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Full Length Research Paper

Patterns and drivers of the adoption of improved groundnut technologies in North-western Nigeria

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The most recent groundnut varieties registered and released in Nigeria are SAMNUT 24, SAMUT 25 and SAMNUT 26. Using appropriate sampling procedures, a total of 224 representatives of farm-families were interviewed with 112 from administrative units where a development project is being implemented (PLGA), and 112 from administrative units where project interventions are absent (NPLGA). Results of the study reveal that improved groundnut varieties are becoming part of a multitude of groundnut varieties being cultivated by farmers in PLGA and NPLGAs. Amongst the improved groundnut varieties, SAMNUT 24 was being planted by 39% and 28% of households in PLGA and NPLGA, respectively. Similarly, amongst the varieties described as local, *Ex-dakar* is grown by 31% and 35% of households in PLGA and NPLGA, respectively. Five underlying factors were found to drive adoption decisions: *farming experience, age, education, access to (improved seeds and extension services) and household size.* Beyond the combined use of seeds of improved groundnut varieties and accompanying management practices, using the right combination of inputs to optimize financial gains remains a challenge to the households involved in the study.

Keywords: Improved groundnut technologies, adoption, Northwestern Nigeria.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most important oil seed crops. According to (Mukhtar, 2009), it is the fourth most important oil seed crop in the world. The production of the crop is estimated at 37.1 million metric tons grown on 26.4 million hectares worldwide, with an average productivity of 1.4 tons/ha. Developing countries constitute 97% of the global area cultivated (FAO, 2011). The production of the crop is concentrated in Asia and Africa, where it is grown mostly under rain-fed conditions with limited external inputs (Ibrahim *et al*., 2012).

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Nigeria is the third largest producer of groundnut in the world, after China and India. Depending on the variety, oil contents vary between 48-50%, and protein content estimated between 26-28% and between 11-27% micro-nutrients (carbohydrate, minerals and vitamin). The crop is commonly consumed during harvesting, roasted and eaten and processed into oil by smallholder farmers for domestic use and for sale. Like other legumes, groundnut is known to be nitrogen accumulator - an attribute which makes it feasible for resource limited farmers to save expenses on organic fertilizers. Saving cash income on fertilizers is particularly important in a context of perpetual rising costs of farm inputs, including interests on loans. According to Simtowe *et al.* (2008), its haulms and cake are rich in digestible crude protein and used as feed for ruminant livestock in the dry season. Unlike other crops, it is typically cultivated for sale in West and Central Africa (WCA) (Singbo *et al.,* 2016).

Smallholder farmers in savannah agro-ecological regions of WCA are very much aware of the benefits of cultivating groundnuts. It is planted in association with many other crops notably cereals. In Nigeria, groundnut is produced in all the agro-ecological zones of the country, though cultivation is conspicuous in (19) States located within the Sahel, Sudan, Northern and Southern Guinea. These States include The Federal Capital Territory (Federal Capital Territory/FCT-Abuja), Kano, Katsina, Kaduna, Jigawa, Sokoto, Zamfara, Kebbi, Adamawa, Bauchi, Yobe, Taraba, Borno, Benue, Plateau, Nasarawa, , Kogi, Niger and Kwara. (National Agricultural Extension and Research Liaison Services - NAERLS, 2011). Groundnut production in these States is most suitable in locations where the Guinea, Sudan and Sahel Savannah agro-ecological zones are found.

Beginning from 1990, twenty-six (26) improved groundnut varieties have been registered and released for commercial use in Nigeria (National Centre for Genetic Resources and Biotechnology, 2014). The scaling of these improved varieties, together with their accompanying management practices, have been the subject and object of USAID support to ICRISAT and development partners in Nigeria since 2015. This project entitled *Increasing Groundnut Productivity of Smallholder Farmers in Ghana, Mali and Nigeria* is being implemented in partnership with twelve (12) partners targeting three improved groundnut varieties SAMNUT 24, SAMNUT 25 and SAMNUT 26. Upon registration and release, the key features of these varieties are: *high pod yields- estimated at 2-2.5 tons/ha instead of less than 1 ton/ha; high haulm yields - estimated at between 2.5-3tons/ha; early maturity – between 80-95 days, making it possible for them to escape end of season droughts compared to other varieties which generally mature at about 120 days; high oil contents - at least 45% oil when processed, moderate resistance to popular groundnut diseases notably early and late leaf spot diseases and rosette virus, small to medium pods and tan in colour* making to fulfil both consumer and market preferences. Unlike many of the popular spreading groundnut varieties, farmers describe these improved varieties in Northern Nigeria to be *Atsaye* (or erect).

This study was initiated to determine the patterns and drivers of adoption of the improved groundnut varieties and recommended crop management practices being scaled out by the USAID funded project in three (3) out of five (5) States in North-western Nigeria. Project implementation started in January 2015 and the technologies being scaled out relate to improved varieties, accompanying crop and aflatoxin management practices. All scaling out efforts were complemented by intensive capacity building events targeting groundnut farmers and other value chain actors.

Underlying Theories of Technology Adoption

According to Loevinsohn *et al*. (2013), technology is the means of producing goods and services, including the procedures of its organization and delivery. The use of technologies helps to do work easier; its use is time and labour saving (Bonabana-Wabbi, 2002). Loevinsohn*et al*. (2013) consider adoption as the integration of technologies into existing practices; this may be proceeded by trials, adaptations and adoption. Broadly, the adoption of technologies can be divided into two comprehensive categories - awareness and effective use. While awareness is linked to the spread of information over time, effective use also describes the intensity of use (Bonabana-Wabbi 2002). This categorization makes it possible to present the adoption of agricultural technologies as discrete variables which can either take zero (for rejection) or one (for adoption). Similarly, three models are used to present the drivers of the adoption of technologies: (i) innovation-diffusion model (ii) economic constraints model and (iii) end-user's context model, also known as the adoption perception model (Negatu and Parikh, 1999). The diffusion of innovation model considers awareness as key to end-users' decisions to adopt technologies (Rogers, 2003). This model assumes that improved innovations are required to improve crop yields and farm-family livelihoods, therefore access to information about innovations can be a key constraint to adoption. The model emphasizes the role of agricultural extension services, farmer involvement in the development of agricultural innovations, mass media, etc. in scaling technologies from research (the source) to end-users (Negatu and Parikh, 1999). The economic constraint model assumes that there are resources notably credit and land that are important for decisions to either adopt or reject technologies. Therefore, resource endowment becomes a critical factor in the decision to either adopt or not to adopt technologies. The user's context model posits that characterising agro-ecological, socioeconomic and institutional contexts of potential users is a useful factor in determining technology adoption decision. This model emphasizes the involvement of farmers in the development of technologies; the aim being to generate technologies that are most appropriate to famers' contexts.

A number of authors have directly and indirectly used these models, either singly or in combination to explain the patterns and/or intensities of adoption of agricultural technologies. If a technology can be divisible into different components - seeds and accompanying crop management practices, the decision to adopt goes along with the decision to allocate resources and take minimum risks. In this case, an adoption decision-making process entails both an estimation of the frequency of its use (usually presented as an adoption rate) and the intensity or fundamental motives or drivers to adopt.

In general, the intensities (drivers) of adoption have been explained using i) characteristics of adopters such as sex, farm-size, age, level of cash income, level of education; ii) institutional factors notably access to land, contacts with extension services, access to credit, source of innovation, and iii) characteristics of the technology notably production/yield differences, storability, availability of the technologies and level of initial investments (costs) required; (iv) other factors including perception of end-users of the technologies, risks/uncertainties, soil type, etc.

RESEARCH METHODOLOGY

Sampling and sample selection

A combination of purposive and multi-stage sampling procedures was used to select representatives of households for the study. Purposive sampling was used at the first stage of the sampling procedure resulting in the retention of three out of five States: Kano, Jigawa and Katsina States. At the second stage of the sampling procedure, twenty (20) Local Government Areas (LGAs) were selected from each of the States where the USAID scaling project is being implemented (PLGAs) and a corresponding number were selected from LGAs where the project is not being implemented (NPLGA) resulting in a total of forty (40) LGAs. The third stage in the sampling procedure consisted of a random selection of a total of 224 groundnut producing households with 112 each from PLGAs and NPLGAs (Table 1). Interviews were then conducted with representatives of households based on their availability and willingness to participate in the exercise. Representatives of households not available or unwilling to participate in the interviews were systematically replaced using the snowball technique. In all cases of replacement, ADP extension agents of each LGA and community leaders were consulted.

Data collection and processing

Data were collected using a structured questionnaire with support from extension agents of the ADPs in the three States. The data collected included: socio-economic characteristics; sex, farming experience, household size, level of formal education, use of different groundnut varieties (local and improved), application of accompanying crop management practices (including pre- and post-harvest management of aflatoxin), cash and non-cash incomes, constraints limiting the use of each of the recommended technologies. Data were collected between March and April 2017 with a focus on the activities of the 2016 cropping season.
Consistency checks on responses provided by households were carried out at the end of each day on all the filled out questionnaires. Data entry was carried out using appropriate spread sheets of the SPSS – Statistical Package for the Social Sciences. Frequency counts were used to summarize the data collected. Two tools were used to determine the profitability of groundnut production: the Gross Profit Margin and Return on investment. While the Gross Profit Margin (GPM) was estimated using $GPM = \sum p_i q_i - \sum r_j x_j$;where GPM is the Gross Profit Margin; pi and qi represent the price and quantity of groundnut outputs and rj and xj are unit costs and quantity of the inputs reported.
Like in several other adoption studies, the binary probit model was used to determine the drivers of adoption (Ng'omb *et al.* 2014). Though the bivariate probit model which assess the effects of two related binary variables is increasingly being used in adoption studies (Jara-Rojas *et al.*, 2012; Chirwa, 2003), it was not used for this study given that this was not its primary objective. The binary probit model systematically isolates single productivity enhancing variables while assuming the others to be constant. This model has been, and is still being extensively used in determining factors responsible for the adoption of agricultural technologies. A few of these studies include those of Chianu *et al.* (2004); Doss (2003); Margaret and Samuel (2015); Meless (2015); Mugisha et al. (2004); Ndjeuga *et al*. 2012) and Ndjeuga *et al*. 2011);

The binary probit model used for this study is presented as follows:

$$A = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + u$$

Where:
A = Adoption of recommended technologies (Adopted =1 or Rejected =0)
β_0 = intercept
$\beta_1$to β_n = coefficients of X_1toX_n
u = error term
X_1 to X_n = each of the factors considered to drive adoption decisions

All statistical tests were done at 1%, 5% and 10% levels.

Basic information about study States

The three study States (Figure 1) are amongst the groundnut producing states of Nigeria. While Kano State harbours Kano City; the Commercial Centre of the entire Northern Nigeria, Jigawa and Katsina States have direct land boundaries with the Republic of Niger which provide opportunities for formal and informal cross-border trade on crops and livestock as well as their products. In general, extension services to farmers in each of the States is provided by a State Agricultural and Rural Development Authority, popularly known as ADP.
All the ADPs are organised into Extension Zones. Kano and Jigawa States were included into the USAID scaling project because they fall within the Feed the Future Zone of Influence (FtFZI). Though Katsina State is out of the

Table 1. Summary of sample sizes in the three States retained for the study.

Project Local Government Areas (PLGA)			Non-Project Local Government Areas (NPLGA)	
State	**Number of households**		**Number of households**	
Kano State	Tofa	5	Bagwai	5
	Kabo	3	Minjibir	3
	Garko	6	Kibiya	6
	Shanono	4	Wudil	4
	Bebeji	5	Bunkure	5
	Dawakin kudu	4	Gwarzo	4
	Bichi	5	Gezawa	5
Sub-total		**32**		**32**
JigawaState	Kazaure	7	Kaugama	7
	Taura	5	MalamMadori	5
	Kiyawa	9	Birnin Kudu	9
	Gagarawa	9	Dutse	9
	Babura	4	Buji	4
	Gumel	5	Ringim	5
	Maigatari	5	Jahun	5
Sub-total		**44**		**44**
KatsinaState	Kankia	7	Jibiya	7
	Mashi	7	Daura	7
	Dutsin-Ma	8	Sandamu	8
	Safana	5	Kurfi	5
	Zango	5	Rimi	5
	Musawa	4	Batagarawa	4
Sub-total		**36**		**36**
Totals		**112**		**112**

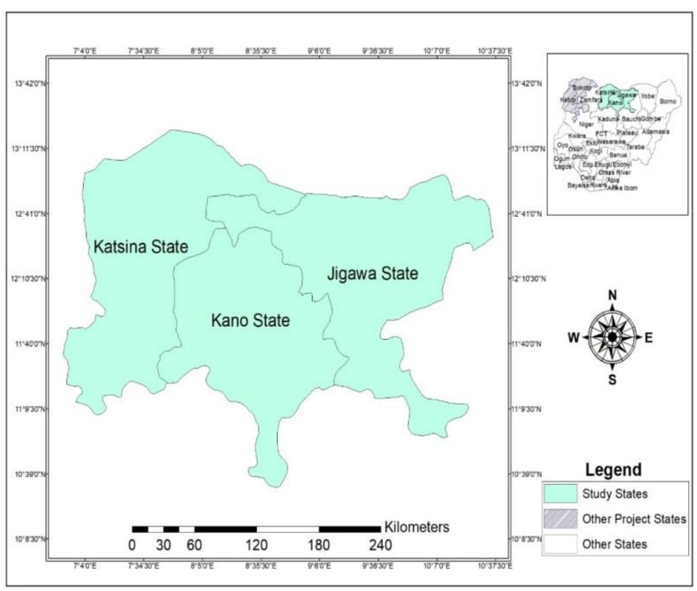

Figure 1. Map of the Federal Republic of Nigeria showing study states.

FtFZI, the State was included to further enhance (leverage) the impacts of efforts of varietal development, for example, the Katsina State Agricultural and Rural Development Authority (KTARDA) has consistently been involved in Farmer Participatory Varietal Selection (FPVS) exercises of improved groundnut varieties over the past one decade including the improved groundnut varieties being promoted by the USAID scaling project.

A total of 20 LGAs were selected for project implementation comprising seven from Kano (out of a total of 44 LGAs); seven from Jigawa State (out of a total of 27 LGAs) and six from Katsina (out of a total of 34 LGAs). In each State, the criteria for selecting LGAs were i*) Feed the Future Zone of Influence ii) important groundnut production area, iii) potential for high impacts iv) accessibility and security v) presence of other implementing partners vi) size of the region and potentials of high women involvement*

Annual rainfall figures in the States vary from 300-1200mm. The number of plant growing days ranges from 90-200. Apart from groundnut, other crops popularly grown by small scale farmers are cowpea, sorghum, millet, maize, cassava and sweet potatoes. All categories of livestock; cattle, sheep, goats, donkeys, camels, goats and chickens constitute part of the farming system. Irrigation schemes are also being developed by the State government for rice and vegetables (onions, pepper and tomatoes).

According to the 2016 population census, the population of the three States were: 9,383,683 for Kano State, 5,792,578 for Katsina State, and 2,829, 929 for Jigawa State. With an annual national population growth rate estimated at 3.3%, these figures are expected to have changed in 2018. Though there are several ethnic/tribal groups (including foreigners) in these States, the farming population are located outside urban LGAs and comprise the Hausa, Fulani and other ethnic/tribal groups (State-based Population Census Reports, 2006).

RESULTSAND DISCUSSIONS

Profile of representatives of the household heads interviewed

The socio-demographic profiles of respondents in PLGAs and NPLGAs are summarised in Table 2. In a region were socio-cultural norms restrict women to certain activities, it is no surprise that most of those interviewed were men (87% in PLGA and 92% in NPLGA), apt in Koranic education than the English Language (61% in NPLGA and 35% in PLGA). Respondents belong to farming groups in PLGAs (73%) and 26% in NPLGA) and carry out crop farming activities on purchase lands (48% in PLGA and 55% in NPLGA). They are generally less than 50 years old and have household sizes with mean of 20 persons in both PLGA and NPLGA. Respondents had at least 30 years of farming with a minimum of 20 years cultivating groundnut in NPLGA and 23 years in PLGA. Mean farm size devoted to groundnut cultivation was about 2 hectares in both PLGA and NPLGA. In terms of extension service support and access to the improved groundnut varieties being promoted by the USAID groundnut funded project and partners, all those interviewed in PLGAs reported having contacts with extension agents (Table 3). Nearly 58% of those interviewed in PLGA and 64%) reported having monthly contacts with extension agents. The sources of extension support were chiefly the State ADPs (93% in PLGAs and 86% in NPLGAs). Farmer groups selected for community-based seed production received improved groundnut varieties from the ADPs; ICRISAT provided breeder and foundations seeds to project partners as revolving funds with equivalent values recuperated after each harvest.

Groundnut varieties grown across the study site

Table 4 shows that the three improved groundnut varieties are being promoted and cultivated alongside a wide range of other varieties described as *local* by the respondents in both PLGA and NPLGA. While SAMNUT 24 was reported being planted by 39% and 28% in PLGA and NPLGA, respectively, *Ex-Dakar* was reported being grown by 31% and 35% of those interviewed in PLGA and NPLGA, respectively. *Jargyada and Maibargo* were also popular local varieties in both PLGA and NPLGA. This pattern is similar to findings of ICRISAT (2007) from the implementation of a sustainable groundnut seed systems project from where an overall adoption rate of improved varieties was estimated to be 32%.

Apart from the popular improved and local groundnut varieties, the varieties are location specific with SAMNUT 26, *Kwankwaso, Yarkosoma, Badankama, Mai-Atampa, Maizabuwa, Ayaya and Maikwarwa* only found in a limited number of LGAs in both PLGA and NPLGA. The restriction of SAMNUT 26 to Katsina and Jigawa States is most probably explained by long-standing interactions of on-farm research teams and lead farmers during FPVS exercises and subsequent awareness raising efforts. SAMNUT 25 is reported to be grown in combination with other improved groundnut varieties in Kano and Katsina States. A combination of all the improved groundnut varieties is evident in all the three States of the study.

While combinations of both improved and local groundnut varieties as shown in Table 4 confirm the effective presence of improved groundnut varieties in both PLGA and NPLGA, this may raise apprehensions if these blends are taking place on farmer's seed production plots. Proactive measures are being implemented by the USAIF funded project to sustain the purity of the varieties being promoted. These measures include on-station re-evaluation, back-stopping of private seed companies in the production and distribution of Foundation Seeds, enhanced certification by the National Agricultural Seeds Council (NASC), continual awareness and targeted trainings.

As should be imagined, varieties described as local could merely be designations by different tribal/ethnic groups of the States included in the survey. This is a classic example of the onset of an acculturation process. According to Ndjeunga *et al.* (2006) Ex-dakar is an improved variety introduced into Nigeria in 1988 from Senegal as IRHO/CRA Bambey and eventually registered

Table 2. Socio-demographic profile of respondents.

Variable	Kano State		Katsina State		Jigawa State		Pooled Results	
	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA
Sex of respondents								
Female	6(5.36)	4(3.57)	6(5.36)	3(2.68)	2(1.79)	1(0.89)	14(12.50)	8(7.14)
Male	26(23.21)	28(25.00)	30(26.79)	33(29.46)	42(37.50)	43(38.39)	98(87.50)	104(92.86)
Level of Educational								
Non/no-formal education	13(11.61)	23(20.54)	7(6.25)	18(16.07)	19(16.96)	28(25.00)	39(34.82)	69(61.61)
Primary education	19(16.96)	11(9.82)	14(12.50)	14(12.50)	8(7.14)	4(3.57)	41(36.61)	29(25.89)
Secondary education	7(6.25)	3(2.68)	5(4.46)	4(3.57)	4(3.57)	5(4.46)	16(14.29)	12(10.71)
Tertiary education	2(1.79)	1(0.89)	4(3.57)			1(0.89)	6(5.36)	2(1.79)
Member of farming group (cooperative)								
Member	32(28.18)	12(10.71)	26(23.42)	7(6.25)	24(21.61)	10(8.93)	82(73.21)	29(25.89)
Not a member	8(7.14)	31(27.68)	13(11.61)	27(24.11)	9(8.04)	25(22.32)	30(26.79)	83(74.11)
Patterns of access to farm-land								
Inherited	10(8.93)	5(4.46)	14(12.50)	3(2.68)	21(18.75)	7(6.25)	45(40.18)	15(13.39)
Purchased	22(19.64)	19(16.96)	13(11.61)	23(20.54)	19(16.96)	20(17.86)	54(48.21)	62(55.36)
Communal	-	3(2.68)	-	5(4.46)	-	14(12.50)	-	22(19.64)
Rented	1(0.89)	-	3(2.68)	2(1.79)	-	3(2.68)	4(3.57)	5(4.46)
Gift	1(0.89)	-	-	2(1.79)	-	-	1(0.89)	2(1.79)
Household owned	2(1.79)	-	1(0.89)		5(4.46)	6(5.36)	8(7.14)	6(5.36)
Age of respondent (years)								
Minimum	23	19	25	20	26	18	25	19
Maximum	68	75	75	72	70	75	71	74
Mean	46	47	50	46	48	47	48	47
Household size (absolute numbers)								
Minimum	4	3	2	5	3	4	3	4
Maximum	37	34	33	35	38	39	36	36
Mean	21	19	18	20	21	22	20	20
Farming experience (years)								

in Nigeria as SAMNUT 14. Kwankwaso, a large seeded groundnut kernel is the name of a village in Kano State. Similarly, Jargyda is the description of small seeded red groundnut kernel while Mai-Atampa, Kampala, Maibargo, Maizabuwa (groundnut with strips like those of guinea fowl. Therefore, irrespective of varietal identity, the kernel itself could assume different names amongst different tribal/ethnic groups of Nigeria. As Abdulrahaman *et al*. (2014) posit, the crop itself has different names amongst different tribal/ethnic groups of Nigeria; for example, “Epa” in Yoruba, “Gyada” in Hausa, “Asibpko“ in Ibo, “Isagwe” in Benin. It is common that registered and released groundnut varieties assume different names as they are introduced and become part of different communities of Nigeria.

Table 2 Cont.

Minimum	3	7	4	3	3	5	3	5
Maximum	59	61	53	57	56	59	56	59
Mean	31	34	29	30	30	32	30	32
Groundnut specific farming experience (years)								
Minimum	3	2	1	2	2	2	2	2
Maximum	46	39	40	35	43	37	43	37
Mean	25	21	21	19	23	20	23	20
Farm size (ha)								
Minimum	0.25	0.5	0.75	0.25	0.5	0.75	0.5	0.5
Maximum	1.5	2.5	3.5	3.5	4.5	3.75	3.17	3.25
Mean	0.88	1.5	2.13	1.88	2.5	2.25	1.83	1.88

Table 3. Contacts with extension services across the States.

Variable	**Kano State**		**Katsina State**		**Jigawa State**		**Pooled results**	
	PLGA	**NPLGA**	**PLGA**	**NPLGA**	**PLGA**	**NPLGA**	**PLGA**	**NPLGA**
	F(%)	**F(%)**	**F(%)**	**F(%)**	**F(%)**	**F(%)**	**F(%)**	**F(%)**
Contacts with extension agent								
Have contact	32(29)	29(26)	36(32)	26(23)	44(39)	22(20)	112(100)	77(69)
No contact	-	12(11)	-	9(8)	-	14(13)	-	35(31)
Frequency of the contact with extension agents								
Weekly	3(23)	-	4(4)	3(3)	-	1(1)	7(6)	4(5)
Bi-weekly	12(11)	7(6)	9(8)	9(8)	8(7)	5(4)	29(26)	21(27)
Monthly	22(20)	19(17)	20(18)	12(11)	24(21)	18(16)	66(59)	49(64)
Quarterly	3(3)	1(1)	2(2)	2(2)	5(4)	-	10(9)	3(4)
Sources of extension support								
State ADP	37(33)	23(21)	41(37)	27(24)	26(23)	16(14)	104(93)	66(86)
State Ministry of Agriculture	1(1)	4(4)	1(1)	-	4(4)	3(3)	6(5)	7(9)
NGO	2(2)	1(1)	-	1(1)	-	2(2)	2(2)	4(5)
Access to revolving seed credit (community-based seed producers)								
Have access	32(29)	8(7)	35(31)	4(4)	44(39)	10(9)	111(99)	22(20)
No access		43(38)	1(1)	31(28)	-	16(14)	1(1)	90(80)
Source of credit (improved groundnut varieties to farmer groups and/or demonstrations)								
ICRISAT	32(29)	-	35(31)	-	44(39)	-	111(99)	-
ADP	--	-	1(1)	-	-	7(6)	1(1)	7(32)

(*) Absolute values followed by percentages in parentheses

Table 4. Groundnut varieties being grown by respondents across selected States.

	Kano State		Katsina State		Jigawa State		Pooled Results	
Variables	**PLGA**	**NPLGA**	**PLGA**	**NPLGA**	**PLGA**	**NPLGA**	**PLGA**	**NPLGA**
	F(%)	**F(%)**	**F(%)**	**F(%)**	**F(%)**	**F(%)**	**F(%)**	**F(%)**
Improved groundnut varieties								
Samnut-23 only	-		3(8)	1(3)	8(18)	4(9)	11(10)	5(4)
Samnut-24 only	16(50)	10(31)	13(36)	8(22)	15(34)	13(30)	44(39)	31(28)
Samnut-26 only	-	-	-		2(5)	7(16)	2(2)	-
Samnut-21 and 26	-	-	-		1(2)	-	1(1)	-
Samnut-23 and 24	3(9)	-	10(28)		5(11)	-	18(16)	-
Samnut-23, 24and25	2(6)	-	1(3)		-	-	3(3)	-
Samnut-24 and 25	6(19)	-	3(8)		5(11)	-	14(13)	-
Samnut-22 and 24	1(3)	-	-		-	-	1(1)	-
Samnut-24 and 26	-	-	1(3)		-	-	1(1)	-
Samnut-24, 25and 26	4(13)	-	3(8)		4(9)	-	11(10)	-
Samnut-25 and26	-		2(6)		4(9)	-	6(5)	-
Totals	**32(100)**	**10(31)**	**36(100)**	**9(25)**	**44(100)**	**24(55)**	**112(100)**	**36(32)**
Local groundnut varieties								
Jargyada	11(34)	2(6)	9(25)	5(14)	14(32)	6(14)	34(30)	13(12)
Ex-Dakar	13(41)	11(34)	10(28)	14(39)	12(27)	14(32)	35(31)	39(35)
Maibargo	3(9)	8(25)	13(36)	12(33)	5(11)	7(16)	21(19)	27(24)
Kwankwaso	3(9)	6(19)	-	-	-	3(7)	3(3)	9(8)
Yarkosoma	2(6)	-	-	-	9(20)	-	11(10)	-
Badankama	-	-	4(11)	-	4(9)	5(11)	8(7)	5(4)
Mai Atampa	-	-	-	-	-	6(14)	-	6(5)
Maizabuwa	-	2(6)	-	3(8)	-	-	-	5(4)
Ayaya	-	1(3)	-	2(6)	-	3(7)	-	6(5)
Maikwarwa	-	2(6)	-	-	-	-	-	2(2)
Totals	**32(100)**	**32(100)**	**36(100)**	**36(100)**	**44(100)**	**44(100)**	**112(100)**	**112(100)**

(*) Absolute values followed by percentages in parentheses.

Patterns of adoption of recommended groundnut technologies across the study States

Table 5 presents the adoption patterns of recommended management practices promoted by the project. These include seed/seed management, agronomic and aflatoxin management practices. It is evident that the uptake of recommended groundnut-based technologies differs between PLGA and NPLA, due to project actions essentially demonstrations, availability of improved seeds and persistent awareness capacity strengthening.

With respect to seed and seed management, while all (100%) of those interviewed in PLGA reported using improved groundnut varieties, only 32% of those included in the survey reported using improved groundnut varieties. Perhaps due to unavailability of improved groundnut varieties in NPLGA, over 90% rely on seeds of previous cropping seasons for planting. The most recent study by McGuire and Sperlin (2015) confirmed that farmers' saved seeds provide as much as 1/3 of seeds sown by African farmers. Similar findings had earlier been reported by Bezner-Kerr (2013) and Cavatassi *et al.* (2011) and Guei *et al.* (2011).

Table 5. Patterns of adoption of recommended groundnut technologies across study States.

Variables	Kano State		Katsina State		Jigawa State		Pooled Results	
	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA
	F(%)	F(%)	F(%)	F(%)	F(%)	F(%)	F(%)	F(%)
Category 1: Seed and seed management								
- Use seeds of improved groundnut varieties	32(100)	10(31)	36(100)	9(25)	44(100)	17(39)	112(100)	36(32)
- Use seeds from previous harvests	15(47)	30(94)	11(31)	34(94)	21(48)	40(91)	47(42)	104(93)
- Shell seeds during planting season	22(69)	24(75)	29(81)	26(72)	34(77)	33(75)	85(76)	83(74)
- Dress seeds before planting	7(22)	-	4(11)	-	5(11)	-	16(14)	-
- Put pods/kernels into similar groups before planting	20(63)	15(47)	22(61)	13(36)	17(30)	8(18)	59(53)	36(32)
Means	**19(60)**	**20(56)**	**20(57)**	**21(42)**	**24(55)**	**25(53)**	**64(57)**	**65(46)**
Category 2: Agronomic practices								
- Use farms that have been in fallow for plant g.nuts	6(19)	-	-	1(3)	-	2(5)	6(5)	3(3)
- Use traction animals for land preparation	15(47)	14(44)	17(47)	7(19)	22(50)	13(30)	54(48)	34(30)
- Use tractor for land preparation	5(16)	1(3)	2(6)	1(3)	2(5)	-	9(8)	2(2)
- Apply pre-emergence herbicides for weeds	9(28)	-	10(28)	-	7(16)	-.	26(23)	-
- Plant when rains are fully established	31(97)	28(88)	33(92)	30(83)	40(91)	95(95)	104(92)	100(89)
- Plant at 10X75cm/2 seeds per hole	17(53)	-	13(36)	-	19(43)	-	49(44)	-
- Apply SSP (2 bags/ha and NPK 1 bag/ha)	29(91)	-	16(44)	-	26(59)	-	71(63)	-
- Use farm yard manure	15(47)	11(34)	12(33)	7(19)	17(39)	3(7)	44(39)	21(19)
- First weeding at 3-4 weeks after sowing	25(78)	7(22)	23(64)	12(33)	27(61)	6(14)	75(67)	25(22)
- Second weeding at 6-8 weeks after sowing	19(59)	3(9	21(58)	5(14)	20(45)	2(5)	60(54)	10(9)
- Remove physically weak stands and off-types	17(53)	-	15(42)	-	16(36)	-	48(43)	-
Means	**17(53)**	**1(19)**	**16(41)**	**9(18)**	**20(41)**	**20(14)**	**50(44)**	**28(16)**
Category 3: Aflatoxin management practices								
- Dry pods on-farm between 5-7 days after lifting	16(50)	15(47)	21(58)	19(52)	18(41)	15(34)	55(49)	49(44)
- Check pods for moisture contents before stripping	20(63)	14(44)	21(58)	11(31)	24(55)	13(30)	65(58)	38(34)
Means	**18(56)**	**15(45)**	**21(58)**	**15(42)**	**21(48)**	**14(32)**	**60(54)**	**44(39)**

(*) Absolute values followed by percentages in parentheses.

In situations like this, the adoption of improved seeds may also imply the re-use of seeds already with farmers while varieties with potentials for productivity enhancement and profitability remain on the shelf of breeders. As Ojiewo *et al.* (2018) rightly argued, the wide scale adoption of improved legume varieties is as important as their development and release. Mean adoption intensities of seeds and seed management practices was 57% in PLGA as against 46% in NPLGA.

In terms of agronomic practices, a mean score of 44% emerged in PLGA as against 16% in NPLGA. The application of pre-emergence herbicides was reported not being used in NPLGA while recommended planting densities were not respected and fertilizers were not applied in NPLGA. As reiterated by Ajeigbe *et al.* (2016), farmers in WCA plant grain crops in rows spaced at 75cm because most tractors and animal drawn ridgers are fixed at widths of 75 cm between rows. Indeed, this practice has been transformed into a recommended practice of 75 cm x 20cm.

Nigam *et al*. (2006) opined that optimum plant spacing is key to higher yields in groundnut production. Combining improved groundnut varieties with appropriate fertilizers and optimum plant densities could increase groundnut productivity and profitability to smallholder farmers. It is known that the use of adequate doses of appropriate fertilizers also enhance root development and improve the availability of required nutrients for all crops including groundnut. As pointed out by Ndjeunga *et al.* (2006), differences in groundnut productivity in WCA can also be explained by deviations in the use of adequate inputs.
Also, as shown in Table 5, drying pods after lifting was reported by 44% of the households interviewed while checking pods for moisture contents was reported by 34% of those involved in the survey. These are core aspects of post-harvest management of aflatoxin contamination in the groundnut production. With a mean adoption score of 39% interventions of the USAID project persistently created awareness on, and demonstrated pre-and post-harvest management options for managing aflatoxin contamination Vabi *et al.* (2017).

Drivers of adoption of improved groundnut technologies

Due to practical difficulties, few adoption studies have used bivariate models in explaining farmer adoption behaviors (Chirwa, 2003; Jara-Rojas *et al,* 2012; Thuo *et al*., 2014). However a plethora of adoption and/or impact studies have confirmed the relations between technology adoption and a series of factors: *farming experience, age, household size, literacy level or education, access to information, credit and extension services.* Of importance to this study are those of Dhraie *et al.* (2018), Mbavai *et al.* (2015), James (2014), Bello (2011), Ahmed *et al.* (2000), Adzawla *et al.* (2016), Idoko and Sabo (2014), Idrisa, (2012), Bello *et al*. (2011), Meless (2015).Three (3) categories of mutually reinforcing factors, summarised in Table 6, positively influenced the adoption decisions of those included in this survey. These are:

Category 1: Farming experience positively influenced the adoption of the improved groundnut varieties and accompanying crop management practices at 1%, 5% and 10% levels of significance. Muhammad, (2015) and Bello, (2011) also reported that farming experience positively and significantly influenced the adoption of agricultural technologies.

Category 2: Access to improved seeds and extension services: while regular contacts between farmers and extension services enhances awareness about improved technologies, access to quality seeds and ability to secure farm inputs (including land and credit) can hinder adoption decisions. Therefore, both ability to access extension services and improved seeds positively influenced the decision to adopt improved groundnut technologies at 5% and 10% levels of significance, respectively. This finding upholds that of Thuo *et al.* (2014) who reported positive associations between access to credit and other farm inputs notably small-scale farm equipment.

Category 3: Age, education and household size. This trio positively influenced the decision to adopt or reject the use of groundnut technologies at 1% and 5% levels of probability. These findings agree with those of Doss (1999) who reported that, age and education significantly affect adoption decisions, and the findings of James (2014) who also found household size to be positively linked to the adoption of groundnut technologies.

Financial gains from adopting improved groundnut technologies in selected States

Assessing the ‘impacts’ of agricultural technologies encompasses at least three components) beneficiaries level impacts ii) effectiveness of delivery and iii) institutions (Anderson and Herdt, 1990; Moshi *et al*., 1998). Beneficiary level impacts comprise the use of different tools to analyse allocative efficiencies, socio-cultural and environmental impacts. This study uses the Gross Profit Margin (GPM) and Returns on Investment (RoI) to assess farm-level allocative efficiencies. It is recognised that a profitable technology enhances its chances of adoption by small-scale farmers.

Table 7 summarises the operational (variable costs) and revenue generated from producing groundnuts in PLGAs and NPLGAs. The cost items comprise seeds, fertilizers/pesticides, rents for farm land, farm labour and transportation of produce from farms to homes. The cost of farm labour for different operations emerged as the most important item in groundnut production, accounting for 49% in PLGAs and 51% in NPLGAs. This corroborates with earlier findings from Focused Group Discussions with groundnut value chain actors in the five States where the USAID project is being implemented (Vabi *et. al.*, 2018). The GPM in PLGAs and NPLGA were 60,136 Naira (about $197) and 18, 256 (about $60), respectively, which is a measure of potential financial gains that smallholder farmers can secure from the adoption of groundnut-based technologies. Returns per Naira invested are 91 Kobo (about 2.78 cents) in PLGAs and 37 Kobo (about 1.13 cents) in NPLGA, suggesting that by adopting recommended groundnut technologies, groundnut farmers in the study States could increase farm-level productivity and cash incomes. Similar results were reported by Kassie *et al.* (2010) in Uganda and Ajeigbe *et al.* (2016) in Nigeria. Whether in PLGAs or NPLGAs, allocative efficiency can be improved through respecting adequate plant densities (planting at 10cm x 75cm), tactical sourcing of farm labour (substituting hired labour with family labour), identifying and recruiting more efficient farm labour, working on the number of persons handling different farm operation, etc. Table 8 demonstrates that groundnut production engages men, women and children making it a potential option for cost-efficient combination of farm labour. A thoughtful combination of hired and family labour and/or male/female farm labour, could help smallholder farmers

Table 6. Drivers of adoption of improved groundnut technologies (Seeds and accompanying crop management practices and aflatoxin).

Variables	UIGV		SSPS		TSBP		UPSS					
Improved groundnut varieties (Seeds)	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**				
Farming experience (years)	1.161	.098*	1.025	.415	1.011	.631	1.002	.936				
Contact with extension agents	.125	.047**	1.001	.988	.409	.056**	1.001	.979				
Access to credit	.104	.097*	1.221	.742	1.032	.539	.695	.439				
Constant	-21.949	.899	20.504	.054	.103	.062	2.065	.539				
	UFF		**UTA**		**UTT**		**APEH**		**PRE**		**10X75cm/2SH**	
On-farm crop management practices (a)	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**	**Coeff.**	**Sign**	**Coeff.**	**Sign**
Farming experience (years)	1.161	.010***	1.005	.838	.988	.744	1.030	.216	1.029	.517	.302	.018**
Age (years)	.884	.099*	.985	.559	.998	.961	1.002	.943	1.063	.336	1.005	.865
Years of education	1.204	.116	.992	.864	.899	.404	1.058	.268	1.256	.131	.344	.034**
Household size	.931	.480	.659	.360	1.022	.717	1.017	.612	.923	.150	.933	.042**
Access to credit	.829	.884	1.087	.014**	12.089	.040**	1.022	.964	.259	.240	.973	.625
Constant	.086	.441	.880	.912	.072	.237	.128	.094	8.188	.998	1.167	.906
	NPK and SSP		**FYM**		**FW3-4W**		**SW6-8W**		**RPWS**			
On-farm crop management practices (b)	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**		
Farming experience (years)	.894	.026**	.971	.559	.989	.829	1.155	.007**	1.219	.069		
Household size	.965	.279	1.038	.242	1.078	.042**	1.036	.273	.892	.014**		
Constant	9.345	.071	1.796	.617	3.280	.321	.428	.469	2.807	.551		
	DP5-7D		**SPMC**		**SKHG**							
Post-harvest management practices	**Coeff.**	**Sign.**	**Coeff.**	**Sign.**	**Coeff.**	**Sign**						
Farming experience (years)	1.070	.009***	.998	.944	1.055	.056**						
Constant	.706	.768	7.995	.234	.097	.057						

*, ** and*** = statistically significant at 10%, 5% and 1% levels, respectively

Variables: UIGV = Use improved groundnut varieties; SSPS = Shell seeds during planting season; TSBP = Treat seeds before planting; UPSS = Use seeds from previous season; UFF = Use fallow fields; UTA = Use animal traction; UTT = Use tractor for tilling; APEH = Apply pre-emergence herbicides; PRE = Planting when rains are fully established; 10x75cm = Plant at 10x75cm/2 seeds per hole; Apply SSP/NPK = Apply SSP (2 bags/ha and NPK 1 bag/ha); FYM = Use farm yard manure; FW3-4Wb = First weeding at 3-4 weeks after sowing, SW6-8W = Second weeding 6-8 weeks after sowing, RPWS = Remove physically weak plants and off-types; DP5-7D = Dry pods on-farm between 5 -7 days after lifting, SPMC = Shake pods for moisture contents before stripping.

Table 7. Profitability of groundnut production in the Study States (2016 Cropping Season).

	Kano State		Katsina State		Jigawa State		Pooled Results	
Expenditure Items	**PLGA**	**NPLGA**	**PLGA**	**NPLGA**	**PLGA**	**NPLGA**	**PLGA**	**NPLGA**
Other inputs (except labour)								
Seeds (Kg)	10,905(16)	8,935(18)	11,229(17)	9,155(19)	1,1118(17)	9,015(18)	11,084(17)	9,035(18)
Fertilizers (Kg)	16,800(25)	5,935(12)	16,890(25)	5,900(11)	16,980(26)	5,970(12)	16,890(25)	5,935(12)
Agrochemicals (Litre)	740(1)	605(1)	820(1)	630(1)	810(1)	610(1)	790(1)	615(1)
Farm Yard Manure (Kg)	2,645(5)	1,657(3)	2,670(4)	1,700(3)	2,650(4)	1,614(3)	2,655(4)	1,657(3)
Hiring of land (N/ha)	993(2)	760(2)	796(1)	740(2)	890(1)	834(2)	893(1)	778(2)
Storage (N/bag)	1,742(3)	1,470(3)	1,900(3)	1,482(3)	1,884(3)	1,476(3)	1,842(3)	1,476(3)
Sub-total (a)	**33,825(51)**	**19,362(39)**	**34,305(52)**	**19,607(40)**	**34,332(52)**	**19,519(39)**	**34,154(52)**	**19,496(39)**
Farm labour								
Land preparation	6,719(10)	5,296(11)	6,534(910)	5,150(10)	6,616(10)	5,250(11)	6,623(10)	5,232(11)
Planting	5,600(9)	5,890(12)	5,626(9)	5,910(12)	5,613(8)	6,014(12)	5,613(8)	5,938(12)
Fertilizer Application	3,706(6)	3,550(7)	3,862(6)	3,617(7)	3,850(6)	3,600(7)	3,806(6)	3,589(7)
Weeding	8,563(13)	6,460(13)	8,566(13)	6,440(13)	8,476(13)	6,477(13)	8,513(13)	6,459(13)
Harvesting	5,750(9)	7,658(16)	5,613(8)	7,666(16)	5,776(9)	7,650(15)	5,713(9)	7,658(16)
Transport Cost (N/100kg bag)	1,794(3)	1,050(2)	1,940(4)	1,000(2)	1,948(3)	1,010(2)	18,94(3)	1,020(2)
Sub-total (b)	**32,132(49)**	**29,904(61)**	**32,141(48)**	**29,783(60)**	**32,279(48)**	**30,001(61)**	**32,162(49)**	**29,896(51)**
Total Operational Costs (a+b)	**65,957.00**	**49,266.00**	**66,446.00**	**49,390.00**	**66,595.00**	**49,520.00**	**66,316.00**	**49,392.00**
Output/Yield (Kg/ha)	1,137.10	428.00	1,081.36	458.00	1,109.23	458.00	1,109.23	448.00
Average market price (N/Kg)	113.00	149.00	115.00	153.00	114.00	151.00	114.00	151.00
Total Revenue	**128,492.30**	**63,772.00**	**124,356.40**	**70,074.00**	**126,452.22**	**69,158.00**	**126,452.22**	**67,648.00**
Gross Profit Margin (GPM)	**62,535.30**	**14,506.00**	**57,910.40**	**20,684.00**	**59,857.22**	**19,638.00**	**60,136.22**	**18,256.00**
Gross Profit Margin (%)	**49%**	**23%**	**47%**	**30%**	**47%**	**28%**	**48%**	**27%**
Returns on Naira Invested	**0.95**	**0.29**	**0.87**	**0.42**	**0.90**	**0.40**	**0.91**	**0.37**

(*) Absolute values followed by percentage in parentheses.

Table 8. Sources and categories of farm labour employed in groundnut production.

Variable	Kano State		Katsina State		Jigawa State		Pooled Results	
	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA
	F(%)	F(%)	F(%)	F(%)	F(%)	F(%)	F(%)	F(%)
Sources of farm labour								
Hired labour	4(4)	5(4)	13(12)	3(3)	3(3)	7(6.25)	20(18)	15(13)
Family Labour	13(12)	14(13)	11(10)	9(84)	15(13)	18(16.07)	39(35)	41(37)
Family and Hired labour	18(16)	16(14)	14(13)	22(20)	21(19)	18(16.07)	53(47)	56(50)
Sex of farm labour								
Male	43(38)	34(30)	37(33)	47(42)	52(46)	31(28)	132(86)	112(78)
Female	12(11)	16(14)	4(4)	9(8)	6(5)	6(5)	22(14)	31(22)
Categories of farm labour								
Adult male	36(32)	32(29)	41(37)	30(27)	28(25)	27(24)	105(68)	89(62)
Adult female	4(4)	3(3)	1(1)	6(5)	3(3)	5(4)	8(5)	14(10)
Male child	13(12)	7(6)	4(4)	5(4)	10(9)	11(10)	27(18)	23(16)
Female child	4(4)	8(7)	2(2)	5(4)	8(7)	4(4)	14(9)	17(12)

(*) Absolute values followed by percentages in parentheses.

to secure cost effective labour combinations. Similarly, efficiency on the cost of production can be reduced through securing discounts on bulk purchases of farm-inputs by smallholder farmers and/or annual tactful increases in market prices of certified seeds.

CONCLUSION

Despite the socio-economic importance of groundnut to the Nigerian economy, productivity of the crop is lower (about 1.2 t/ha) compared to global averages of between 1.7 and over 3 t/ha. Prospects for enhancing productivity of the crop exist through the adoption of both improved varieties and accompanying crop management practices. Despite the multitude of factors limiting technology adoption, improved groundnut varieties SAMNUT 24, SAMNUT 25 and SAMNUT 26 are becoming part of the multitudes of groundnut varieties cultivated by farmers in PLGA and NPLGAs of the States targeted for this study. However, productivity gains resulting from the adoption of these improved groundnut varieties require more than the availability of improved seeds. Beyond the combined use of improved seeds and accompanying crop management practices, using appropriate levels of inputs and/or their combination to optimize productivity remains at stake. As should be expected, adoption rates of recommended practices of improved varieties and accompanying crop management practices (agronomic and aflatoxin) are higher in PLGA than in NPLGA.

Despite the central role of improved seeds in productivity enhancement, adoption studies have often lumped seed/seed management into technology adoption. Consequently, efforts to promote the adoption of improved groundnut varieties also need to access proactive extension services, education, farming experience of beneficiary actors, access to farm labor and the challenge posed by aflatoxin contamination.

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