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Determinants of improved groundnut variety adoption among farmers in Northern Ghana: a seed system analysis

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Abstract

Background Despite the release and registration of several groundnut varieties in Ghana, adoption by farmers is low. Farmer-saved seeds have remained the most reliable source of planting material in the groundnut seed system leading to low productivity of the crop.

Methods This study analysed the groundnut seed system in Ghana based on data from 593 northern Ghanaian farmers. It used probit regression and descriptive statistics to identify factors influencing farmers' adoption of improved groundnut varieties, including household size, education, gender, ownership of bicycles, mobile phones, motorcycles, farming experience, farm size, demonstrational site visits, and proximity to agro-dealer shops.

Results The study highlights a farmer's decision to adopt an improved groundnut variety was significantly influenced by household size, education, sex, ownership of bicycle, ownership of mobile phones, ownership of motorcycle, farming experience, groundnut farm size, demonstrational site visit, and distance to agro-dealer shops.

Conclusion The study has provided valuable insights into the dynamics of improved groundnut variety adoption in Northern Ghana and underscored the need for farmer education to promote improved seed adoption and enhance agricultural productivity and livelihoods.

Keywords Adoption, Groundnut seed system, Improved varieties, Northern Ghana

Background

Globally, groundnut cultivation spans tropical, subtropical, and warm temperate regions [57], with Africa being a significant contributor to world groundnut production. Ghana, among the top groundnut-producing countries in Africa, cultivates approximately 20 million hectares of groundnuts, a crop widely favoured by smallholder farmers in Northern Ghana due to its profitability [20].

In Ghana, seed supply relies on formal and informal systems. The informal system, supplying about 80% of seeds, involves farmers obtaining seeds through exchanges or local markets [33]. This unstructured system depends on local knowledge and biodiversity management [49]. In contrast, the formal system involves national research institutions, seed firms, extension programmes, and NGOs producing and distributing certified seeds. Supported by the Ministry of Food and Agriculture, this system integrates activities from germplasm collection to seed purchasing.

The formal seed system seeks to promote the adoption of improved varieties. Knowledge of the level of adoption of improved seeds remains crucial for developing a

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healthy seed system in Ghana. This may be brought to light by addressing the underlying problems threatening the development of the groundnut seed system and the adoption of improved varieties, as the use of high-yielding improved varieties has been shown to substantially increase the incomes of farmers in developing countries [59]. Adoption refers to a farmer's decision to use a novel methodology, innovation, or practice [25]. In practice, the adoption process is a change that occurs within a farmer regarding an innovation from the period they first become aware of the innovation to the end, whether to use it or not [51].

The rate of adoption is expressed as the percentage of farmers who have adopted a particular innovation, methodology, or practice. Also, the intensity of adoption of a technology denotes the level of adoption. In practice, the number of acres or plots with which a farmer cultivates an improved groundnut variety [47].

Farmers' selection criteria vary repetitively among and within households. The gender and age of farmers greatly influence the responsibilities and tasks of a particular household in choosing the kind of improved seeds [47]. Farmers' appreciation of the characteristics of improved varieties cannot be overemphasized. Perhaps the characteristics of crops are the most important criteria that are looked out for by farmers in satisfying their interests and need for adoption [58]. These characteristics may include seed colour, yield, maturity time, seed size, pod size, oil content, protein content, growth habit, marketability, and storage qualities. The desirability for home consumption, taste, ease of sale, cost, compatibility with existing practices, nutritional value, cooking quality, and tolerance to pests and diseases form part of these noticeable characteristics for adopting improved varieties [58]. According to Nkonya et al. [47], farmers adopt a particular variety through crop performance by looking at the crop on their farms and other parameters as discussed within their communities.

In Northern Ghana, the adoption of improved seed varieties stems from factors regarding institutional, personal, household, and demographic variables, as well as socioeconomic and industrial parameters. Earlier reports have indicated that the price of inputs, size of land owned, access to extension agents, access to credit support facilities, fertilizer use, and household economic status are the dominant factors pressing for the adoption of improved seeds [60]. Similarly, other factors such as frequency of contact with extension agents, age of farmers, and on-farm income level influence adoption. Also, improved groundnut seeds may be rejected by a farmer who has access to an off-farm source of income, owns many livestock, and has affluent status [14].

Accessibility to land, labour, capital, and information on improved varieties influences adoption rates between different farmers. Likewise, Ayinde et al. [7] and Idrisa et al. [21] showed that farmers' accessibility to such resources influences the rate of adoption of improved seed technology. Morris et al. [41] indicated that wealth has a positive relationship with adoption decisions because it increases a farmer's risk-bearing ability. Also, farmers' perceptions of the associated risk to profits of an improved seed contribute immensely to the adoption of a particular improved seed variety [64].

Other factors, for example, level of education, farm size, and farming experience, have been reported to have a substantial and positive influence on the adoption of improved seed varieties. According to Khanna [29], there is a positive relationship between experience and technology adoption, which increases a farmer's ability to evaluate the profitability of the innovation. According to Asfaw et al. [5], better-educated farmers tend to appreciate the adoption process and are therefore capable of managing the risks associated with agricultural technology.

In most African nations, agriculture remains a major contributor to economic growth. In 2010, the agricultural sector contributed 30.2% to Ghana's gross domestic product [40]. Nonetheless, the sector is dominated by small-scale farmers, especially in the northern part of the country, where production has historically been low. Farmers usually cultivate less than 5 acres of land and are challenged by unfavourable climatic conditions, pests, and diseases [11, 32]. Moreover, the seed systems lack organized production processes [30], as well as adequate processing structures, transportation networks, marketing systems, and storage facilities. These factors have constrained groundnut farmers in Ghana, leading them to rely on low-quality, farmer-saved seeds over the years. Consequently, farmers experience low yields and incomes, which hinder their overall economic growth and development.

In light of these challenges, understanding the factors that influence the adoption of improved groundnut varieties is essential for improving productivity and enhancing farmers' livelihoods. Additionally, assessing the rate of adoption of these improved seeds will contribute significantly to the existing body of knowledge on agricultural technology adoption. This study aims to determine the factors influencing the adoption of improved groundnut varieties in Northern Ghana. The specific objectives of the study were to:

i. determine the factors influencing the adoption of improved groundnut varieties.

ii. estimate the level of adoption of improved groundnut varieties in Northern Ghana.

Methodology

Study area

Northern Ghana consists of 5 regions, namely: Upper West, Upper East, North East, Northern, and Savannah. These regions cover a land area of 95,000 km^2 with a population of 10.4 million [17]. There are 65 districts in Northern Ghana. Northern Ghana is bordered by Ivory Coast, Togo, and Burkina Faso to the west, east, and north, respectively. The region is characterized by a single rainy season that starts in April or May and ends in September or October, followed by a continuous dry season from early November to the end of March. Northern Ghana is made up of predominantly rural communities, with agrarian activities being its chief economic activity. Groundnut, maize, sorghum, rice, millet, and cowpea are the major staple crops. In Northern Ghana, over 625,000 households cultivate groundnut, which constitutes 74% of all groundnut-producing households in the Northern and Savannah Regions (Strengthening Agri-Food Value Chains for Nutrition (SAFVC), 2013). In 2011, local farmers earned GH¢2,449 gross profit per hectare from groundnut production (Developing the Rice Industry in Africa (DRIA), 2012).

The region has a high potential for animal production [38], with sheep, goats, cattle, guinea fowls, and donkeys as the major animals reared. Although some farmers can afford the use of bullocks and tractor ploughing services for land preparation, hoe, and cutlasses remain important tools for farming. The study area (Fig. 1) has been identified as among the poorest in Ghana, with an average poverty level of 44% (Ghana Statistical Service (GSS), 2014). This area is ranked as the most insecure in the Comprehensive Food Security and Vulnerability Analysis by the World Food Programme (WFP) [61].

Sampling procedure

The survey followed random and purposive sampling methods. A total of 593 farmers were sampled from four regions and five districts. The districts selected were Binduri, Nadowli-Kaleo, Tolon, East Gonja, and Central Gonja from the Upper East, Upper West, Northern, and Savannah regions. The study targeted Aniisi, Atuba, Bazua, Chaangu, Dakpemyili, Darvoguyili, Dimabi, Dunjangu, Gbanko, Jangyili, Jello, Kampong, Kpandu, Kpatingyeg, Kumpalgeogo, Nachembia, Narango, Ombo, Sanpkala, Tapko, Tingoli, Tunayili, Wabguyili, Kamonayili, Yepelgu communities for respondents in various districts.

The household survey sourced both qualitative and quantitative data from the farmers. Farmers were

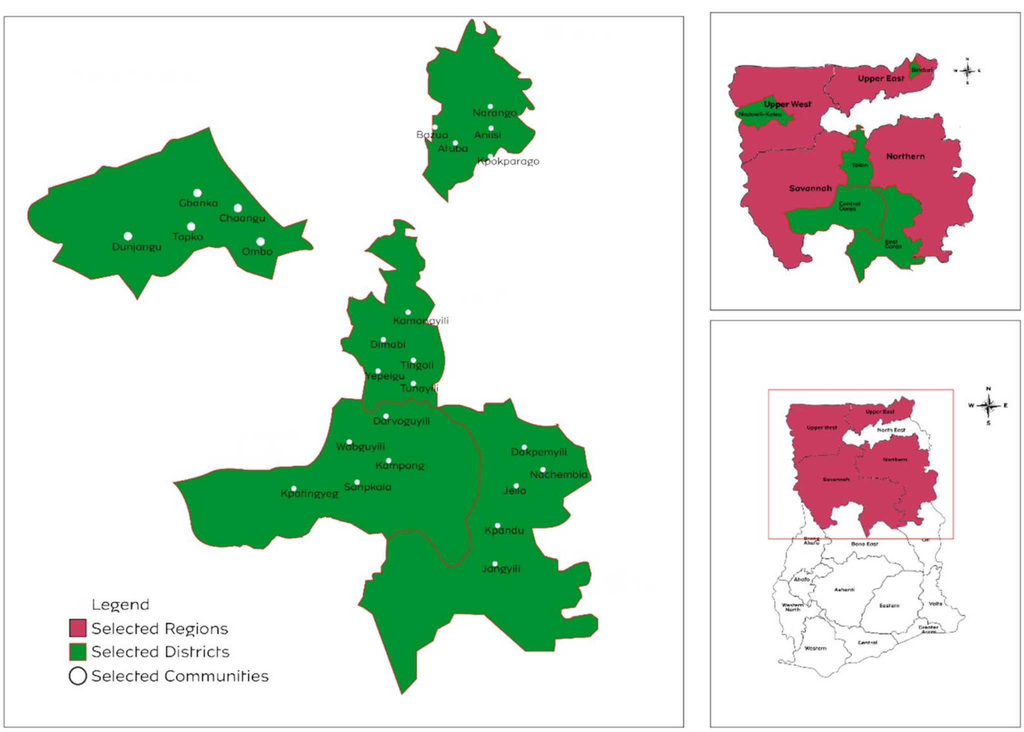

Fig. 1 Map of selected regions with districts. Source: Author's construct (2024)

interviewed with the aid of an 8-page pre-tested questionnaire which comprised questions on household demography and groundnut seed systems in Ghana (crops cultivated, framer's revenue, land used for cultivation, household assets, agro-dealer distance, agricultural advisory extension support services, household participation in adoption trials, storage practices, post-harvest practices, adoption of new practices or technologies, farming practices, variety evaluation, challenges to obtain certified seeds, and household food security).

There were a total of 10 enumerators which included national service personnel, masters' students, and CSIR-SARI staff. Also, the study lead worked with local experts, AEAs, seed sector experts, and farmers' organizations for data collection. The study used a Computer-Assisted Personal Interviewing (CAPI) system where questionnaires were transferred onto 10-in. Huawei MediaPad T3 handheld tablets. Information was collected from farmers using the KoboCollect Toolbox; version 1.25.1 (a software for data collection).

Level of adoption of improved groundnut seeds

Analytically, a farmer's decision to adopt an improved groundnut variety can be viewed as dichotomous, with two mutually exclusive alternatives, thus, either adopts or does not adopt [36]. Also, it had been reemphasized by Rahm and Huffman [50] on the utility maximization theory. The adoption of agricultural technology is the result of the optimization of heterogeneous agents [13] such that it takes place in the presence of prevailing constraints such as credit access, information, and other inputs. Therefore, groundnut farmers are assumed to maximize their utility function subject to these prevailing parameters [5]. Hence, the clear difference between the utility of adopters of improved varieties (Y_{iA}) and the utility of non-adopters of improved varieties (Y_{iN}) maybe denoted Yi^*, such that a utility-maximizing farm household, i, will choose to adopt new technology if the utility gained from adopting is greater than the utility from not adopting ($Yi^* = Y_{iA} - Y_{iN} > 0$). These utilities are unobservable and can, therefore, be expressed as a function of observable elements in the latent variable model as depicted below (Eq. 1). In the case of this study, farmers' adoption decisions of modern varieties can be modelled in a utility framework as follows:

$$Yi^* = X'_{i\gamma} + u_i \tag{1}$$

$$\text{with } Y_i = \begin{cases} i \text{ } if \text{ } Y_i^* > 0 \\ 0 \text{ } otherwise \end{cases}$$

where Y_i^* = the latent variable (the probability of household's decision to adopt an improved groundnut variety (which takes the value 1, if the farmer adopts and 0 otherwise)), X_i' = explanatory variables which explain the adoption decision, γ = a vector of parameters to be estimated and u_i = is the error term that is assumed to be independent and normally distributed, $u_i \sim N(0,1)$.

The study utilized a binary probit model to evaluate the probability of adopting improved groundnut varieties using the primary data. The probit model is acceptable in determining the probability of whether or not to grow an improved groundnut variety [16]. The dependent variables were categorized into two namely the improved varieties and other varieties. Further, the study assessed the influence of each of the independent variables on the decision of the household to adopt improved groundnut varieties. The study predicted the marginal effect of the explanatory variables in the model as follows [19]:

$$^{\partial[Y_i^*|X_i]}/_{\partial X_i} = \phi(X_i{\prime}\gamma)\gamma \tag{2}$$

Regarding the theoretical model above and previous research works of Newman et al. [45] and Noltze et al. [48], the study selected these explanatory variables based on a priori expectation of improved seed adoption literature and specified the probit model as follows:

$$\begin{aligned} Y_i = {} & \gamma_0 + \gamma_1 X_1 + \gamma_2 X_2 + \gamma_3 X_3 + \gamma_4 X_4 + \gamma_5 X_5 \\ & + \gamma_6 X_6 + \gamma_7 X_7 + \gamma_8 X_8 + \gamma_9 X_9 + \gamma_{10} X_{10} \\ & + \gamma_{11} X_{11} + \gamma_{12} X_{12} + \gamma_{13} X_{13} + u_i, \end{aligned} \tag{3}$$

where Y_i = adoption of improved groundnut seeds (binary dependent variable) with two categories [improved varieties and other varieties]. X_1 = education (in years); X_2= household size (number of persons); X_3 = sex (dummy); X_4 = ownership of land (dummy); X_5 = ownership of radio (dummy); X_6 = ownership of bicycle (dummy); X_7 = ownership of mobile phone (dummy); X_8 = ownership of motorcycle (dummy); X_9 = groundnut farm size (acres); X_{10} = demonstrational site visit (dummy); X_{11} = years in farming (years); X_{12} = distance to input shop (km);X_{13} = extension support (dummy); u_i = error term γ_0 to γ_{12}= coefficients to be estimated.

Adoption of improved groundnut varieties

The study utilized a binary probit (STATA 13.0) to evaluate the probability of adopting improved groundnut varieties using the primary data. The probit model is acceptable in determining the probability of whether or not to grow an improved groundnut variety [16]. The dependent variables were categorized into two namely the improved varieties and other varieties. Further, the study assessed the influence of each of the independent variables on the decision of the household to adopt improved groundnut varieties. The study computed the marginal effect of the explanatory variables in the model by estimating the first differential of the equation as follows [19]:

$$\partial[Y_i^*|X_i]/\partial X_i = \phi\left(X_i'\gamma\right)\gamma. \tag{4}$$

Based on the theoretical model above and previous research works of [5, 45, 48], the study selected these explanatory variables based on a priori expectation of improved seed adoption literature and specified a probit model as follows:

$$\begin{aligned} Y_i = \gamma_0 + \gamma_1 X_1 + \gamma_2 X_2 + \gamma_3 X_3 + \gamma_4 X_4 + \gamma_5 X_5 \\ + \gamma_6 X_6 + \gamma_7 X_7 + \gamma_8 X_8 + \gamma_9 X_9 + \gamma_{10} X_{10} \\ + \gamma_{11} X_{11} + \gamma_{12} X_{12} + \gamma_{13} X_{13} + u_i, \end{aligned} \tag{5}$$

where Y_i = adoption of improved groundnut seeds (binary dependent variable) with two categories [improved varieties and other varieties]; X_1 = education (in years); X_2= household size (number of persons); X_3 = sex (dummy); X_4 = ownership of land (dummy); X_5 = ownership of radio (dummy); X_6 = ownership of bicycle (dummy); X_7 = ownership of mobile phone (dummy); X_8 = ownership of motorcycle (dummy); X_9 = groundnut farm size (acres); X_{10} = demonstrational site visit (dummy); X_{11} = years of farming (years); X_{12} = distance to input shop (km); X_{13} = extension support (dummy); u_i = error term; γ_0 to γ_{12}= coefficients of to be estimated.

Education

Education (X_1) has consistently emerged as a key determinant influencing farmers' decisions regarding the adoption of agricultural technologies. It is hypothesized that a farmer's years of education is positively correlated with the adoption of improved groundnut varieties [42]. Specifically, research by Kassie et al. [26], and Asfaw et al. [5] demonstrates that educated farmers tend to be better equipped to comprehend innovative practices and exhibit a greater propensity to embrace them.

Household size

Previous research has identified household size (X_2) as a significant factor in the acceptance of modern agricultural technology. Household size, referring to the number of individuals living under the same roof and sharing resources with the household head, has been shown to play a substantial role in the adoption of innovations [8]. The adoption of improved groundnut varieties often requires intensive labour, making larger household sizes advantageous. This proposition finds support in the work of Sodjinou et al. [54], who observed that households with more members were more likely to adopt innovations, such as organic cotton.

Sex

The impact of the gender of farmers on the adoption of improved seed varieties has yielded mixed results in the literature. Recent findings on sorghum adoption in Mali indicate that the sex (X_3) of household heads does not significantly influence the acceptance of improved rice varieties [53]. However, Matata et al. [37] have reported that gender plays a contributory role in the adoption of improved varieties, suggesting that females may have a higher propensity to embrace novel varieties compared to their male counterparts. This aligns with the findings of Mansaray et al. [34], where gender was found to increase the likelihood of accepting NERICA varieties in Sierra Leone.

Ownership of land

Land ownership (X_4) stands out as a crucial asset influencing the adoption of agricultural innovations. It is generally hypothesized that farmer land ownership positively promotes the adoption of improved seed varieties and enhances overall agricultural production. This argument stems from the assumption that landless farmers may face higher production costs due to land rental expenses, potentially limiting their ability to invest in new agricultural technologies. In contrast, landowners enjoy more stable access to land resources and may have better access to credit facilities [15].

Ownership of radio

The ownership of a radio (X_5) has been documented as a factor influencing farmers' decisions regarding agricultural technology [1]. Farmers with access to radios are more likely to receive information about advancements related to local crop varieties in their vicinity, which can stimulate their interest in and adoption of improved groundnut varieties. Additionally, Shiferaw et al. (2010) note that radios are a primary source of external information for farmers.

Ownership of bicycle

The ownership of a bicycle (X_6) has been posited to increase the likelihood of farmers acquiring improved groundnut seeds [24]. Moreover, it has been demonstrated to have a significant positive impact on the adoption of agricultural technology [24]. Research by Ibrahim et al. [20] indicates that farmers who own bicycles as private property tend to have higher incomes from their agricultural activities. This suggests that bicycle owners may be more open to adopting improved groundnut varieties, as wealthier individuals tend to be less risk-averse [62]. Notably, in Northern Ghana, bicycles serve as a primary means of transportation between grain markets and farming sites.

Ownership of mobile phone

Household assets like mobile phones (X_7) are hypothesized to exhibit a significant positive correlation with the adoption of improved seed varieties [31]. Ownership of mobile phones increases farmers' chances of adopting improved seeds since they provide easy access to information from agro shops, farmer-based organizations (FBOs), fellow farmers, and extension agents, among other sources.

Ownership of motorcycle

Contrarily, the ownership of a motorcycle (X_8) by a farmer has been found to have a non-significant effect on the adoption of improved seed varieties [4]. While motorcycles facilitate farmers' mobility, not all farmers possess this asset, making it less likely to significantly influence the adoption of improved groundnut varieties.

Groundnut farm size

Previous studies have consistently suggested that farm size (X_9) plays a significant role in the adoption of improved seed varieties [62]. Other pieces of literature document a positive relationship between farm size and the adoption of improved seed varieties [18, 35].

Demonstration site visit

Farmers visit to demonstration sites (X_{10}) is estimated to positively affect adoption decisions on improved groundnut varieties in the study area [39, 52]. Practical field demonstrations of improved varieties on farmers' lands inform household heads and elders about the performance of various varieties and the potential benefits of adopting improved seeds.

Years in farming

The study expects a significant correlation between the adoption of improved groundnut varieties and farmers years (X_{11}) of groundnut farming [23]. It is hypothesized that farmers with more years of experience are more likely to adopt improved groundnut varieties as they possess a greater understanding of crop management and agricultural technology.

Distance to input shop

Distance to an input shop (X_{12}) has been recorded as a determinant that increases the likelihood of farmers adopting improved seed varieties [21]. Farmers located farther from input shops are less likely to adopt improved groundnut varieties, primarily due to the transportation costs and limited access to information on improved varieties.

Extension support

Agricultural extension agents serve as a key source of technical information on farm innovation to farmers; the extension supports (X_{13}) is expected to increase the likelihood of farmers adopting improved groundnut varieties [6].

Intensity of the adoption of improved groundnut seeds

The observed decision to adopt an improved agricultural technology is hypothesized to result from a complex set of preference comparisons among various technologies made by farmers. To analyse the factors influencing the adoption and intensity of the use of new agricultural technologies, it is common practice to estimate the Tobit model. Literature indicates that the Tobit has variously been used in adoption studies [3] to establish the intensity of adoption [43]. For example, [9] used the Tobit model to conduct a study on the adoption of modern beehive technology and determinant factors in Southern Ethiopia. The model is specified as follows,

Let I be the intensity of the use of improved groundnut varitety (IGV), I* is equal to an index reflecting the combined effect of explanatory variables promoting or hindering the of an improved groundnut variety. I* is not observable and is recorded as zero (0) or not having an area under improved variety. This can be expressed as:

$I^* = \beta 0 + \beta 1\chi 1 + \beta 2\chi 2 + \ldots. + \beta n\chi n + \mu i = f(\chi i)$.

$I = I^*$, if $I^* > 0$

$$= 0 \text{ if } I^* \leq 0 \quad (6)$$

Equation (1) represents a censored distribution of intensity of the use of an improved groundnut variety, where χ = a vector of explanatory variables; β = a vector of Tobit maximum likelihood estimates; μi = the independently and normally distributed error term assumed to be normal with mean zero and constant variance σ.

The value of I for all non-users equals zero. Following Tobin [56], the expected intensity of use of a given technology, E(I), is: Im.

$$E(I) = \chi\beta F\left(\frac{I_m}{\sigma}\right) + \sigma f\left(\frac{I_m}{\sigma}\right), \quad (7)$$

where χ as defined above,

$$\mathrm{F}\left(\frac{\mathrm{I}_m}{\sigma}\right)$$

is the cumulative normal distribution function at

$$\left(\frac{X\beta}{\sigma}\right), f\left(\frac{\mathrm{I}_m}{\sigma}\right)$$

is the value of the derivative of the normal curve at

$$\left(\frac{X\beta}{\sigma}\right), \left(\frac{\mathrm{I}_m}{\sigma}\right)$$

is the value of the normalized index at the mean values of all the explanatory variables and represents the Z scores for the area under the normal curve. β is a vector of Tobit maximum likelihood estimates, and σ is the standard error of the error term. The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\left(\frac{\partial \mathrm{E(I)}}{\partial \chi i}\right) = \mathrm{F}\left(\frac{\mathrm{I}_m}{\sigma}\right)\beta i. \tag{8}$$

The change in the probability of using a technology as an independent variable χi is:

$$\frac{\partial F\left(\frac{I}{\sigma}\right)}{\partial \chi i} = f\left(\frac{\mathrm{I}_m}{\sigma}\right) = \frac{\beta i}{\sigma} \tag{9}$$

And, the change in the intensity of the use of technology to a change in an explanatory variable among users is:

$$\frac{\partial \mathrm{E(I^*)}}{\partial \chi i} = \beta i\left[1 - \frac{\mathrm{I}_m}{\sigma}\left(\left(\frac{\mathrm{f}\left(\frac{\mathrm{I}_m}{\sigma}\right)}{\mathrm{F}\left(\frac{\mathrm{I}_m}{\sigma}\right)}\right)\right) - \frac{\mathrm{f}\left(\frac{\mathrm{I}_m}{\sigma}\right)^2}{\mathrm{F}\left(\frac{\mathrm{I}_m}{\sigma}\right)^2}\right] \tag{10}$$

Intensity of adoption of improved groundnut varieties

To achieve the objective of estimating the intensity of use of improved groundnut varieties, the number of hectares of land of improved groundnut variety (IGV) cultivated is specified as a function of socioeconomic and institutional factors as follows:

$$\begin{aligned} IGV_i = {} & \beta_0 + \beta_1 AGE + \beta_2 SEX + \beta_3 AGE + \beta_4 HHS \\ & + \beta_5 EDU + \beta_6 FAREX + \beta_7 VLSAMEM + \beta_8 DISCR \\ & + \beta_9 LAND + \beta_{10} RADIO + \beta_{11} TV \\ & + \beta_{12} BIC + \beta_{13} DIS + \beta_{14} DEMO + \mu_i, \end{aligned}$$

where $\beta_1 AGE$ = age of the household head; $\beta_2 SEX$ = sex of the household head; $\beta_3 HHS$ = household size (adult members); $\beta_5 EDU$ = years of education; $\beta_6 FAREX$= years in farming; $\beta_7 VLSAMEM$ = VSLA membership; $\beta_8 DISCR$ = distance to credit facility; $\beta_9 LAND$ = ownership of land;

$\beta_{10} RADIO$ = ownership of radio; $\beta_{11} TV$ = ownership of television; $\beta_{12} BIC$ = ownership of bicycle; $\beta_{13} EXT$ = access to extension; $\beta_{14} DIS$ = distance to Input shop (log); $\beta_{15} DEMO$ = participation in demo.

Results

Household descriptive statistics

The survey findings (Table 1) showed that out of the 593 respondents interviewed, 143 were females representing 24.1%. The majority of farmers had no formal education (422) corresponding to 71.2% followed by respondents who had only primary education (68) corresponding to 11.5%. Farmers who had tertiary education were the least (18) representing 3% of the population. Two hundred and thirty-one respondents were members of farmer based organizations (FBO) in the study area representing 38.0%. Out of the total number of farmers, 60.7% were not members of any savings or loan group. Descriptive analysis of the data showed that out of the population of female respondents, about 26% were adopters (Table 1). Seventy-four percent (74%) of the total male respondents happened to be adopters of improved groundnut varieties. About 60% of household heads were users of improved groundnut varieties. Out of members of FBO, about 36% reported growing improved groundnut seeds. The results on Good Agronomic Practices (GAP) showed that 142 of the farmers planted in rows constituting 23.9% of the respondents. About 67%, 5%, and 19% of farmers who used herbicide, pesticide and planted in rows, respectively, were users of improved groundnut seeds (Table 1). Further observations from the continuous variables (Table 2) indicate that the mean age of farmers interviewed in the four regions was 40 years (standard deviation = 12.75). On average, the number of household members was 11 with a standard deviation of 7.7. Heads of the households interviewed had an average of 16.45 years in groundnut farming and the farmers had an acreage of 3.2 acres. Besides, the mean age of adopters was approximately 40 years while non-adopters was 43 years (Table 2).

Determinants of improved groundnut varieties adoption

The results of the probit regression (to determine the variables that influence the adoption of improved groundnut varieties in Northern Ghana) is presented in Table 3. Household demographics; household size, education, and sex were significant at 1%, 5%, and 10%, respectively. Education and sex of groundnut farmers were negatively significant while household size was positively correlated to the adoption of improved groundnut seeds.

Table 1 Descriptive statistics of categorical variables

Categorical variable	Description	Non-adopters		Adopters		Total
		Obs	Percent	Obs	Percent	
Respondent sex	Female	32	19.63	111	25.81	143
	Male	131	80.37	319	74.19	450
Education	No education	86	52.76	336	78.14	422
	Primary	36	22.09	32	7.44	68
	JHS	23	14.11	18	4.19	41
	SHS	13	7.98	31	7.21	44
	Tertiary	5	3.03	13	3.02	18
Community	Intervention					378
	Control					200
Household head (HH)	Yes	123	75.6	254	59.07	377
	No	40	24.54	176	40.93	216
HH resident status	Native	39	97.50	167	94.89	206
	Settler	1	2.50	9	5.11	10
Member of FBO	Yes	77	7.24	154	35.90	231
	No	86	52.76	275	64.10	361
Member of savings/loans	Yes	53	32.52	180	41.86	233
	No	110	67.48	250	58.14	360
HH own land	Yes	148	90.80	419	97.44	567
	No	15	9.20	11	2.56	26
Own radio	Yes	135	82.82	310	72.09	445
	No	28	17.18	120	27.91	148
Own mobile phone	Yes	6	3.68			6
	No	157	96.32	430	100.00	587
Own bicycle	Yes	126	77.30	352	81.86	478
	No	37	22.70	78	18.14	115
Own motorcycle	Yes	75	46.01	223	51.86	298
	No	88	53.99	207	48.14	295
Extension support	Yes	3	1.84	52	12.09	55
	No	160	98.16	378	87.91	538
Demonstration site visit	Yes	28	17.18	53	12.33	81
	No	135	82.82	377	87.67	512
Herbicide use	Yes	72	44.17	289	67.21	361
	No	91	55.83	141	32.79	232
Pesticide use	Yes	15	9.20	22	5.12	37
	No	148	90.80	408	94.88	556
Fungicide use	Yes	15	9.20	22	5.12	37
	No	163	100.00	429	99.77	592
Row planting	Yes	61	37.42	81	18.84	142
	No	102	62.5	349	81.16	451

Obs observation, percent percentage, HH household

Regarding household assets (radio, land, bicycle, mobile phone, and motorcycle), the analysis showed that land ownership was positive but not significantly related to the adoption of improved groundnut varieties. However, ownership of radio, bicycle, and mobile phone proved to be significant at 10%. Both radio and bicycle ownership contributed negatively to the adoption of improved groundnut varieties. Ownership of motorcycle was positively significant at 5%.

From the probit analysis, years of farming experience and farm size were significant at 1% while visits to demonstrational sites was significant at 10%. Farm

Table 2 Descriptive statistics of continuous variables

Continuous variable	Mean	SD	Non-adopters			Adopters		
			Size	Mean	SD	Size	Mean	SD
Age of respondents	40.13	12.75	163	42.840	13.353	430	39.109	12.39
Years of farming	16.45	11.00	163	18.355	11.444	430	15.762	10.77
Farm size	3.23	2.84	161	1.054	0.736	422	1.951	6.69
Household size	30.81	12.15	163	9.889	4.567	430	11.353	8.49

size had a positive effect on increasing the likelihood of adopting an improved groundnut variety by 8%. On the contrary, years of farming and visits to demonstrational sites had a negative effect on the adoption of improved groundnut varieties. This result, along with that of radio, is contrary to our a priori expectations and therefore requires further research.

Distance to agrochemical shops had a negative effect on the decision to adopt improved groundnut varieties.

Level of adoption of improved groundnut varieties in Northern Ghana

The result of the Tobit model (to determine the intensity of use of improved groundnut varieties in Northern Ghana) is presented in Table 4. It showed that household size (adult members) and years in education were the only household demographics that positively increased the use of improved groundnut varieties at 1% and 5% significance, respectively. Also, the ownership of land and television showed significance at 5%.

Access to extension support services indicated positive significance at 10% likewise distance to the credit facility.

Discussion

Factors influencing the adoption of improved groundnut varieties

The probit model predicted that household size, education, sex, ownership of radio, ownership of bicycle, ownership of mobile phones, ownership of motorcycle, farming experience, groundnut farm size, demonstrational site visit, and distance to agro-dealer shops had a significant effect at 1%, 5% and 10% level of significance on the adoption of improved groundnut varieties (Table 3). Farmers' demographics play a pivotal role in adoption decision-making since it shows how capable farmers are, for example, the educational level of farmers, household size, and sex have been used as a measure of human capital [28]. The educational level of farmers was significant at 5% level however, there was a negative correlation between the farmers' decision to adopt an improved groundnut variety (Table 3). Educated farmers often are reported to have more formal knowledge and exposure to farming environments compared to experienced but illiterate fellows [42]. However, studies conducted by Khanna [29], and [22] reported that education had a negative effect on the adoption of agricultural technology.

Many relatable studies have concluded that a larger household size relaxes the labour challenges faced by adopting farmers [65], [44]. Household size from the study could be observed to have contributed significantly at a 10% level of significance to the adoption of improved groundnut varieties (Table 3). The sex of farmers had a negative relation concerning the adoption of improved groundnut varieties. However, there was a significant difference recorded at the 10% level. Matata et al. [37] reported that the gender of farmers immensely contributes to the rate of adoption. Studies have highlighted that females show a keen interest in matters of the adoption of improved crop varieties compared to their male counterparts [34]. Regarding household holdings, it was generally observed that significant differences at 5% and 10% levels existed among these factors but for land ownership.

The results showed that ownership of radio does not contribute positively to the adoption of improved groundnut varieties. Similarly, the ownership of mobile phones had no impact on the decision to adopt groundnut varieties. Our finding is empirically synonymous with studies conducted in Ethiopia on improved maize varieties [63]. There is evidence that farmers are informed on the needful reasons why to opt for agricultural technology on local radio stations which in the long run influences their decisions positively [31]. The results from the household head on the adoption status of owners of motorcycles and bicycles showed that 51.9% and 81.9% of farmers were adopters of improved groundnut varieties (Table 1). Motorcycles and bicycles are some of the most utilized means of movement by inhabitants in the study areas. This signifies that the majority of farmers' access to improved groundnut seeds are not constrained due to the availability of motorcycles and bicycles.

The results showed that the groundnut acreage size of farmers was positive in its effect on the adoption of improved groundnut varieties. A unit increase in the

Table 3 Determinants of improved groundnut varieties adoption decisions

Variable	Coefficient	Marginal effect	Robust SD of the marginal effect
Household demographics			
Education	−0.041	−0.012**	0.004
Household size	0.016	0.005***	0.003
Sex	−0.337	−0.093*	0.039
Household assets			
Ownership of land	0.790	0.284	0.114
Ownership of radio	−0.340	−0.09*	0.037
Ownership of bicycle	0.195	0.060*	0.049
Ownership of mobile phone	−0.293	−0.079*	0.044
Ownership of motorcycle	0.114	0.034**	0.036
Production practices			
Groundnut farm size	0.289	0.086*	0.022
Demonstrational site visit	−0.211	−0.066*	0.058
Years in farming	−0.016	−0.005***	0.002
Proximity to agro-chemicals			
Distance to input shop	−0.008	−0.002***	0.003

***, **, * signified significance at 1%, 5% and 10%, respectively

acreage allocated to groundnut cultivation increased the probability of adoption by 0.8%. The farm size and adoption of improved crop varieties have a significant and positive correlation. This assertion is supported by earlier works on the adoption of agricultural technology [18, 26]. The results from the probit regression further showed a negative and non-significant effect of demonstrational site visit by farmers on the adoption of improved groundnut varieties (Table 3). The mean attendance of farmers to demonstrational sites was 1.88 (Table 2), but its contribution to the adoption decision was not significant. Our finding is in contrast with that of Mmbando and Baiyegunhi [39] and Danso-Abbeam et al. [12] who reported a positive and significant effect of field demonstration on adoption decisions. Distance to agro-dealer shops negatively and significantly influenced the adoption of improved groundnut varieties (Table 3). This result is in line with the findings of Hailu et al. (2014) and Tefera et al. [55]. Farmers travel relatively long distances to acquire inputs from dealers and this might result in a negative influence on the adoption of improved groundnut varieties hence easy access to these inputs should be ensured to increase the intensity of adoption.

Level of adoption of improved groundnut varieties in Northern Ghana

The estimated results from the Tobit model are presented in Table 3. The model's sigma was significant at the 1% level, indicating that the data were well-suited for this analysis. Out of the 14 variables included, 6 were significant in explaining the intensity of improved groundnut adoption.

Regarding household demographics, the years of education of the household head positively and significantly influenced the use of improved groundnut varieties. Specifically, in Northern Ghana, each additional year of schooling increased the probability of adoption by 4.9 percent. This finding aligns with other studies, such as those by Ahmed [2] and [27], which also identified a positive relationship between education and the intensity of adoption of improved farm technologies. The study also found that larger family sizes, particularly with members aged 18 and older, increased the likelihood of using improved groundnut varieties. An additional household member boosts the availability of family labour, which is crucial since these improved seeds are labour-intensive and require good agronomic practices such as timely weeding and agrochemical application. This result supports the findings of Sodjinou et al. [54], who reported a positive and significant effect of family size on the adoption of organic farming.

Institutional factors, such as access to extension services and credit, were notably significant. Extension services play a crucial role in the adoption of improved groundnut varieties, as extension agents provide essential technical information to farmers in Northern Ghana about the availability and use of these varieties. The findings underscore the importance of extension services in promoting the increased use of advanced farm technologies. Greater household exposure to extension

Table 4 Tobit model results of the intensity of use of improved groundnut variety in Northern Ghana

Variables	Intensity
Age of respondent	0.015
	(0.020)
Sex of respondent	0.027
	(0.526)
Community type	0.385
	(0.464)
Adult members	0.083***
	(0.030)
Years in education	0.098**
	(0.049)
Years in farming	0.000
	(0.009)
VSLA membership	0.674*
	(0.402)
Distance credit (log)	0.553*
	(0.298)
Own of land	10.548***
	(0.938)
Ownership of radio	−0.128
	(0.515)
Ownership of television	1.208***
	(0.413)
Ownership of bicycle	0.822
	(0.671)
Access to extension	0.823*
	(0.430)
Distance to input shop (log)	0.207
	(0.345)
Participation in demo	−0.819
	(0.596)
Sigma	4.352***
	(0.810)
Constant	−18.191***
	(2.139)
Observations	593
F(15, 579)	30.08
Prob > F	0.0000
Pseudo-R2	0.1523

Robust standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1

programmes, facilitated by frequent visits from extension agents, effective information dissemination, and comprehensive technical support, significantly enhances farmers' awareness of available technologies [66]. Similarly, access to credit is vital for farmers' production, as it influences the availability of farm inputs, particularly when personal income is insufficient. Credit facilities boost the adoption of improved technologies and are regarded as a key driver in promoting agrarian production [46].

Furthermore, household assets, such as land ownership and access to television, were found to significantly increase the intensity of adoption of improved groundnut varieties in Northern Ghana. Households with land ownership are more likely to experiment with new farming practices compared to those without land [10]. Television also plays a pivotal role in disseminating information about improved groundnut varieties, and educating farmers on the intricacies of cultivating these improved varieties.

Conclusions

This research offers valuable insights into the adoption of improved groundnut varieties in Northern Ghana, revealing several critical factors that influence this process. A notable gender disparity was observed, with male farmers demonstrating significantly higher adoption rates compared to their female counterparts. This highlights the need to develop tailored adoption strategies that address gender-specific barriers and promote equitable access to improved varieties.

The study also uncovers a surprising negative correlation between education levels and adoption. Educated farmers may exhibit caution or skepticism toward new technologies, suggesting that extension services need to adopt nuanced approaches to effectively bridge knowledge gaps and foster technology adoption.

Household size emerged as a positive factor in adoption, indicating that larger households with more labour resources are better positioned to implement innovative farming practices. This underscores the potential benefits of targeting larger households in adoption promotion efforts to enhance agricultural productivity. Conversely, ownership of communication tools like radios and mobile phones did not significantly impact adoption rates, calling for a reassessment of the role of traditional extension channels and interpersonal communication in promoting improved groundnut varieties.

Farm size was identified as a crucial factor, with larger farms showing a higher likelihood of adopting improved varieties. This aligns with the idea that larger farms can achieve greater returns on investments in improved technologies, highlighting the need to support smallholder farmers with better access to seeds and resources.

The study also highlights challenges within the groundnut seed system in Northern Ghana, including low education levels, limited access to extension services, and insufficient awareness of improved varieties. Addressing these issues through targeted educational campaigns, improved extension services, and farmer-focused breeding programmes will be essential in advancing adoption rates and enhancing agricultural productivity.

The analysis of adoption intensity revealed that education positively correlates with the degree of adoption, emphasizing the importance of informed decision-making in enhancing agricultural practices. Larger family sizes and access to institutional support, including extension services and credit, were significant contributors to adoption intensity. Additionally, household assets like land and television positively influenced adoption, with land ownership encouraging experimentation and television serving as a key medium for information dissemination.

In summary, this study provides a comprehensive understanding of the factors influencing the adoption and intensity of the use of improved groundnut varieties in Northern Ghana. While acknowledging limitations such as potential sampling bias and reliance on self-reported data, the findings offer a robust foundation for developing informed policies and interventions. Enhancing educational outreach, improving access to extension services, and expanding credit facilities are crucial for supporting farmers and ensuring the sustained adoption and effective use of improved groundnut varieties, ultimately contributing to increased agricultural productivity and food security in the region.

Abbreviations

WFP	World Food Programme
MoFA	Ministry of Food and Agriculture
GAP	Good agronomic practices
SARI	Savanna Agricultural Research Institute
WACCI	West Africa Centre for Crop Improvement

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Author contributions
KAI carried out the study, analysed and interpreted the data and drafted the manuscript. DKD, and PKD participated in the study design and were contributors in writing and correcting the manuscript.

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Availability of data and materials
Data are within the paper and its supporting information files. The datasets are available upon reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate
The participants involved in the study provided informed consent prior to their participation. Also, permission was obtained from local community leaders, including extension agents, village chiefs and local lead farmers before field investigations were conducted. The authors have all copyrights.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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