need to create and sustain platforms to continuously educate, and guide farmers on sustainable agronomic and management practices of the crop.

Table 2*:* Socio-economics Characteristics of Cowpea Farmers Surveyed across 36 Communities in the Northwestern part of Nigeria in 2017

Attributes of the Respondents		**Frequency (420)**	**Percent**
Sex of Responder	Male	356	84.8
	Female	64	15.2
Age distribution of Responder	11-20	9	2.1
	21-30	56	13.3
	31-40	127	30.2
	41-50	108	25.7
	51-60	91	21.7
	> 60	29	6.9
Level of Responder's Education	Primary	88	21.0
	Secondary	89	21.2
	Tertiary	88	21.0
	Informal	155	36.9
Attendance of cowpea field-days	None	251	59.8
	1-5 attendance	129	30.7
	>5 attendance	40	9.5
Contact with Extension Agents	None	186	44.3
	1-5 visit/contacts	139	33.1
	>5 visit/contacts	95	22.6

Assessing Farmers' Knowledge on Cowpea Production Technologies

Farmers' knowledge of new cowpea production technologies through the number of cowpea field-days attended and contacts with agricultural extension agents was determined. Cowpea field-days demonstrate and promote improved cowpea technologies. Over half of the farmers (60%) across the study areas, had not attended any field-day specifically on cowpea cultivation practices and about 10% had attended field-days for more than five times (Table 2). The trend was similar for contacts with extension services as 44.3% had no contacts and 33.1% had one to five visits/contact while only 23% had more than five contacts with extension agents. This demonstrates the need to provide farmers with training and education on improved cowpea

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agronomic practices to achieve sustainable productivity. Farmers' access to information and guidance through extension services could positively influence the use of improved varieties and other technologies (Umar *et al.*, 2014). For farmers to adopt new varieties, they must be educated on the benefits of the improved varieties. Extension services provide an excellent opportunity for exposing farmers to new technologies and innovations.

The poor access to extension personnel has been previously reported in Nigeria to be due to a low ratio of 1: 10, 000 extension agents to farmers (Haruna & Abdullahi, 2013; NAN, 2016), which is significantly lower than recommendation of 1: 800 - 1,000 extension agent to farmers by the World Bank for Nigeria. Contacts with extension personnel provide an excellent opportunity for agricultural information exchange including better crop management practices and soil fertility improvement strategies. Such information usually results in farmers having better knowledge about yield increasing factors. Agricultural input use and advisory guides are important to educate smallholder farmers on knowledge about crop management practices (Belt *et al.,* 2015).

Use of Improved Cowpea Varieties among Smallholder Farmers in Northwestern Nigeria

The cultivation of landraces (local varieties), vis-a-vis improved cowpea varieties, is still very popular among farmers. On average across the study areas, 79% of the respondents used landraces and only 21% used improved varieties (Figure 1). The 21% that reported the use of improved varieties includes farmers with separate farms planted to both improved and local varieties. Use of improved varieties was more popular at Tsanyawa, Albasu, Minjibir, and Matazu (Table 3). Our interviews and FGD confirmed that the use of improved cowpea varieties by farmers was low and adoption of improved varieties was mostly in areas with substantial contacts with projects like IITA programmes, and recently concluded USAID - commissioned cowpea up-scaling project in some northern Nigerian states of Kano, Katsina and Sokoto (Adetonah *et al.,* 2016; ICRISAT, 2017b). Some farmers said improved cowpea varieties were not used by them because they do not grow well in intercrops and they were more interested in planting cowpea as an intercrop.

Ten variables were hypothesized to determine farmers' decision to use improved cowpea varieties in the study areas as described earlier in Table 1. Four of these were found to be significant in influencing farmers' probability of adopting improved varieties. These are cropping system ($P < 0.05$), level of education ($P < 0.05$), years of experience in cowpea cultivation ($P < 0.1$) and contact with extension agents ($P < 0.001$) (Table 4). The cropping system and level of education were significant at 5%, while the contact with extension agents was the most significant factor that determines farmers' choice of using improved varieties. This is consistent with the opinion that farmers' education is an important factor for the successful adoption of farming technologies and recommendations (Hoffmann *et al.,* 2007). The model used to assess factors determining use of improved varieties of cowpea has been previously used to estimate factors influencing knowledge of Napier stunt disease (Khan e*t al.,* 2014)**,** knowledge of pea weevils (Mendesil *et al.,* 2016) and farmers' decision to use pesticides on vegetable crops (Sharma *et al.,* 2015)**.**

Farmers use, several names to describe some landraces that sounded like names of Projects/Programmes. These so-called local lines might be improved varieties introduced to farmers by different Projects/Interventions programmes, and the real names might have changed to local names overtime making it difficult to distinguish them from local cultivars. Based on the nomenclature and physical attributes of these cowpea lines, we believe these lines might be improved varieties since most of the names in question sounded like Projects or

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Programmes. These included names like Dan-Project (son of a project), Dan-Research (son of research), Kwankwaso (name of former Governor of Kano State), Dan-OC (son of officer-in-charge), Dan-KATARDA, Dan-KNARDA, and Dan-Acres (son of Acres). These are probably improved varieties that were introduced to farmers at different times. We did not try to clearly distinguish these as improved varieties and grouped them as landraces.

Further studies aimed at determining the level of adoption of improved cowpea varieties and their impact among smallholder farmers should determine when and where their varieties were obtained and take samples for identification using molecular tools. Widespread use of landraces over improved varieties was reported by farmers indicating there is poor adoption of improved varieties. Several reasons given by farmers include poor awareness of the existence of improved varieties and lack of access to the seeds. Similar reasons have been reported elsewhere where there was no involvement of end-users in the process of development and deployment of cowpea varieties (Nkongolo *et al.,* 2009). Horn *et al.* (2015) reported that over 70% of cowpea farmers in northern Namibia used landraces instead of improved varieties and 76% in northern Ghana used landraces (Akpalu *et al.,* 2014). Farmers indicated during interviews that their varietal preferences were mostly determined by market demand and consumption. This is consistent with Boukar *et al.* (2018) findings that white seeded grains are preferred and produced for local markets in northern parts, while brown seeded types are produced for markets in the southern parts of Nigeria. These findings corroborate earlier reports that market demand constitutes an important determinant for farmers to adopt and produce certain varieties (Coulibaly & Lowenberg-Deboer, 2002; Mishili *et al.,* 2007).

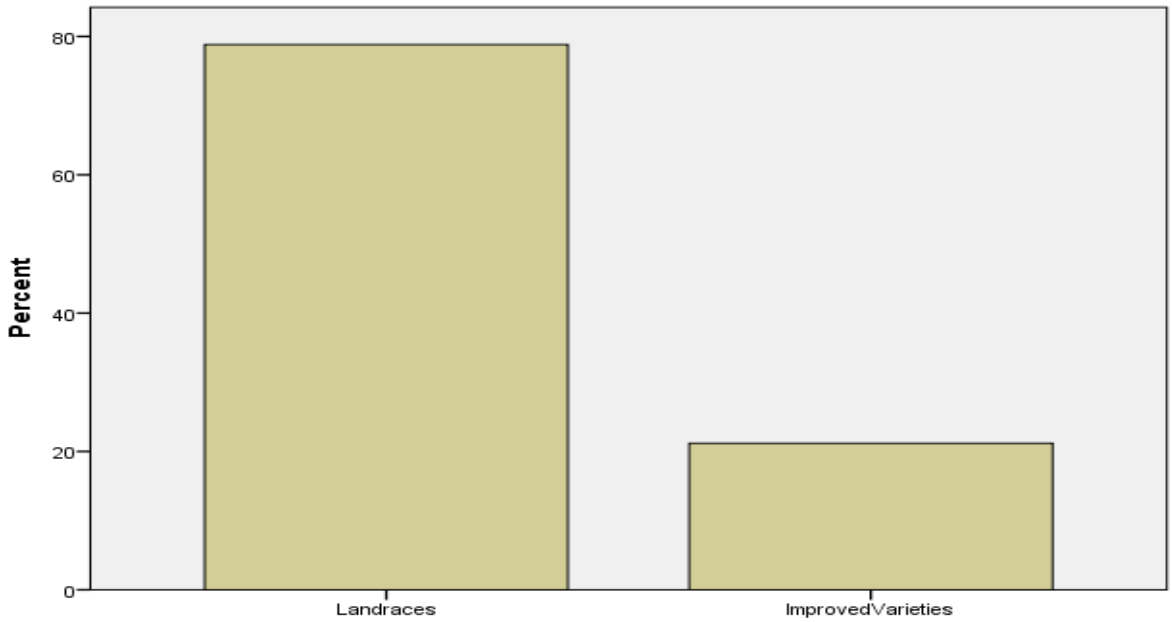

Figure 1: *Cultivation of improved varieties vis-a-vis landraces, where x-axis refers to the type of cowpea varieties used by farmers and y-axis represents percentage of farmers across the study areas.*

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Table 3: Percentage of Farmers reporting the Use of Local vis-a-vis Improved Varieties acros three States in the Northwest part of Nigeria in 2017

	Local Government Areas												
	Albasu	Birnin Gwari	Bunkure	Dandume	Danja	Giwa	Kaita	Kajuru	Makarfi	Matazu	Minjibir	Tsanyawa	Mean
Varieties in use by farmers (%)													
Landraces	45	100	94	97	97	86	93	100	90	71	46	29	79
Improved varieties	55	0	6	3	3	14	7	0	10	29	54	71	21

Table 4: Logit Outputs on Variable Influencing Use of Improved Cowpea Varieties in North-Western Nigeria

Variable	Coefficient	Standard Error	b/St. Er.	P[|Z|>z]
Constant	-4.994	2.264	-2.206	0.0274
Sex	0.148	0.502	0.295	0.7678
Marital status	-0.446	1.138	-0.392	0.6948
Age	0.199	0.191	1.040	0.2983
Household size	0.024	0.202	1.173	0.2407
Education	0.849	0.426	1.99	0.0462**
Experience cowpea	0.369	0.221	1.671	0.0946*
Def-Symptoms	0.060	0.573	0.105	0.9166
Cropping System	0.828	0.401	2.063	0.0391**
Field-days	0.290	0.285	1.018	0.3089
Extension contact	0.873	0.286	3.054	0.0023***

*P < 0.1, **P < 0.05, ***P < 0.001, N = 420, log likelihood = -100.7008, LR X^2 (11) = 53.39966, Prob > x^2 = 0.5788967E-05, Mcfadden pseudo-R^2 = 0.1746917

CONCLUSION AND RECOMMENDATIONS

The use of improved cowpea varieties among farmers in the dry savannah areas of Nigeria was low and most cowpea growers used landraces with low yield potential. Four out of the ten independent variables used to determine the probability of farmers' using improved cowpea varieties significantly influence the choice of farmers in adopting improved cowpea varieties. Adoption of improved varieties was positively related to the level of education and cowpea cropping systems at (P < 0.05) level of significance while contact with extension agents was found to be very significant at (P < 0.001) probability. Therefore, to achieve high and widespread use of improved varieties of cowpea, it is important to increase the level of awareness of improved varieties to farmers through extension services. Use of improved varieties will go a long way to increase farmers' productivity, income, and food security and could reduce poverty among cowpea farmers in the study areas and beyond. The study recommends that farmers' preferences should be incorporated into new varieties, as this will greatly facilitate their diffusion and adoption.

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