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Adoption of varietal and accompanying groundnut technologies in Sokoto and Kebbi States of Northwestern Nigeria

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ABSTRACT

The most recent improved groundnut varieties with farmers in Nigeria are SAMNUT 23, SAMNUT 24, SAMNUT 25 and SAMNUT 26. Amongst other things, this paper summarises outcomes of an adoption survey of these varieties in Sokoto and Kebbi States of North-western Nigeria. A total of 110 respondents were selected from administrative units where a donor funded project is being executed (coded herein as PLGA) and 110 from administrative units where project actions are absent (coded herein as NPLGA). The survey reveals that improved groundnut varieties are being grown amidst several other varieties designated as local. While SAMNUT 24 is being grown by 39% of respondents in PLGA and 19% of those in NPLGA, *Kampala* (a local groundnut variety) is being planted by 35 and 40% of respondents in PLGA and NPLGA, respectively. Farming experience, level of education and household size were found to influence household decisions to adopt groundnut varietal technologies and accompanying crop management practices at 1, 5 and 10% levels of significance. Gross Profit Margins in PLGA and NPLGA were 66,854 Naira (or $219) and 23,744 Naira (or $78), respectively, indicating that smallholder farmers could make nearly 64% additional cash incomes by adopting improved groundnut technologies.

Keywords: Adoption, groundnut technologies, Northwestern Nigeria.

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INTRODUCTION

Background and objective pursued

Groundnut (*Arachis hypogaea* L.) is one of the most important oil seed crops in the world. The FAO (2017) estimates that production of the crop stands at about 47 million metric tons cultivated on a total of 28 million hectares worldwide, with an average productivity of 1.6 tons/ha. Developing countries constitute 97% of the global area cultivated. Groundnut production is concentrated in Asia and Africa, where it is mostly grown under rain-fed conditions with limited external inputs (Ibrahim et al., 2012). Nigeria is the third world producer of the crop, after China and India. Depending on the variety, the oil content of the crop varies between 48 and 50%, and protein content is estimated at between 26 and 28% and between 11 and 27% micro-nutrients (carbohydrate, minerals and vitamins). The crop is commonly consumed during harvesting, roasted/boiled and processed into oil by small-scale farmers and city dwelling women for domestic use and/or cash income generation. Like other legumes, groundnut is known to be a nitrogen accumulator - an attribute which makes it feasible for resource limited farmers to save expenses on organic fertilizers. 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 in many countries of West and Central Africa (WCA).

Smallholder farmers in savannah agro-ecological regions of WCA are very much aware of the benefits of cultivating groundnut. Broadly, both local and improved

varieties are planted in association with many other crops notably cereals. In Nigeria, the crop is produced in all the agro-ecological zones of the country, though cultivation is predominant in nineteen (19) States located within the Sahel, Sudan and Guinea agro-ecological zones. These States are: 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 (NAERLS, 2017).

A total of twenty-nine (29) varietal technologies have been registered and released for commercial use in Nigeria since 1990 (NACGRB, 2014). The scaling out of these improved varieties, together with accompanying crop management practices, have been the subject of the support of the United States Agency for International Development (USAID) to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). In Nigeria, this project entitled *Increasing Groundnut Productivity of Smallholder Farmers in Ghana, Mali and Nigeria* is being implemented in partnership with twelve (12) partners with a focus on three improved groundnut varieties SAMNUT 24, SAMNUT 25 and SAMNUT 26. Upon registration and release, the key features of these varietal technologies are: high grain 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 them fulfil both consumer and market preferences (Echekwu et al., 2012). Unlike many of the popular groundnut varieties, farmers describe these improved varieties as *Atsaye* (or erect).

This study was initiated to determine the adoption of the varietal technologies and accompanying crop management being scaled out by ICRISAT and national partners in two (2) out of five (5) States in North-western Nigeria. Project implementation started in January 2015 and the technologies being scaled out relate to varietal technologies, accompanying crop and aflatoxin management practices. All scaling out efforts were complemented by systematic capacity building interventions targeting groundnut value chain actors in the States.

RESEARCH METHOLOGY

Sampling and sample selection

A combination of purposive and multi-stage sampling procedures was used for the selection of respondents. The first stage of the sampling procedure was a straight forward decision to extend this survey to Sokoto and Kebbi after an enlightening survey in Kano, Katsina and Jigawa as reported by Vabi et al. (2019). The second stage of the sampling procedure coincided with the confirmation of the eleven (11) Local Government Areas (LGAs) where the USAID funded 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 twenty-two (22) LGAs. The third stage in the sampling procedure consisted of a random selection of groundnut producing households with 110 from the PLGAs and NPLGAs. Giving a total of two hundred and twenty households (Table 1). Interviews were then conducted with representatives of households based on their availability and willingness to participate in the exercise. Representatives of selected households not available and/or not willing to participate in the interviews were replaced in consultation with ADP extension agents of each LGA and community leaders.

Data collection and processing

After prior hands-on survey briefing in each State, data were collected using a structured questionnaire by extension agents of the Sokoto and Kebbi ADPs. The data collected included: sex, farming experience, household size, level of formal education, different groundnut varieties being planted (local and improved), the use 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 2018 with a focus on activities of the 2017 cropping season. Consistency checks on responses provided were carried out at the end of each day by State-based survey supervisors on all the filled out questionnaires. Data entry was carried out using SPSS – Statistical Package for the Social Sciences version 22. Frequency counts were used to summarize the data collected.

The Gross Profit Margin (GPM) and Return on investment (RoI) were used to establish the profitability of groundnut production (Edwards, 2016). The GPM was estimated using = $\sum p_i q_I - \sum r_j x_{j;} pi$ where pi and qi represent the price and quantity of groundnut outputs, respectively, and rj and xj represent unit cost and quantity of the inputs used, respectively. RoI was determined by simply dividing the value of the GPM by total operational costs.

Modeling relationships between decisions to adopt or not to adopt agricultural technologies, usually requires the use of qualitative response models. Commonly used models are the binary probit model (which assumes an underlying normal distribution) and logit models (which take alogarithmic distribution functions). The logit model was used in this study to determine the drivers of farmers' decisions to adopt the improved groundnut varieties technologies considering that the model is simpler to interpret; it is also commonly used in adoption studies (Ng'ombe et al., 2014).

The binary logit 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
β_1 to β_n = coefficients of X_1 to X_n
u = error term
X_1 to X_n = each of the factors considered to drive adoption decisions

Background information about Sokoto and Kebbi States

Both Sokoto and Kebbi States lie to the far extreme northwest of Nigeria (Figure 1); with both States sharing land borders with the

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

State	PLGA	Number of households	NPLGA	Number of households
Kebbi State	Argungu	10	Arewa	10
	Aleiro	10	Bagudo	10
	Birinin Kebbi	10	Jega	10
	Dandi	10	Koko Besse	10
	Danko Wasagu	10	Sakaba	10
	Maiyama	10	Yauri	10
Sub-total		60		60
Sokoto State	Bodinga	10	Yabo	10
	Dange Shuni	10	Rabah	10
	Shagari	10	Sabon Birni	10
	Tambuwal	10	Tureta	10
	Tangaza	10	Wurno	10
Sub-total		50		50
Totals		110		110

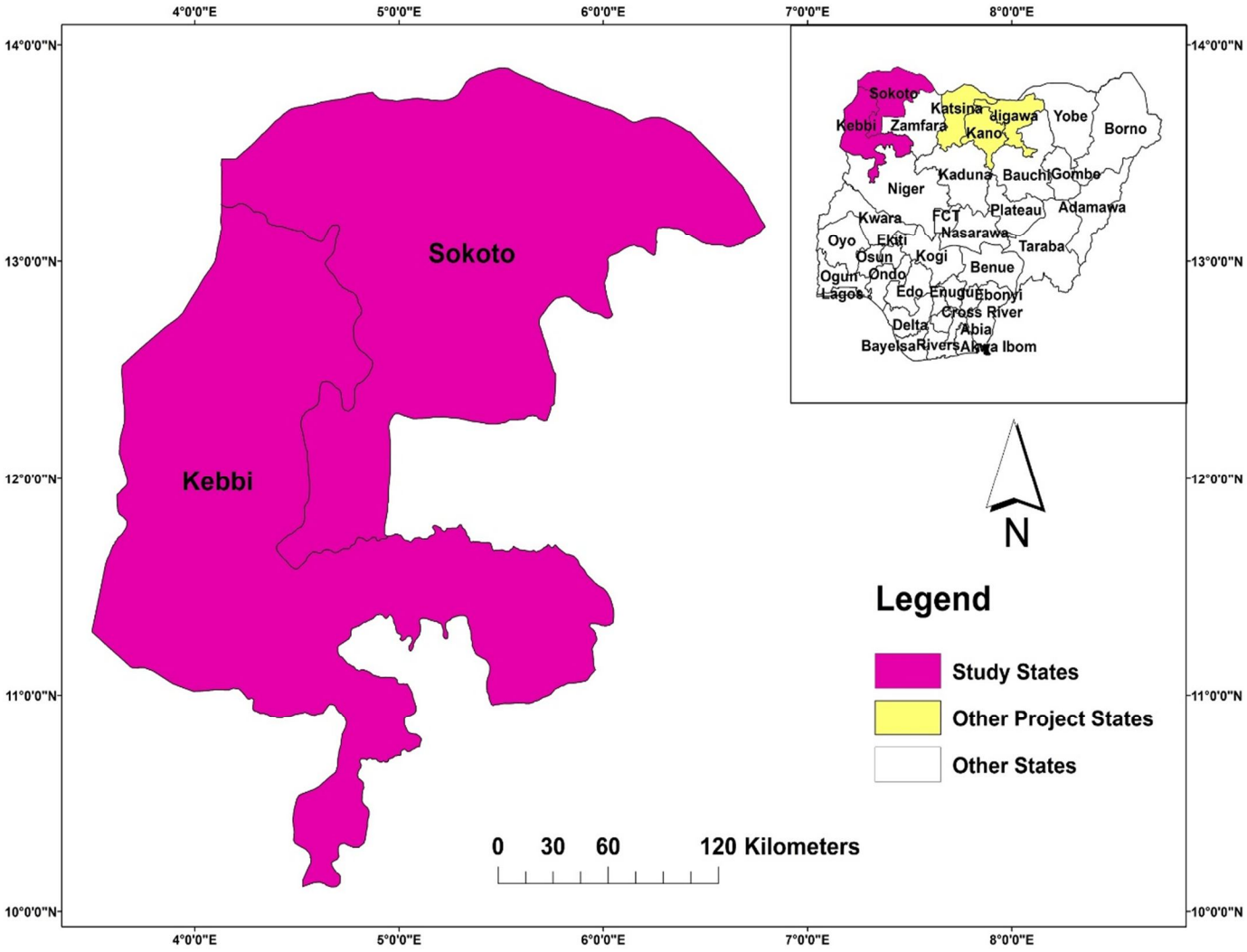

Figure 1. Map of the Federal Republic of Nigeria Showing Study States. Source: USAID Groundnut Upscaling M&E.

Republic of Niger hence providing vast opportunities for cross-border formal and informal exchanges. While Sokoto State has twenty-three (23) Local Government Areas (LGAs), Kebbi State twenty-one (21) LGAs. Both States have Agricultural and Rural Development Authorities, generally called ADP organized into Extension Zones (Dodo, 1996).

Using projections of 2006 National Population Census, the population of Sokoto State is estimated at 4,998,100 while that of Kebbi State is estimated at 4,917,327 (State-based Population Census Reports, 2006 and subsequent projections). With an annual national population growth rate of 3.3% and recurrent manipulations for different purposes, these figures have been changing and usually differ by source. The population primarily comprises the Hausa, Fulani and other ethnic/tribal groups. Christianity is also practiced in both States to a limited extent. Apart from Hausa and Fulani, other ethnic/tribal groups are also found in the two States. The main medium of communication is Hausa and Fulfulde.

Over eighty percent (80%) of the population of both States are engaged in agriculture. The main crops produced are millet, sorghum (guinea corn), maize, rice, potatoes, cassava, groundnuts and common beans, these crops are grown for both subsistence and for sale. All categories of livestock – cattle, sheep, goats, chickens, camels and donkeys; cattle, camels and donkeys are frequently used for transportation and traction. Households resident along the Rivers Sokoto, Niger, Rima, dams and lakes also do fishing, and cultivate vegetables in the dry season.

Broadly, both States have dominant features of the Sudan and Savanah agro-ecological zones identified as appropriate for the improved groundnut varieties being promoted by the USAID project (Ajeigbe et al., 2015). The dry season starts from October, and lasts up to April and could extend to May or June in the southern parts of the States. The wet season generally begins in April-May and might extend to September-October. Mean annual rainfall ranges between 500 and 1,300 mm. Annual average temperatures is 28.3°C, with Sokoto being one of the hottest cities in the world, though maximum daytime temperatures stay around 40°C most of the year. The warmest months are February to April, where daytime temperatures can exceed 45°C. In Kebbi State, mean annual temperature can be as high as 26°C. However, between December and February, mean annual temperatures can go down to about 21°C and up to 40°C during the months of April to June. The highest recorded temperature in Sokoto has been 47.2°C, which is also the highest recorded temperature in Nigeria.

A key motive for including both States into the USAID funded project was that they fall within the Feed the Future Zone of Influence (FtFZI). A total of 11 Local Government Areas (LGAs) were selected from both States with six (6) from Kebbi (out of a total of 27 LGAs) and five from Sokoto (out of a total of 23 LGAs).

RESULTS AND DISCUSSION

Profile of households interviewed

The socio-demographic profiles of representatives of the households interviewed in PLGAs and NPLGAs are summarised in Table 2. Most of those interviewed were men with 78% in PLGA and 92% in NPLGA, generally between 36 and 50 years of age. In both PLGA and NPLGA, household sizes vary between 2 and 49 with a mean of 14 persons. Mean farm size is about 2 hectares in both PLGA and NPLGA. Some have attempted formal education (28%) and have even gone above primary education in NPLGA (24%) compared to PLGA where some are better apt in Quranic education in PLGA. Many more (88%) are members of farming groups in PLGAs than NPLGA (63%) and reported having inherited their farm-fields (63% PLGA and 66% in NPLGA). Mean farming experience of 23 years in PLGA and 28 years in NPLGA. Farm sizes emerged to be similar in both PLGA and NPLGA; mean of five (5) hectares with minimum and maximum of about one (1) hectare and fourteen (14) hectares, respectively. Similarly, mean land sizes devoted to groundnut production were about 2 hectares, though differences in maximum and minimum emerged in both PLGA and NPLGA. Farmers in PLGA estimated the values of their groundnut farms during the 2017 cropping season at 120,000 Naira (393 USD) in NPLGA as against 115,000 Naira (377USD) in PLGA; these were translated into mean values of 2,226,730 (7,300 USD) for NPLGA and 2,093,650 Naira (686 USD) in PLGA.

The socio-demographic profile of respondents of this survey suggests that groundnut production in Sokoto and Kebbi States is dominated by men aged over 50 years, with thirty years working as farmers. Respondents have large household sizes and do not belong to farming groups. Farm-field devoted to groundnut production are less than two hectares, a majority of which are inherited. Adoption studies have often explained technology acceptance or rejection to socio-demographic profiles of end-users. Representative adoption studies include those of Mwangi and Kariuki (2015), Dhraief et al. (2018), Muhammad (2015), Mbavai et al. (2015), Bello et al. (2011), James (2014), Adzawla et al. (2016), Idoko and Sabo (2014), Melesse (2015), Njeuka et al. (2013), Lavison (2013), Thuo et al. *(*2014), Ndjeuga et al. (2011), Ndjeuga et al. *(*2012), Kassie et al*.* (2010), Kariyasa and Dewi (2011), Akudugu et al. (2012), Chianu and Tsujii (2004), Doss 2013 and Mauceri et al*.* (2005)

With respect to access to extension service delivery and support with improved groundnut varieties (Table 3), majority of respondents (82%) in NPLGA report having monthly extension service support from ADP extension agents while 79% of those in PLGAs reported having extension service support from ADP extension agents though the periodicity of this extension service support was higher in PLGA (74%) than in NPLGA (67%).The key source credit (finances) for farm operations was from owned savings for respondents in both PLGA (62%) and NPLGA (61%). Though Foundation Seeds were given out either to farmer groups as in-kind loans by the USAID funded project; this was not perceived as credit by respondents in both PLGA and NPLGA in the two States. The equivalents of Foundation Seeds given out to community-based seed producers were recovered after harvest, drying and bagging.

The extension service is the key driving factor behind technology deployment and adoption. Access to regular and credible extension services could neutralise the negative effect of lack of formal education of farmers which could hinders technology adoption Agriculture extension is popular methods of introducing agricultural technologies to end users. Mwangi and Kariuki (2015),

Table 2. Socio-demographic profile of respondents.

Variable	Kebbi State		Sokoto State		Pooled Results	
	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA
Sex						
Female	10 (17)	4 (7)	14(28)	5(10)	24 (22)	9 (8)
Male	50 (83)	56 (93)	36(72)	45(90)	86 (78)	101 (92)
Age						
20-35	2(3)	4(7)	--	2(4)	4(4)	6(6)
36-50	39(65)	35(58)	24(48)	20(40)	59(54)	55(50)
51-65	17(28)	19(32)	25(50)	24(48)	41(37)	43(39)
66 and above	2(3)	2(3)	1(2)	4(8)	6(6)	6(6)
Household size						
Minimum	2	2	3	2	3	2
Maximum	30	59	30	39	30	49
Mean	12	13	13	16	12	14
Education						
Attempted formal education	3(5)	30(50)	2(4)	1(2)	5(5)	31(28)
Above primary education	13(22)	12(20)	9(18)	14(28)	22(20)	26(24)
Functional/Tertiary	15(25)	5(8.3)	13(26)	8(16)	28(26)	13(12)
Member of a farming groups						
Member	50 (83)	34 (43)	47(94)	7(14)	97(88)	41(37)
Not a member	10 (17)	26 (57)	3(6)	43(86)	13(12)	69(63)
Land ownership						
Inherited	37(62)	35(58)	32(64)	38(76)	69(63)	73(66)
Purchased	12(20)	10(17)	9(18)	10(20)	21(19)	20(18)
Rented	2(3)	1(2)	4(8)	--	6(6)	1(1)
Communal	--	--	1(2)	--	1(1)	0(0)
Gift	3(5)	--	2(4)	1(2)	5(5)	1(1)
Family land	6(10)	14(23)	2(4)	1(2)	8(7)	15(14)
Farming experience						
Minimum	2	5	6	8	4	6.5
Maximum	38	55	50	60	44	57.5
Mean	21	25	26	31	23	28
Farm size (ha)						
Minimum	0.5	0.5	1	1	0.75	0.75
Maximum	15	11	13	20	14	15.5
Mean	4.78	4.96	4.47	5.57	4.62	5.26
Land size for groundnut production						
Minimum	0.5	0.5	0.5	0.3	0.5	0.4
Maximum	8.5	13.5	4	5	6.25	9.25
Mean	1.82	2.19	1.59	1.16	1.71	1.68
Value of farmlands						
Minimum	150,000	100,000	80,000	140,000	115,000	120,000
Maximum	10,000,000	6,000,000	8,500,000	12,000,000	9,250,000	9,000,000
Mean	1,940,000	1,628,661	2,247,300	2,824,800	2,093,650	2,226,730

(*) % in parentheses; PLGA = Project LGAs; NPLGA = Non-project LGAs.

Table 3. Contacts with extension services across the states.

Variables	Kebbi State		Sokoto State		Pooled Results	
	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA
	F (%)	F (%)	F (%)	F (%)	F (%)	F (%)
Source of extension support						
State ADP	47(78)	52(87)	40(80)	38(76)	87(79)	90(82)
State Ministry of Agriculture	--	--	1(2)	--	1(1)	--
Research institutes (IAR, CDA, etc.)	9(15)	4(7)	9(18)	--	18(16)	4(4)
NGO	3(5)			--	3(2.7)	
Others	1(2)	4(7)	--	12(24)	1(1)	16(15)
Frequency of extension support visits						
Weekly	2(3)	--	1(2)	--	3(2.7)	--
Bi-weekly	2(3)	12(20)	11(22)	7(14)	13(12)	19(17)
Monthly	46(77)	36(60)	35(70)	38(76)	81(74)	74(67)
Quarterly	9(15)	8(13)	2(4)	5(10)	11(10)	13(12)
Others	1(2)	4(7)	1(2)		2(2)	4(4)
Sources of credit for groundnut production						
Banks	1(2)	4(7)	6(12)	--	7(6)	4(4)
ADPs	5(8)	4(7)	4(8)	--	9(8)	4(4)
Relatives	11(18)	10(17)	1(2)	6(12)	12(11)	16(15)
Friends	4(7)	2(3)	3(6)	9(18)	7(6)	11(10)
Community money lenders	4(7)	7(12)	1(2)	1(2)	5(5)	8(7)
Government Credit Schemes	--	--	--	--	--	--
NGOs	--	--	2(4)	--	2(1.8)	--
Personal efforts	35(58)	33(55)	33(66)	4(68)	68(62)	67(61)

(*) Absolute values followed by percentages in parentheses.

Mignouna et al. *(*2011), reported direct relationships between technology adoption and access to extension services. As reported by Simtowe and Zeller (2006), access to credit is a determinant of the adoption of risky technologies given that credit eases liquidity constraints and household risk bearing abilities.

Configuration of the adoption of improved groundnut technologies

Table 4 shows that the varietal technologies (seed and seed management) being promoted are cultivated alongside a wide range of other groundnut varieties described as *local* in both PLGAs and NPLGAs. SAMNUT 24 is being grown by 39% of respondents in PLGAs and 19% of those in NPLGAs. Similarly, *Kampala* was reported to be a popular variety in PLGA (35%) and NPLGA (40%). Also, *Yar Madali* and *Yar-dakar* were common local varieties in PLGA and NPLGA of the two States.

Three groundnut varieties namely SAMNUT 24, *Yar Madali* and *Ex-dakar* are popular in both PLGA and NPLGA of the two States while the rest are location specific; such is the case with SAMNUT 26 and most of the local groundnut varieties. Despite sharing physical boundaries, not all the local groundnut varieties were common in both States; while *Zabuwa, Bakar Anniya*, etc. were reported only in Kebbi State, *Bayal, Bazamfara*, etc. were only reported in Sokoto State. Many of the groundnut varieties described as local, are attributed and recognized by the names of individuals *(Kosoma, Yar Ula, Yar Jigila*, etc.), colour of the kernel (*Jar-gyada, Mai Atampa, Kampala,* etc.), kernel shape (*Mota, Haska,* etc.), kernel size (*Kwandala, Boleka,* etc.), growth behaviour (*Mai Jega, Tattabara,* etc.), Tribe (*Bahausa, Yar Gwari,* etc.). Labels of registered and released crop varieties could disappear through a wide range of socio-cultural transformations. *Ex-dakar*, for example, was officially endorsed in Nigeria from Senegal as SAMNUT 14.

This survey confirms that SAMNUT 24, *Kampala* and *Ex-Dakar* are most popular groundnut varieties in the two States. Due to their demonstrated features, SAMNUT 24, SAMNUT 25 and SAMNUT 26, proactive measures are being supported by the USAID funded Groundnut Scaling Project to sustain varietal purity. These measures include on-station re-evaluation by appropriate project

Table 4. Groundnut varieties being grown by respondents in Sokoto and Kebbi States.

Improved groundnut varieties	Kebbi State		Sokoto State		Pooled Results	
	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA
Samnut-23	2(3)	--	--	1(2)	2(2)	1(1)
Samnut-24	25(42)	19(32)	18(36)	2(4)	43(39)	21(19)
Samnut-25	3(5)	1(2)	1(2)	2(4)	4(4)	3(3)
Samnut-26	2(3)	-	1(2)	--	3(3)	--
Samnut-23/24	4(7)	--	1(2)	--	5(5)	--
Samnut-24/25	--	--	6(12)	1(2)	6(6)	1(11)
Samnut-24/26	2(3)	--	3(6)	--	5(5)	--
Samnut-22/23/24	2(3)	--		--	2(2)	--
Samnut-23/24/25	4(7)	--	1(2)	--	5(5)	--
Samnut-23/24/26	--	1(2)	3(6)	--	3(3)	1(1)
Samnut-24/25/26	6(10)	--	15(30)	--	21(19)	--
Samnut-23/24/25/26	10(17)	--	1(2)	--	11(10)	--
Local groundnut varieties						
Kampala	23(38)	37(62)	15(30)	7(14)	38(35)	44(40)
Bahausa	--	--	16(32)	8(16)		8(7)
Yar-Dakar	19(32)	11(18)	--	12(24)	19(17)	23(21)
Yar Kosoma	--	--	--	--		
Yar Madali	10(17)	14(23)	25(50)	16(32)	35(32)	30(27)
Kanannada	6(10)	--	--	--	6(6)	
Yar Maradi	12(20)	3(5)	--	--	12(11)	3(3)
Yar Kwanche	10(17)	10(17)	--	--	10(9)	10(9)
Yar Tsaye	4(7)	--	--	--	4(4)	
Markwai	6(10)	5(8)	--	--	6(6)	5(5)
Mota	11(18)	5(8)	--	--	11(10)	5(5)
Zabuwa	--	3(5)	--	--	--	3(3)
Garo Garo	--	9(15)	--	--	--	9(8)
Yar Ula	--	9(15)	--	8(16)	--	17(16)
Farar Anniya	--	5(8)	--	--	--	5(5)
Bakar Anniya	--	7(12)	--	--	--	7(6)
Bayala	--	--	1(2)	--	--	--
Yar Tambuwal	--	--	1(2)	--	--	--
Yar Tsungune	--	--	4(8)	--	--	--
Yar Gidima	--	--	9(18)	--	--	--
Mai Wada	--	--	10(20)	--	--	--
Yar Kasa	--	--	--	2(4)	--	2(2)
Bazamfara	--	--	--	12(24)	--	12(11)

(*) Absolute values followed by percentages in parentheses.

implementation partners, 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 of value chain actors by ICRISAT and NASC.

Likewise, Table 5 outlines the extent of utilisation of both the varietal and accompanying crop and aflatoxin management practices being promoted in both Sokoto and Kebbi States. The pooled results show that mean update rates for varietal technologies (the seed) is 81% in PLGA compared to 19% in NPLGA. Similarly, mean update rate of on-farm management practices is 76% in PLGA as against 24% in NPLGA, the mean uptake of post-harvest management technologies is 75% in PLGA compared to 25% in NPLGA. This trend is consistent for all individual technologies related to varietal technologies and accompanying crop and aflatoxin management practices in the two States. These results are similar to those reported by Vabi et al. (2019) in the other three

Table 5. Summary of the adoption of recommended groundnut technologies in study states.

Category 1: Seed and seed management	PLGA Kebbi State		NPLGA Kebbi State		PLGA Sokoto State		NPLGA Sokoto State		Both States	
	Adopters	Non-Adopters	Adopters	Non-Adopters	Adopters	Non-Adopters	Adopters	Non-Adopters	Adopters	Non-Adopters
- Use improved groundnut varieties	60(100)	--	54(90)	6(10)	47(94)	3(6)	11(22)	39(78)	172(78)	48(22)
- Shell seeds during planting season	56(93)	4(7)	50(83)	10(17)	42(84)	8(16)	37(74)	13(26)	185(84)	35(16)
- Sort and clean seeds before planting	54(90)	6(10)	50(83)	10(17)	43(86)	7(14)	35(70)	15(30)	182(83)	38(17)
- Treat seeds before planting	54(90)	6(10)	48(80)	12(20)	40(80)	10(20)	32(64)	18(36)	174(79)	46(21)
Means	56(93)	4(7)	50(84)	10(16)	43(86)	7(14)	29(58)	21(42)	178(81)	42(19)
Category 2: On farm management practices										
- Use farms with sandy-loamy soils	60(100)	--	47(78)	13(22)	47(94)	3(6)	46(92)	4(8)	200(91)	20(9)
- Till/ridge farms before planting	60(100)	--	47(78)	13(22)	50(100)	--	40(80)	10(20)	197(90)	23(10)
- Sow at 10cm x 75cm/2SH	40(67)	20(33)	31(52)	29(48)	37(74)	13(26)	24(48)	26(52)	133(60)	88(40)
- Sow at 20cm x 75cm/2SH	49(82)	11(18)	36(60)	24(40)	36(72)	14(28)	28(56)	22(44)	149(68)	71(32)
- Use Farm Yard Manure (FYM)	50(83)	10(17)	42(70)	18(30)	41(82)	9(18)	38(76)	12(24)	161(73)	59(27)
- Apply SSP (2 bags/ha and NPK I bag/ha),	50(83)	10(17)	32(53)	28(47)	44(88)	6(12)	38(76)	12(24)	154(70)	66(30)
- First weeding at 3-4 weeks after sowing	59(98)	1(2)	45(75)	15(25)	49(98)	1(2)	37(74)	13(26)	190(86)	30(14)
- Second weeding 6-8 weeks after sowing	57(95)	3(5)	27(45)	33(55)	49(98)	1(2)	33(66)	17(34)	166(75)	54(25)
- Remove physically weak stands/weeds and off-types	58(97)	2(3)	41(68)	19(32)	48(96)	2(4)	36(72)	14(28)	183(83)	37(17)
- Spray with appropriate pesticide	49(82)	11(18)	29(48)	31(52)	32(64)	18(36)	33(66)	17(34)	143(65)	77(35)
Means	53(89)	7(11)	37(63)	23(37)	43(86)	7(14)	35(71)	15(29)	167(76)	53(24)
Category 3: Post-harvest Management practices										
- Lift pods when mature (85 - 90 days)	58(97)	2(3)	21(35)	39(65)	48(96)	2(4)	34(68)	16(32)	161(73)	59(27)
- Dry pods on-farm between 5 -7 days after lifting	54(90)	6(10)	29(48)	31(52)	44(88)	6(12)	35(70)	15(30)	162(74)	58(26)
- Shake pods for moisture contents before stripping	58(97)	2(3)	17(29)	43(71)	50(100)	--	43(86)	7(14)	168(76)	52(24)
- Store pods in clean in ventilated stores	52(87)	8(13)	34(57)	26(43)	45(90)	5(10)	41(82)	9(18)	177(78)	48(22)
Means	55(92)	5(8)	25(42)	35(58)	47(94)	3(6)	38(76)	12(24)	166(75)	54(25)

(*) Absolute value followed by percentage in parentheses.

States where the project is also being implemented.

The mean adoption rates of improved groundnut varieties contrast with the findings of McGuire and Sperling (2015), Bezner-Kerr (2013), Cavatassi et al. (2011) and Guei et al. (2011) where they demonstrate that farmers' saved seeds constitute the foremost source of seeds sown by African farmers. Targeted and persistent awareness and capacity building actions could improve and sustain the use of both varietal and crop management practices.

Overall, the adoption rates of non-varietal technologies or accompanying crop management practices are encouraging – these vary from 60% for sowing at 10 cm × 75 cm to 91% for selecting sites with potentials of better fertility. Alene et al. (2006) argued that adoption of non-varietal

technologies is imperative for varietal technologies to fully express their genetic potentials. Also, as explained by Ajeigbe et al. (2016), farmers in West Central Africa (WCA) plant grain crops in rows spaced at 75 cm because most tractors and animal drawn ridgers are fixed at widths of 75 cm between row spacing. In Nigeria, this practice was upheld as a recommended practice of 75 cm × 20 cm. Indeed, Nigam et al. (2006) opined that optimum plant spacing is key to higher yields in groundnut. Combining improved groundnut varieties with appropriate fertilizers and optimum plant densities could increase groundnut productivity and profitability of smallholder farmers in WCA. It is known that the use of adequate doses of appropriate fertilizers enhance root development and improve the availability of required nutrients for all crops including groundnut. As recurrently pointed out by Ndjeunga et al. (2006), Ndjeunga et al. (2011) and Ndjeunga (2012), differences in groundnut productivity in WCA can also be explained by insufficient and unsuitable uses of inputs.

In addition to the use of improved groundnut varieties alongside appropriate crop management practices, a number of post-harvests practices from the pooled results are signals of the adoption post-harvest measures to mitigate the development of aflatoxin producing fungi in PLGA. These include: lifting groundnut when mature (73% of respondents), adequate drying (71% of respondents), shaking of pods to check dryness before stripping and bagging (78% of respondents), adequate storage (75% of respondents).

Determinants of the adoption of groundnut technologies

The three (3) categories of factors driving the adoption of groundnut technologies emerged from the Sokoto and Kebbi State survey (Table 6). These are:

Category 1: Farming experience positively influenced the use of improved groundnut varieties (UIGV), first weeding at between three and four weeks (FW3-4W),drying pods on-farms for between five and seven days (DPO5-7D) at 5% level of significance, while the application of fertilizers (SSP and NPK) was statistically significant at 1%.

Category 2: Level of education positively influenced the adoption of use of improved groundnut varieties, (UIGV) and planting at 10 cm × 75 cm (10 cm × 75 cm/2SH) at 5 % level of significance while treating seeds before planting (TSBP) was statistically significant at 1%.

Category 3: Household size positively influenced adoption of shelling seeds during the planting season (SSPS), planting at 10 cm × 75 cm/2SH (10 cm × 75 cm/2SH) and second weeding at between six and eight weeks (SW6 -8W) at 5% level of significance while shelling seeds before planning (SSBP), planting at 20 cm × 75 cm (20 cm x 75 cm/2HS) and lifting pods when mature (LP85-90) (10%,) were statistically significant at 1%.

Adoption studies of crop and livestock technologies have not deliberately isolated the seed (or breed) component from accompanying management practices during technology promotion stages. This trend limits prospects for setting subsequent research agendas, providing feedback for setting agenda for delivery research and demonstration of the totality of the benefits of research products. Nevertheless, a plethora of adoption studies have confirmed the combined effects of farming experience, age, household size, education, access to information, credit and extension services, etc. on end-user's adoption decisions. Recent cases in point are the studies of Dhraief et al. (2018), Muhammad (2015), Mbavai et al. (2015), Bello et al. (2011), James, (2014), Adzawla et al. (2016), Idoko and Sabo (2014), Melesse (2015) and Loevinsohn et al. (2013).

Muhammad (2015) and Bello et al. (2011) reported that farming experience positively and significantly influenced the adoption of agricultural technologies. The outcomes of this survey on education and household size are in line with the findings of James (2014) who reported household size to the adoption of groundnut productivity enhancement technologies.

According to Mignouna et al. (2011) and Lavison (2013), education increases end-users' abilities to obtain, process and use information relevant to the adoption of technologies. Also, Mignouna et al. (2011) considered household size to influence the adoption of recommended agricultural technologies given that large household sizes ease labour requirements for sowing, weeding, lifting, stripping and shelling of groundnut. The combined results in Table 7, for example, shows that paid labour is the main source of labour for groundnut production in PLGA accounting for about 45% with a combination of paid and family labour accounting for about half of labour requirements. Child labour constitutes an important source of farm labour for groundnut production in both PLGA and NPLGA; male children account for slightly more than female children in both PLGA and NPLGA (Table 7).

Estimated financial gains from groundnut production in the study states

Table 8 summarises the operational (variable) costs and revenue generated from producing groundnuts in PLGAs and NPLGAs. The operational cost comprises seeds, fertilizers, and pesticides, seasonal rents for farm land, farm labour and transportation of produce from the farms to house of groundnut producing households. The pooled

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

Variables	UIGV		SSPS		SSBP		TSBP	
Improved groundnut varieties (Seeds)	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.
- Farming experience	0	0.041**	0.065	0.414	0.017	0.694	0.046	0.247
- Age	-0.299	0.815	-0.535	0.646	0.073	0.908	-0.097	0.864
- Level of education	1.208	0.015**	-0.329	0.453	0.22	0.321	-0.001	0.003***
- Household size	-0.034	0.762	0.064	0.049**	-0.012	0.004*	-0.019	0.725
Constant	-8.478	0.126	-2.653	0.392	-3.484	0.057	-2.436	0.112

	UFSLS		TRBP		10 cm × 75 cm/2SH		20 cm × 75 cm/2SH		FYM	
On-farm crop management practices	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.
- Farming experience	-0.081	0.305	0.017	0.694	0.035	0.274	-0.024	0.371	-0.024	0.371
- Age	0.745	0.563	0.073	0.908	-0.183	0.687	-0.048	0.915	-0.048	0.915
- Level of education	0.045	0.923	0.22	0.321	0.292	0.048**	0.021	0.897	0.021	0.897
- Household size	-0.054	0.686	-0.012	0.841	-0.094	0.043**	0.049	0.000***	0.049	0.241
Constant	-3.64	0.298	-3.484	0.057	-1.276	0.289	-1.245	0.304	-1.245	0.304

	SSP and NPK		FW3-4W		SW6-8W		RPWS		SAP	
On-farm crop management practices	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.
- Farming experience	-0.02	0.003***	-0.052	0.053**	-0.116	0.247	-0.042	0.577	0.029	0.333
- Age	-0.005	0.992	0.891	0.497	0.64	0.618	-0.354	0.775	-0.487	0.281
- Level of education	0.008	0.967	-0.319	0.563	0.759	0.076	1.026	0.077	-0.02	0.893
- Household size	0.013	0.802	-0.165	0.364	-0.345	0.031**	-0.12	0.295	-0.012	0.774
Constant	-1.508	0.291	-2.184	0.541	-2.658	0.406	-5.139	0.185	-0.223	0.846

Variables	LP85-90		DPF5-7D		SPMC		SPVA	
Post-harvest management practices	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.
- Farming experience	-0.085	0.148	-0.085	.017**	0.217	0.207	-0.002	0.948
- Age	0.142	0.683	0	0.998	1.091	0.142	-0.097	0.643
- Level of education	-0.087	0.928	0.09	0.879	-5.279	0.535	0.015	0.98
- Household size	-0.011	0.000***	0.01	0.859	-0.336	0.161	-0.008	0.884
Constant	-1.789	0.447	-0.612	0.683	-0.088	0.996	-1.53	0.327

UIGV: Use improved groundnut varieties; SSPS: Shell seeds during planting season; SSBP: Sort and clean seeds before planting; TSBP: Treat seeds before planting. UFSLS= Use farms with sandy-loamy soils; TRBF=Till/ridge farms before planting; 10 cm × 75 cm/2SH = Sow at 10 cm × 75 cm/2 seeds/hole, Sow at 20 cm × 75 cm/2SH = 20 cm × 75 cm/2SH, FYM = Use Farm Yard Manure; SSP and NPK = Apply SSP (2 bags/ha and NPK I bag/ha), FW3-4W = First weeding at 3-4 weeks after sowing, SW6-8W = Second weeding 6-8 weeks after sowing, RPWS=Remove physically weak stands/weeds and off-types; SAP =Spray with appropriate pesticide, LP85-90D = Lift pods when mature;DPF5-7D = Dry pods on-farm between 5-7 days after lifting, SPMC= Shake pods for moisture contents before stripping, SPVS = Store pods in ventilated areas.

results show that the cost of farm labour compares closely with the cost of other farm inputs; 48% compared to 43% in PLGA and NPLGA, respectively.

Annual Gross Profit Margin (GPM) in PLGAs and NPLGA were 66,854 Naira (or $219) and 23,744 Naira (or $78), respectively, indicating that by adopting improved technologies, smallholder farmers could make about 64% additional cash incomes. Returns per Naira invested are 70% in PLGAs and 30% in NPLGAs, suggesting that by adopting improved groundnut technologies, smallholder farmers in the two States could increase farm-level production and productivity. Whether in PLGAs or NPLGAs, cost efficiency

Table 7. Sources and categories of farm labour employed in groundnut production.

Variable	Kebbi State		Sokoto State		Pooled results	
	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA
	F (%)	F (%)	F (%)	F (%)	F (%)	F (%)
Sources of farm labor						
Paid	14(23.3)	9(15)	35(70)	23(46)	49(45)	32(29)
Family	1(1.7)	5(8.3)	3(6)	5(10)	4(3.6)	10(4)
Paid and family	45(75)	46(76.7)	12(24)	22(44)	57(52)	68(52)
Farm-labor by sex						
Adult male	59(98)	60(100)	50(100)	49(98)	109(99)	109(99)
Male child	48(80)	54(90)	27(54)	39(78)	75(68)	93(85)
Adult female	45(75)	50(83)	31(62)	13(26)	76(69)	63(57)
Female child	33(55)	39(65)	16(32)	4(8)	49(43)	43(39)

(*) Absolute values followed by percentages in parentheses.

Table 8. Profitability of groundnut production in the study states (2017 cropping season).

Cost component	Kebbi State		Sokoto State		Pooled Results	
	PLGA	NPLGA	PLGA	NPLGA	PLGA	NPLGA
Expenses on farm inputs (except farm labour)						
Seeds (kg)	15,479(18)	18,712(21)	18,960(20)	15,985(19)	17,219(19)	17,348(20)
Fertilizers (kg)	16,845(19)	13,908(15)	14,853(16)	12,405(14)	15,849(18)	13,157(15)
Pesticides (Litre)	650(1)	137(0)	1,568(12)	900(1)	11,09(1)	5,18(1)
Farm Yard Manure (kg)	6,990(8)	4,520(5)	83,98(9)	4,823(6)	7,694(9)	4,671(5)
Transport Cost of Pods (N/100 kg bag)	1,818(2)	2,946(3)	1,829(2)	2,118(2)	1,824(2)	2,532(3)
Transport Cost of fodder (N/100 kg bag)	2,035(2)	18,839(2)	1,560(2)	17,38(2)	1,798(2)	1,810(2)
Purchase of bags For Storage (N/bag)	2,123(2)	2,967(3)	2,683(3)	4,111(5)	2,403(3)	3,539(4)
Sub-total(a)	45,940	45,072	49,850	42,080	47,895	43,576
Expenses of farm labor for different farm operations						
Land preparation	7,472(9)	11,540(13)	5,483(6)	9,947(12)	6,478(7)	10,743(12)
Planting	4,902(6)	9,177(10)	6,641(7)	5,769(7)	5,771(6)	7,473(8)
Fertilizer Application	1,805(2)	1,933(2)	2,026(2)	3,577(4)	19,15(2)	2,755(3)
Weeding	12,031(14)	11,873(13)	14,257(15)	12,813(15)	13,144(15)	12,343(14)
Harvesting	15,528(18)	11,499(13)	15,020(16)	12,330(14)	15,274(17)	11,914(13)
Sub-total(b)	41,739	46,022	43,427	44,436	42,583	45,229

Table 8. Continues.

Total operational cost (a+b)	87,678	91,094	93,277	86,516	90,478	88,805
Average output (kg/ha)	1,080	851	1,042	818	1,061	834
Average price (N/kg)	123	130	175	140	149	135
Total revenue	132,608	110,189	182,055	114,908	157,332	112,549
Gross Profit Margin (GPM)	44,929	19,096	88,778	28,392	66,854	23,744
Returns per Naira invested	0.5	0.2	1	0.3	0.7	0.3

(*) Absolute values followed by percentage in parentheses.

can be improved by improving plant population densities (planting at 10 cm × 75 cm), close follow-up of the sources and different categories of farm labour (substituting paid labour with family labour), identifying and recruiting more efficient farm labour, working on the number of persons handling different farm operation, etc. While demonstrating that groundnut production is a source of cash and non-cash incomes, a tactful combination of hired and family labour and/or male/female farm labour, could help the smallholder farmer move onto more cost effective combinations. Similarly, efficiency on the cost of production can be reduced through securing discounts on bulk purchase of inputs by farming groups and/or annual tactful increases in market prices of certified seeds. This study revealed that only 88 and 37% of respondents belong to farming groups in PLGA and NPLGA, respectively.

CONCLUSION

Despite the national and socio-economic importance of groundnut to the Nigerian economy, productivity of the crop is lower (about 1.2 t/ha) compared to global means of between 1.7 and over 3 tons per ha in the USA and China. Prospects for improving the productivity of the crop exist through the adoption of both varietal and non-varietal technologies of the crop. Amongst other things, this paper has presented outcomes of a survey to determine the adoption of groundnut varietal and non-varietal technologies in Sokoto and Kebbi States of North-western Nigeria. Outcomes of the survey show that the improved groundnut varieties being scaled out are cultivated alongside a wide range of local varieties in both PLGA and NPLGA. Three (3) categories of complementary factor drive the adoption of both varietal and non-varietal technologies: farming experience, level of education and household size. The positive values of both the gross profit margin and returns on naira invested point to the fact that by adopting varietal and non-varietal technologies, smallholder farmers could make up to 64% additional cash incomes. In terms of returns on investment, by adopting improved groundnut technologies, smallholder farmers can expect to earn nearly forty kobo per season for each naira invested.

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