Original Research Article

Impact of improved groundnut varieties adoption on income, food security and nutrition of farming households in Katsina State, Nigeria

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Abstract

Previous empirical studies on improved groundnut varieties in Nigeria have not focused on the impact of the adoption of improved groundnut varieties on monetary returns, food security, and the nutrition of farming households. It is therefore important to provide evidence to justify the expenditure on improved groundnut varieties development in Nigeria. Using observational data from 100 randomly sampled groundnut farmers, this study determined the impact of improved groundnut varieties (IGV) adoption on farming households' income, food security, and nutrition in a rural area of Northwestern Nigeria. The Propensity Score Matching Technique was used for data analysis. The majority of the respondents (75%) are adopters of IGV. The likelihood of adoption increases with extension contact, labour, and the level of commercialization. Adopters of IGV had an increase of ₦48171.7 ($133.1) and 14.96 in Gross margin/hectare and dietary diversity increased by 14.96, respectively. There was also an improvement in the food security status of the adopters. The study concluded that adopting improved technologies can enhance farming households' welfare. It was therefore recommended that farmers be encouraged to adopt IGV to increase the returns from groundnut production and household food security and nutrition status.

Keywords: groundnut farmers; farming households; demographic characteristics; dietary diversity; food security

INTRODUCTION

The Nigeria agricultural sector focused on groundnut production as one of the major cash crops before the independence in 1960, especially within the northwestern zone of the country. The sector later experienced serious setbacks which led to the fall of the famous groundnut pyramids in the northern parts of the country. Notwithstanding, groundnut production is still one of the popular enterprises in Nigeria (Bashir, 2012). According to Nwalem et al. (2023), groundnut output decelerated in Nigeria between 1980 and 2016, implying that a shortfall in groundnut output exists in Nigeria. Groundnut production in Nigeria has suffered challenges in terms of diseases and pest infestations and also inadequately improved seed varieties (Bashir, 2012). On the other hand, the low level of productivity in groundnut production can also be attributed to dependence on the continuous use of traditional farming methods. This has considerably affected output and subsequently a drop in production. To regain its pride of place, it is imperative to develop new improved groundnut varieties (IGV) that are high-yielding and disease-resistant. In a bid to address the problem of low productivity of groundnut, research institutes have developed improved varieties such as SAMNUT 21, SAMNUT 22, SAMNUT 23, SAMNUT 24

(Abade et al., 2011), to increase the yield of groundnuts in Nigeria.

Furthermore, there is limited information on the roles of IGV in enhancing household welfare. Some empirical studies on IGV have been conducted in Nigeria (Rekwot et al., 2014; Shuaibu, 2018; Ahmed et al., 2020; Thawur et al., 2020). However, none of these studies focused on the adoption of IGV with particular emphasis on the monetary returns, food security, and nutrition of farming households. It is therefore very imperative for a study of this nature to be carried out in order to fill the research gap in knowledge and to contribute to knowledge on impact evaluation studies in Nigeria. This study compared the demographic features of adopters and non-adopters of improved groundnut varieties, identified determinants of adoption of IGV in households, and determined the impact of adoption of IGV on income from groundnut production, and household food security and nutritional status, in Katsina State. The study will contribute to existing previous works on the impact of the use of IGV on households' income, food security, and nutrition outcomes in Nigeria.

Hypothesis

H_0 = There is no significant difference in income, food security and nutrition of farming households of non-adopters and adopters of improved groundnut varieties.

MATERIALS AND METHODS

The study was conducted in five rural areas in Katsina State, Nigeria. The state lies between latitude 12°391′ and 10°481′ North and longitude 8°551′ and 9°101′ East. The area is dry (500 to 550 mm average annual rainfall distributed over 65 to 100 days) and the soils are generally light and sandy, poor in structure and organic content with low to moderate inherent fertility. It occupies an area of about 24,192 square kilometres, with an estimated population of about 5.8 million people as per 2006 projection. Katsina is a mono-ethnic and monolingual state and the people are generally Hausa/Fulani. Major cash crops produced in the state are millet, guinea corn, groundnut, cotton, maize, beans, rice, and wheat. Katsina State is the largest producer of cotton in Nigeria and livestock production is also a major preoccupation of people in the state. The areas have low humidity and precipitation with a high frequency of drought. Desertification is also a very common occurrence in the areas (Tanimu, 2018).

Sampling technique

The multi-stage sampling procedure was employed for this study. In the first stage, five villages (Kagadama, Bugaje, Zandam, Mazanya, and Kwarare) were purposively selected due to the intensity of groundnut production and the introduction of IGV into these areas. In the second stage, due to cost and time constraints, a sample size of 100 groundnut farmers was used for the study because it is higher than the minimum sample size of 30 which is required and also appropriate for a standard normal deviation and statistically ideal to get a meaningful result from a study (Mensah et al., 2020). In the third stage, the proportionality factor stated below was used to determine the number of farmers to be selected from each village. However, in the final stage, 20 groundnut farmers were randomly sampled from each village via balloting due to the little or no variation in the number of groundnut farmers required to be selected proportionately in each of the selected villages.

$$x = n/N*100$$

x = number of groundnut farmers selected per village
n = Number of groundnut farmers in each village
N-Population of groundnut farmers (220)

The distribution of groundnut farmers based on sampling in the study area is presented in Table 1.

Analytical technique

Data were analysed using the logistic regression model and propensity score matching (PSM). In the logistic regression model, the dependent variable takes the value of "0" for those that did not adopt IGV and the

Table 1. Sampling frame of groundnut farmers in the study area

Villages	Number of groundnut farmers	Number of groundnut farmers to be selected based on proportionality factor	Number of groundnut farmers selected
Kadagama	45	20	20
Bugaje	43	19	20
Zandam	46	20	20
Mazanya	41	18	20
Kwarare	45	20	20
Total	**220**		**100**

value of "1" for those that have adopted improved groundnut varieties.

Logit Regression Model (i)

The explanatory notes are:
X_1 = Age of household head (years)
X_2 = Level of education
X_3 = Household size (number of persons)
X_4 = Plot size (ha)
X_5 = Number of extension visits
X_6 = Years since joining a farmer's cooperative
X_7 = Groundnut income (GM/ha)
X_8 = Number of economic activities
X_9 = Dependency ratio (Number of dependent relatives/ Total number of persons in the household
X_{10} = Distance to market (kilometres)
X11 = Access to credit = 1 if yes and 0otherwie
X12 = Total labour used man-hour
X13 = Commercialization index (monetary value of groundnut sold/monetary value of groundnut harvested.
μ = (Error term)

Propensity Score Matching (PSM) (ii)

The propensity Score matching technique (PSM) is a means of establishing a valid counterfactual that will approximate randomisation in impact evaluation when using observational data. The difference between the outcome of the treatment and control group with and without technology adoption is the impact of the intervention (Smith and Todd, 2011). This was used to create a control group and also to control for the problem of selection bias due to the observable attributes of the respondents. This was achieved by estimating groundnut farmers' propensity or the probability of adopting improved groundnut varieties. A Logit model was initially estimated as a function of the observable attributes of the groundnut farmers. Secondly, the propensity scores were generated and used to match adopters and non-adopters of IGV with similar scores or propensity. The matching of adopters and non-adopters of IGV creates a condition similar to a control experiment where assignment to treatment status is random hence eliminating the problem of selection bias.

Measurement of impact indicators (iii)

The gross returns from groundnut production were computed using the Gross Margin Analysis. This can be specified as follows;

GM = Gross Margin/Ha TR = Total Returns/ Ha – TVC = Total Variable Cost / Ha

Food security status (iv)

The Household Food Insecurity Assessment Scale (HFIAS) was used to determine the household food security status. The score for each household was obtained by adding the scores for all questions. A given household can only obtain a score between 0 and 27 only. For details, see Coates et al. (2007).

Household nutrition status (v)

The nutrition outcome of the respondents was assessed using the household dietary diversity score. Lists of the types of food commonly consumed in the study area were presented to households. The household head was required to indicate Yes or No against the food they have consumed in the last seven days. A simple summation of all the food types consumed or indicated as Yes was done to obtain the dietary diversity score of a given household. Households with higher scores were considered to have a good nutritional status and vice versa (Hussein et al. 2018).

RESULTS AND DISCUSSION

Demographic characteristics of the households in the study area

A comparison of the demographic features of the two categories of respondents was undertaken and presented in Tables 2 and 3. This was done to determine if there are any differences between them. The result shows that 88% of the adopters in the study area were men, while the rest of the 12% were women. A similar pattern was also noted for the non-adopters in the study area. This shows that groundnut farming activities are mostly done by male farmers. In terms of age, the adopters' average household head age is 40 years whereas the non-adopters have a mean of 35 years. The average household size of the adopters is about 12 members while the non-adopters have an average of 7 members. This shows that adopters have larger household sizes than non-adopters. The adopters of IGV have between 0.5–5 hectares of farmland, while the non-adopters have about 0.5–1.1 hectares. On average, the adopters cultivated 2.1 hectares of farmland, while non-adopters cultivate 1.1 hectares of farmland. This implies that all the respondents in the study area are smallholder farmers. The dependency ratio for the majority of the adopters and non-adopters was greater than 1, which implies that the majority of their household members are unemployed. The non-adopters of IGV have a large number of unemployed members compared to the adopters. The commercialization index for the adopters shows that they are more oriented toward the market compared

Table 2. Demographic characteristics of the groundnut farmers

VARIABLES	ADOPTERS				NON-ADOPTERS				t-value	p-value
	MIN	MAX	MEAN	SD	MIN	MAX	MEAN	SD		
Age	28	57	40	8.585	30	50	35	8.585	4.254***	0.000
Household size	9	45	12	12	3	16	7	10.165	1.684*	0.095
Size of groundnut plot	0.5	5	2.1	8.072	0.5	2	1.1	5.123	–0.687	0.493
Distance to market	5	18	10.65	4.9613	7	18	10.6	5.12	8.676***	0.000
Dependency ratio	4	25	8.0	1.588	3	14	7.00	1.581	1.419	0.159
Membership (years)	1	2	1.5	0.969	0.5	1	2	1.020	–3.976***	0.002
Total labour	1840	39600	10105.33	9533.014	4000	138720	19076	33633.45	–0171	0.864
HFIAS	0	24	7	6.526	1	24	8.17	6.170	1.897*	0.061
HDDS	7	13	10.64	2.079	7	13	11.12	1.80	6.055***	0.000
Gross margin	42000	207,998	97617.9	47529.94	2625	62000	36425	20564.72	3.170***	0.002

Table 3. Level of adoption of improved groundnut varieties

Categories	No. of farmers	Percentage (%)
Adopters	75	75
Non-adopters	25	25
Total	**100**	**100**

Source: Field Survey (2019).

Table 4. I GV adopted by farmers

S/No	Improved roundut varieties	No. of adopters	Percentage (%)
1	Samnut 23	05	6.67
2	Samnut 24	70	93.33
3	Samnut 25	00	0
	Total	**75**	**100**

Source: Field Survey (2019).

to the non-adopters. On the other hand, the majority of both adopters and non-adopters do not have access to credit. The major source of capital for farming activities is their personal savings. Furthermore, access to climate information was very low among both categories of respondents. The majority of both groups of respondents do not own a transport asset on average, adopters of improved groundnut variety have a higher frequency of extension contact and market information compared to the non-adopters. The relationship between adoption, access to extension services, and market information was significant at 10% and 5%, respectively. In terms of distance to the market, the adopters are closer compared to the non-adopters. The difference in the mean distance of the respondents from the nearest market is, however, significant at $p = 0.01$. Finally, the adopters spend less on labour input, however, the difference was not significant at $p = 0.10$.

Adoption of improved groundnut varieties

The result in Table 3 shows the level of adoption of IGV by farmers in the study area. The majority (75%) of the groundnut farmers have adopted improved varieties while 25% of the respondents did not adopt any improved groundnut variety.

The improved varieties adopted by farmers

The results in Table 4 show that IGV adopted by the farmers were Samnut 24 and Samnut 23 with 93.33% and 6.67%, respectively. The groundnut farmers in the study area preferred Samnut 24 which is locally called Yarjigile due to the following reasons early maturity (80 to 90 days), oil content estimated at 48%, resistance to rosette diseases, and moderately resistant to early and late leaf spot.

Table 5. Logit regression result for determinants of adoption of improved groundnut varieties

VARIALES	Odd Ratio	Std. Err	P > z
Frequency of extension	0.119225	0.2878578	**0.016****
Labor	1.870865	–3.284833	**0.079***
Farm size	0.1264048	.1478663	0.242
Occupation	0.7618835	.2266053	0.766
Association in membership	0.4051957	–.1863786	0.646
Commercialization index	0.4633231	.8948268	**0.053***
Distance to market	–.1299546	.1312246	0.322
CONSTANT	4.67385	–9.411055	0.044

Omnibus Test of Model Coefficients: Chi-square **39.20** Hosmer Lemeshow test: Chi-square **8.12** Sig (**0.422**)
*, ** = significant at 10% and 5%, respectively.

Table 6. Gross margin from groundnut production among the respondents

	GROSS MARGIN (₦/$)	
	Adopters	**Non-Adopters**
Minimum	42,000 (116)	2625 (7.29)
Maximum	207,998 (577.77)	62,000 (172.22)
Mean	97617.9 (271.2)	36425 (101.18)

Source: Field Survey (2019) value in US Dollars in parentheses ()

Table 7. Household dietary diversity among the respondents

Range	Adopters	Non adopters
≥ 11 (Nutritionally adequate diet)	60.3%	4%
< 11 (Nutritionally inadequate diet)	14.7%	21%

Source: Field Survey (2019)

Table 8. Categories of HFIAS

Categories	Range	Participants (%)	Non-participants (%)
Food secure	0–1	26.10	0
Mildly food insecure	2–13	28.3	15
Moderately food insecure	14–16	10.3	10
Severely food insecure	17–27	10.30	0

Source: Field Survey (2019)

Determinants of adoption of improved groundnut varieties

The result for the determinants of IGV is presented in Table 5. The value of the H–L goodness of fit test statistic (4.17) is not significant at (p = 0.05) which means that the Logistic model had a good fit for predicting the adoption of improved groundnut varieties. Secondly, the Chi-square static of 39.20 was significant at (p = 0.01) implying that all the exogenous in the model can be used to predict the technology adoption decision of the respondents. The result further shows that the likelihood of adoption of improved groundnut variety increases with the frequency of extension contact, labour, and the level of commercialization. The level of education was however not significant. A likely explanation for education is that it works indirectly by influencing farmers when making decisions. Literate farmers are very willing to get and use new technologies. Groundnut farmers with other occupations of livelihood activities have the tendency not to adopt the improved variety.

Outcome indicators

The summary of the outcome indicators (Gross-margin/ha, HDDS, and HFIAS) for the respondents is presented in Tables 6, 7, and 8. The result shows that adopters had a higher gross margin/ha compared to non-adopters. The result also indicated that on average, the adopters have a higher nutritional status and are more food-secure compared to the non-adopters of IGV. However, a valid attribution of improved groundnut variety on the outcome variables cannot be made without a suitable counterfactual. The PSM technique was used to create a valid counterfactual on the basis of which attribution of the outcome variables can be made with respect to the adoption of IGV.

The average gross margin for adopters and non-adopters of IGV was ₦97618 ($271) and ₦36425 ($101), respectively. This implies that the adopters of IGV realised a higher gross margin per hectare compared to the non-adopters.

An improvement in household dietary diversity implies diversity in a household's diet. An HDDS target was set by taking the average diversity score of 33% of households with the highest diversity (upper tercile of diversity) (Food and Nutrition Technical Assistance Project, 2006). Therefore, using the approach above, an HDDS target of 11 was established. Most importantly, only 60.3% and 4% of the adopters and non-adopters of IGV have nutritionally balanced diets, respectively.

Propensity score and matching quality test

The propensity score is a predicted probability of adoption of IGV and it was estimated from a logistic regression model. The results for the propensity matching score are presented in Table 9. The average probability for all households is 0.576 which suggests that the likelihood that a specific household chosen at random to adopt IGV is 57.6% with respect to the

Table 9. Propensity score distribution

Variable	observation	Mean	Std. Dev.	Min	Max
Propensity score	100	**0.5762712**	0.3657851	0.0233449	0.9999536

Source: Field Survey (2019)

Table 10. Covariate balancing and matching quality test

Sample	Ps R^2	LR chi^2	p > chi^2	MeanBias	MedBias
Unmatched	0.4875	32.01	0.007	22.5	172.5
Matched	0.004	3.4	0.845	3.5	2.5

Source: Field Survey (2019)

Table 11. Impact of adoption on income from groundnut (GM)

GM/ha	Sample	Treated	Controls	Difference	S.E.	T-stat
Groundnut farmers	Unmatched	121554.124	45636	75918.12	10600.5058	7.16***
	ATT	121554.124	73382.3529	**48171.77**	18766.5704	2.57
	ATU	45636	92828.8	**47192.8**	–	–
	ATE	–	–	**47756.95**	–	**–**

Source: Field Survey (2019)*, *** = significant at 10%, and 1%, respectively.

Table 12. Impact of improving groundnut variety on household food security

HFIAS	Sample	Treated	Controls	Difference	S.E.	T-stat
	Unmatched	3.94117647	1.20324997	2.74	–10.62	–12.775
	ATT	3.94117647	14.8235294	**–10.88**	–2.54	0.07794
	ATU	16.72	1.76	14.96	–	
	ATE	–	–	**12.6101**	–	

*** = significant at 10%, and 1%, respectively.

exogenous variables hypothesised to influence the adoption of improved groundnut farming.

The quality of matching was assessed in Table 10 using the overall covariate balancing test with and without matching. A large total bias reduction, the non-significant probability values of the likelihood ratio test after matching, low pseudo-R^2, and a large reduction in the mean standardised bias is a pointer that a successful balancing of the covariates was achieved (Wossen et al., 2018). The results in Table 10 reveal that the standardised mean difference for all covariates used in the PSM reduced from 22.5% pre-matching to 3.5% post-matching. Matching caused a reduction in bias by 84% and the joint significance of covariates after matching (p-value = 0.845) was rejected but accepted before matching (p = 0.007). As a result of the matching, the pseudo-R^2 dropped from 0.180 to 0.4875. This implies that there is a successful balance of covariates between the two categories of respondents.

Impact of improved groundnut variety adoption on income from groundnut

The results presented in Table 11 show that the adoption of IGV had a positive impact on income from groundnut production in the study. The Average Treatment Effect on the Treated (ATT) for the total population of groundnut farmers that have adopted IGV was ₦48171.7/ha ($133.8/ha). The Average Effect of The Treatment (ATE) on the population in the study area i.e. selecting any groundnut farmer at random was ₦47756.95/ha ($127/ha). This implies that when both adopters and non-adopters in the area are considered, income from groundnut due to the adoption of improved varieties will increase by about 48171.7 GM/ha ($133.8/ha). For the effect on the control group, the Average Treatment on the Untreated (ATU) value of 47192.81/ha (131.1$/ha) implies that for this category of respondents assuming they were treated, groundnut income will increase by 47192.8/ha ($131.1/ha). In essence, the adoption of IGV will lead to an increase in income from groundnut production.

Impact of improved groundnut variety adoption on household food security

The adoption of IGV had a positive and significant impact on household nutrition in the study area (Table 12). The value of the Average Treatment Effect on The Treated (ATT) on the adopters implies that HFIAS will reduce by 14.8235294 for all adopters of IGVs. On the other hand, the average effect of the treatment (ATE) for a household drawn at random is 12.61. The ATU was estimated as 14.96 which means that the food insecurity

Table 13. Impact of improved groundnut variety on household nutrition

HDDA	Sample	Treated	Controls	Difference	S.E.	T-stat
	Unmatched	94.96	93.873	1.09	–1.08647068	6.081
	ATT	93.87	87.17	**6.7**	6.69705873	0.0779
	ATU	94.96	100.84	**–5.88**	–	
	ATE	–	–	**–6.35**	–	

Source: Field Survey (2019)

assessment score for the non-adopters will increase by 14.96 if they adopt IGV. The results clearly show that the adoption of improved groundnut varieties increases the household food security of the adopters.

Impact of improved groundnut variety adoption on household nutrition

The result presented in Table 13 shows the impact of IGV on household dietary diversity as a measure of household nutrition. The result shows that the adoption of IGV had a positive and significant impact on household nutrition. The Average Treatment Effect on The Treated (ATT) on the entire population of the adopters was 6.7 this implies that the adoption of improved groundnut varieties will increase the household dietary diversity by 6.69 for all groundnut farmers that have adopted improved groundnut varieties. However, the average effect of the treatment (ATE) for a household drawn at random is 6.35084741. A significant and positive impact on household nutrition was observed for non-adopters with an ATU value of 5.88. The results show that the adoption of improved groundnut variety will increase the household nutrition of the groundnut farmers.

CONCLUSION AND RECOMMENDATIONS

The adoption of improved groundnut variety (IGVs) has the potential for enhancing the welfare (income and food security) of groundnut farmers. It is therefore justifiable and important for the government to provide funds for the evaluation of improved crop varieties in Nigeria. However, it is imperative to conduct further studies on how the cultivation of IGV can affect household welfare using a more robust impact evaluation tool.

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DECLARATION OF INTERESTS STATEMENT

The Authors declare that they have no competing interest.

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CONFLICT OF INTEREST

The authors declared no conflicts of interest with respect to the research, authorship, and publication of this article.

ETHICAL COMPLIANCE

The authors have followed ethical standards in conducting the research and preparing the manuscript.

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