Analysis of Farmers' Willingness to Adopt Improved Peanut Varieties in Northern Ghana with the use of Baseline Survey Data.

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Abstract

This study employed a probit model to identify the factors that influence the willingness of farmers in northern Ghana to adopt improved peanut varieties. A cross-sectional data of 206 peanut farmers from the Tamale Metropolitan, Tolon-Kumbungu and Savelugu-Nanton districts in the northern region of Ghana were used in the analysis. The estimated results indicate that Tolon-Kumbungu district (location), early maturity, farm size, ownership of a radio and membership in a farm organization significantly influence farmer willingness to adopt improved peanut varieties.

JEL classification:
Key words: improved peanut variety, technology adoption, Ghana, probit model

Introduction

Agriculture continues to be a major contributor to the growth of the Ghanaian economy. The sector's contribution to gross domestic product (GDP) was 30.2 percent in 2010 (MoFA, 2011). Agriculture's contribution to employment is 50.6%. The sector is dominated by smallholder farms. About 90 percent of farms are less than 5 acres in Ghana. More than one-half (56.2 percent) of the nation's population live in rural areas. Despite the prominent role of agriculture in Ghana, poverty levels are high in rural areas, particularly among small scale farmers, especially the northern part of the country. To improve farmers' incomes, the introduction of new agricultural technologies/innovations such as improved seed varieties, have been advocated over the years (Besley and Case, 1993). The rates of adoption of such new agricultural technologies have however been mixed (Faltermeier and Abdulai, 2009). Increasing adoption rates of improved seeds is therefore essential for boosting crop production and increasing smallholder welfare in agriculture based societies.

In the case of Ghana, low agricultural technology adoption has been linked to the over reliance on the supply-driven approach to technology generation and dissemination, costs of production, cultural practices, tastes, and lack of existing market (MOFA, 2007; Asiedu-Darku, 2014). Understanding farmers' willingness and intensity in adopting a new agricultural technology remains a challenge for agricultural researchers and the various stakeholders (governments, donors and non-governmental organizations). It is therefore important to determine the factors that influence farmers' willingness to adopt an agricultural technology innovation such as improved peanut varieties (IPV). These IPVs have largely been developed by the Savanna Agricultural Research Institute (SARI), mostly in collaboration with international research institutions and donors (Ibrahim et al, 2012; Masters et al, 2013; Asiedu-Darku, 2014). To our knowledge, it appears farmers' willingness to adopt these technologies and practices have not been studied at the farm level.

With these considerations in mind, the objective of this study is to determine the factors that influence farmers' willingness to adopt IPV at the farm level in northern Ghana. In doing so this study makes an empirical contribution to both the technology adoption, adoption of IPV literature in Ghana.

Development and Release of Improved Peanut Varieties in Ghana

In Ghana, until recently, seed development was the sole responsibility of the government research institutions which worked in collaboration with international research institutions and external donor governments and agencies. There is however a gradual introduction of certified commercial seed production in the country (Tripp and Mensah-Bonsu, 2013). But all these commercial seed companies depend heavily on the government and donor agencies. Thus the rate of growth in the development of certified seeds depend heavily on government and donor demands at that particular time (Tripp et al, 2013). Currently the crops that are getting the most attention are maize, rice and soybeans (see table 1). Peanuts however still mostly depend on the traditional model of farmers using saved seeds from the previous harvest. As a result the demand for certified peanut seeds is very small to nonexistent. Table 1 shows that the largest quantity of certified peanut produced occurred in 2005 (63MT) whilst maize had its highest quantity of certified maize seeds produced in 2010 with 4327 MT.

The development, release and dissemination of IPV seeds is mostly done by the Ghanaian government. For example, the Savanna Agricultural Research Institute (SARI) and the Crops Research Institute (CRI) develop cultivars but the release is done by the National Varietal Release Committee of Ghana (NVRC). The NVRC is made up of Directors of CRI, SARI, Department of Agricultural Extension Services, Women in Agricultural Development, Crops Services Division, Grains and Legumes Development Board, Plant Protection Regulatory Services Division, the representative of the Universities of Ghana, a plant breeder, a representative of the Seed Growers' Association, a seed technologist, Head of the Ghana Seed Inspection Division, Head of the National Seed Service, a representative of the seed dealers' association and a farmers' representative (Sentimela et al, 2009). But the formal introduction (dissemination) of the improved crop varieties to farmers is the responsibility of the Extension Department of Ministry of Food and Agriculture (MOFA) (Asiedu – Darko, 2014). The development-release-dissemination protocol does create some problems. For instance, when SARI develops new peanut technologies (seeds), at some point, they provide farmers with the improved seeds for the purpose of on-farm trials. These farmers turn around and share the seeds with other farmers. By the time the improved seeds are released farmers have already contaminated the new seed and, in almost all cases, have already given the seeds names. The names are usually for the persons who introduced the seeds into a village or to farmers. It is therefore sometimes very difficult to track the adoption rate of the IPV since the variety may have numerous names. Moreover, the improved seeds are not usually available for farmers to purchase.

Officially, the following IPVs have been released over the years: Mani pinta (1986), Shi Tao Chi ((Chinese) 1980), F-mix (1986), ICGS 114 ((Sinkarzei) 1989), JL 24 (not known), Endorpo Munikpa- SARGV (2005), Nkatiesari-SARGV (2005), Gusie-Balin-ICGV 92099 (2005) and Kpaneli –ICGV 90084 (2005)). Some of these improved varieties are rereleases. For example, a review of literature on peanut varieties in northern Ghana shows that Mani pinta was first released to local farmers for on-farm trials in 1960 (McEwen, 1961). To our surprise, Chinese (50.2%) and Mani pinta (38%) still appear to be popular among farmers in the research area (see Table 3). This finding is similar to what Atuahene-Amankwa et al. (1990) observed in the late 1980s.

Peanuts in Ghana

Ghana is one of the leading producers of peanuts in the world (see Table 2). Ghana ranked tenth with 530,887 MT of in-shell peanut production volume in the world and fourth in Africa (FAOSTAT, 2011). Peanut is the most important legume crop grown in Ghana in terms of the total production and value (Tsibey et al., 2003). Agro-ecologically, peanuts are grown mostly in the northern savanna zone, which is conducive for peanut production. The zone receives an average of 43.31 inches of rain per annum. Ministry of Food and Agriculture (MOFA, 2011) reports show that farm yields of peanuts are considerably below the achievable levels (2.50 MT/Ha). The Northern region recorded the highest yield of 1.92 MT/Ha in 2010. Peanuts are commonly grown alongside major crops such as maize, yams and millet (Tsibey et al., 2003). The 2010 agricultural production figures show that the Northern Region (227,650 MT) and Upper West (196,676 MT) together produced about 80 percent of the nation's total peanut production (MOFA, 2011). Almost all peanuts produced in Ghana are consumed domestically and the market is entirely controlled by the informal sector. The export market is almost non-existent with aflatoxin contamination being the major constraint for peanut exports to Europe and America (Awuah et al., 2009; Pazderka and Emmott, 2010; Florkowski and Kolavalli, 2013).

Like the rest of Sub-Saharan Africa, the peanut crop is a valuable cash crop and a food staple for millions of Ghanaians (MoFA, 2011). Peanuts are high in edible oil, protein, essential vitamins and minerals. Peanuts are also processed into paste (butter) and widely used by Ghanaians to make soup, stews, and cereal mixtures (Asibuo et al, 2008; Masters et al, 2013). In the Northern Region, women process the meal into cakes which are consumed as snacks (kulikuli) or further processed into powdered form (kulikuli zim). Kulikuli zim is generally used as soup or stew thickener and condiments for local (traditional) foods such as tubaani, fried bean cakes, yams and kebabs. Peanut cake from industrial oil processing is mostly used to feed poultry and livestock, especially in the southern Ghana where most of the commercial poultry and livestock establishments are located (Goldworthy and Fisher, 1987; Awuah et al., 2009).

Data

The cross-sectional data used in the study were obtained from a survey conducted in July and August 2010. The face-to-face interviews were conducted in 13 communities within three districts (Tamale Metropolitan, Savelugu-Nanton and Tolon-Kumbungu) of the Northern Region. Some changes have already been made in terms of districts since the survey. In 2012, Savelugu-Nanton was made municipality and Tolon-Kumbungu was split into two separate districts. For the purpose of this study, we will retain the old classifications. A random sample of 251farmers was selected from the 13 communities to ensure full representation.

In this analysis, "improved peanut variety" is defined as the variety that is not indigenous to Ghana. Three major varieties of peanuts cultivated in the research area were identified. They include "Chinese", "Bugla" and Mani Pinta. This is in direct contrast with Tsibey et al. (2003) findings which implied that only sinkarzei was cultivated in the research area. Bugla is the only local variety still in cultivation. Mani Pinta and Chinese continue to be dominant even though they were introduced over a generation ago. It is not clear why farmers and traders in this part of the country appear not to be able to differentiate varieties. What is, however, clear is that names given to varieties are generally descriptive. For example, the Chinese variety is generally referred to as "simbaligu," meaning, small kernel, while bugla means enormous kernels. Table 3 shows that the most cultivated IPV by the respondents are Chinese (50.2%) and Mani Pinta (38%). It was difficult to obtain specific names for some varieties, especially the newly improved varieties.

Descriptive statistics and explanation of the variables used in the study are provided in Table 4. The farm characteristics incorporated in our models include, farmland area, information, farmer's assets and the farm location. It is shown in Table 4 that 91 percent of respondents adopted improved peanut varieties and about 20 percent of the adopters were females. Farmers, on average, had one contact with an extension officer during the 2009 farming season. The average age of a respondent was 39 years and 47 percent reported being the head of household. The average household size was 15 persons. The average peanut cultivated area was about 4 acres, while the average total farmland was 9 acres. About 16 percent of the respondents had formal education.

Model

The adoption model is based on the theory that farmers make decisions to maximize their expected utility or benefits (e.g., profitability). The farmer will adopt the new technology if the benefits of adopting the new technology exceed that of the old technology. According to Mauceri et al (2005), factors such as farmer characteristics, economic barriers, access to information, technology characteristics and farmer perceptions affect farmers' perceptions. In their study, Gyasi et al (2003) listed farmer's age, family labor, farm size, farming experience, extension contact, technology and technology characteristics influence adoption of innovations. In this study we used factors such as farmer characteristics (location, age, education, income earned from peanut production and farm size), Farmer assets (Own radio, own motorcycle, and own a pair of bullocks), and access to information (extension contacts and membership in a crop organization).

Qualitative response models are often used if the dependent variable takes one of a number of discrete values. A review of existing studies revealed that most adoption studies model the decision to adopt as a categorical variable (Kassie et al, 2010; Mojo et al, 2010; Simtowe et al, 2010). However, we chose to use binary response model since adoption is considered as a yes or no decision by farmer. The probit model was selected because its asymptotic characteristic constrains the predicted probabilities to a range of zero to one.

The probit model assumes that while we only observe the values of 0 and 1 for the variable willingness to adopt (W), there is a latent, unobserved continuous variable W* that determines the value of W. We assume that W* can be specified as,

$$W_i^* = x'\beta + u_i \qquad (1)$$

where W_i^* is a latent variable.

and that:

W_i = 1 if a peanut farmer is willing- to - adopt IPV

W_i = 0 otherwise

x_i' represents a vector of random variables, and u represents a random disturbance term.

Now from equation 1,

$$\Pr(W_i = 1) = \Pr(x'\beta + u_i > 0) \qquad (2)$$

Rearranging terms:

$$\Pr(W_i = 1) = \Pr(u_i > -(x'\beta)) \qquad (3)$$

$$= 1 - \Pr(u_i < -(x'\beta))$$

$$= 1 - F(-(x'\beta))$$

where F is the cumulative density function of the variable u if one makes the assumption that

$$\Pr(W_i = 1) = 1 - \Phi(x'\beta) \qquad (4)$$

$$= \Phi(x'\beta)$$

where Φ represents the cumulative normal distribution function. Then, it follows that the probabilities for each response category are given by:

$$\Pr ob[W_i = 0] = \Phi[\mu_0 - \alpha X] \qquad (5)$$

$$\Pr ob[W_i = 1] = \Phi[\mu_1 - \alpha X] - \Phi[\mu_0 - \alpha X] \qquad (6)$$

Where $\alpha = \frac{\beta}{\sigma}$ and $\frac{\theta}{\sigma} = 0{,}1$. Note that the only ratios that are estimable are $\alpha = \frac{\beta}{\sigma}$ and $\frac{\theta}{\sigma}$ (Dustman, 1996).

Using maximum likelihood technique we compute estimates of the coefficients (βs) in equation (1) and their corresponding standard errors that are asymptotically efficient.

The corresponding likelihood function is given by

$$L = \prod_{y_i=0}\left[F(-\sum x_i'\beta)\right]\prod_{y_{=1}}\left[1 - F(-\sum x_i'\beta)\right], \qquad (7)$$

Which can be rewritten as:

$$L = \prod_{y_i=1} \left[F(-\sum x_i'\beta)\right]^{1-y_i} [1 - F(-\sum x_i'\beta)]^{y_i} \quad (8)$$

These estimates, however, cannot be interpreted in the same manner we interpret normal regression coefficients. These coefficients give the impact of the independent variables on the latent variable W*, not W itself. To transfer W* into a probability estimate for willingness to adopt, we compute the cumulative normal of W*. Because of this transformation, there is no linear relationship between the coefficients and $\Pr(W_i = 1)$. Hence, the change in $\Pr(W_i = 1)$ caused by a given change in x_{ji} will depend on the value of all of the other x_s and their corresponding coefficients, or more precisely on the value of the sum $X_i\beta$, as well as the change in x_{ji}.

To estimate the probabilities of a peanut farmer expressing willingness-to -adopt IPV, we specify a model that is linear in parameters as

$$\begin{aligned} W_i = {} & \beta_0 + \beta_1 Tolon\_Kumbungu + \beta_2 Farm\_size + \beta_3 Maturity\_Time + \beta_4 Ext\_Cont + \beta_5 Own\_Radio \\ & + \beta_6 Own\_Bicycle + \beta_7 Own\_bullock + \beta_8 Own\_motorcycle + \beta_9 Org\_Memb + \beta_{10} Age \\ & + \beta_{11} Age\_Squared + \beta_{12} Formal\_Ed + \beta_{13} \ln nut\_inc + \varepsilon_i \end{aligned} \quad (9)$$

where β_s are parameters to be estimated, and the error term ε is assumed to be independently, and identically distributed. This limited dependent variable model can be estimated using maximum likelihood, probit procedure. The model is estimated using STATA statistical software package.

Results

We used a probit model to estimate the probability of adoption of new technologies, with the dependent variable representing use of improved seeds. The explanatory variables included the farmer's age, location (Tolon-Kumbungu District), maturity time, ownership of a radio, motorbike, and bullock, membership in a farmer organization, extension contacts, farm income from peanut production, formal education of the farmer and farm size. Results of the probit model are summarized in table 5. Five variables are significantly explained by the probability to adopt IPV: membership in a farmer organization (MEMBERSHIP), Farm size (FARM_SIZE), early maturity considered important or very important (MATURITY TIME), ownership of a radio (OWN_RADIO), and the location of the farmer (TOLON_KUMBUNGU DIST). The membership in farmer organization was positively related to the probability to adopt IPV, implying that farmers who belong to a farmer organization or group are more likely to adopt IPV. Farmers, who consider maturing time characteristic of IPV to be important or very important, are more likely than those who do not consider maturity time to be important to adopt IPV. The variable ownership of a radio is significant but negative, implying farmers who own radios are less likely to adopt IPVs. TOLON_KUMBUNGU DIST variable is negatively related to the adoption of an IPV. This means that a farmer located in the Tolon-Kumbungu district is less likely to adopt an IPV compared with a farmer located in either Savelugu-Nanton district or Tamale Metropolitan areas.

For comparison purposes, table 5 reports the results of a conventional probit model which shows that MEMBERSHIP, FARM SIZE, MATURITY TIME, OWN_RADIO and TOLON_KUMBUNGU district are factors that influence farmers' willingness to adopt IPV. The marginal effects, reported in column 5 of Table 5 show that a farmer who belongs to a farmer organization is 6% more likely adopt an IPV as opposed to those who do not have membership in a farmer related organization. The coefficient for Maturity time is 0.097, implying that farmers who consider maturity time to be important are 10% more likely to adopt IPV than those who do not.

Farm size, the total number of acreage cultivated by the farmer, appears to have a negative influence on the adoption of IPV. This means that increasing the farm size by one acre decreases the probability of the farmer adopting IPV by 0.004%, but the decrease is negligible for small farmers. The variable Tolon-Kumbugu district is also negative (-7%), meaning farmers in the Tolon-Kumbungu District are 7% less likely to adopt IPV compared to the other districts in the survey area (Tamale Metropolitan and Savelugu-Nanton district). Similarly, the coefficient of -0.06 for ownership of a radio means that those farmers with radios are 6% less likely to adopt IPV as opposed to those who do not have radios. It is important to note that factors such as education, extension visits, income earned from peanut sales and age did not significantly contribute to willingness of the farmer to adopt IPV.

Conclusion

The study employed a probit estimation procedure to examine the factors that influence the willingness of peanut farmers in northern Ghana to adopt IPV. The factors that negatively influence adoption include ownership of a radio, the farmer living in the Tolon-Kumbungu district and the total farmland. Maturity time and membership in a farm organization, however, were found to positively affect the farmer's willingness to adopt IPV.

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Table 1. Certified Peanut Seed Production in Ghana: 2003 – 2010 in Metric Tons

Year	Maize	Rice	Soybean	Peanuts
2001	996	732	87	-
2002	1,498	457	190	-
2003	1,341	407	179	9
2004	1,356	495	-	9
2005	2,035	233	356	63
2006	1,672	516	218	23
2007	1,677	344	92	3
2008	2,474	550	154	7
2009	3,789	2,378	295	9
2010	4,327	1,450	340	18
2011	2,670	2,367	189	-

Source: Tripp and Mensah-Bonsu, 2013

Table 2. The World peanut production (in-shell) in 2010

Rank	Country	Production (MT)
1	China	15,709,039
2	India	5,640,000
3	Nigeria*	2,636,230
4	United States	1,884,950
5	Senegal*	1,286,860
6	Myanmar	1,135,100
7	Indonesia	779,607
8	Sudan*	762,500
9	Argentina	611,040
10	Ghana*	530,887
11	Viet Nam	485,792

Source: FAOSTAT
*African countries

Table 3. Major peanut cultivars grown in the survey area

Variety	Percent of growers
Local (bugla)	11.3
Chinese (Simbaligu)	50.2
Simkarizee	0.05
Mani Pintar (Abain)	38.0

Source: Survey data

Table 4. Descriptive Statistics

Variable	Description	Mean	Min.	Max.
HHold size	Household size (#)	15.05	1	80
Male_ 13	Male 13 years and over	4.35	1	23
Female_13	Female 13 years and over	4.59	0	20
Head	Head of Household; 1 if the respondent is the head of house; otherwise 0	0.467	0	1
Own_Tractor	1 if the respondent is the owns a tractor; otherwise 0	0.037	0	1
Farm_size	Farm size in acres (#)	8.70	1	75
Ext_Cont	Number of extension contact	0.97	0	3
Credit	1 if farmer had access to credit; 0 otherwise	0.14	0	1
Improved (IPV)	1 if farmer planted IPV; 0 otherwise	0.907	1	3
Own_Radio	1 if farmer owns a radio; 0 otherwise	0.79	0	1
Own_bicycle	1 if farmer owns bicycle; 0 otherwise	0.79	0	1
Own_bullock	1 if farmer owns bullock; 0 otherwise	0.06	0	1
Own_mororbike	1 if farmer owns a radio; 0 otherwise	0.06	0	1
Crop_Org	1 if farmer is a member a crop organization; 0 otherwise	0.23	0	1
Gender	1 if farmer is a male; 0 otherwise	0.80	0	1
Age	Age of farmer in years	38.65	18	75
Informal_ed	1 if farmer has attended formal educ; 0 otherwise	0.156	0	1
Hiyield	1 if farmer thought improved varieties were important in their seed choice; 0 otherwise	0.93	0	1
Insect	1 if farmer thought improved varieties were important in their decision making process; 0 otherwise	0.30	0	1
Disease	1 if farmer thought improved varieties were important in their seed choice; 0 otherwise	0.28	0	1
Drought	1 if farmer thought improved varieties were important in their seed choice; 0 otherwise	0.45	0	1
Kernel_size	1 if farmer thought improved varieties were important in their seed choice; 0 otherwise	0.50	0	1
E_Maturing	1 if farmer thought improved varieties were important in their seed choice; 0 otherwise	0.72	0	1
Hiprice	1 if farmer thought improved varieties were important in their seed choice; 0 otherwise	0.84	0	1

Table 5. Summary of the probit results: dependent variable =1 (for adopters), 0 otherwise

Variable	Coefficient	Standard Error	Z	Marginal Effect
Constant	2.9685	1.9417	1.53	
Tolon Kumbugu District	-0.7302	0.3296	-2.22	-0.0718*
Farm size	-0.0380	0.0159	-2.38	-0.0037*
Maturity Time	0.7318	0.2884	2.54	0.0973*
Extension Contact	-0.1920	0.1225	-1.57	-0.0189
Own Radio	-0.9393	0.5100	-1.84	-0.0628*
Own Bullock	-0.7638	0.5902	-1.29	-0.1266
Own motorcycle	0.0738	0.3371	0.22	0.0070
Organization	0.0832	0.4707	1.71	0.0570*
age	-0.0835	0.0845	-0.99	-0.0082
Age squared	0.0010	0.0010	1.05	0.0001
Formal Education	0.3974	0.4668	0.85	0.0313
LnPeanut Income	0.0164	0.1991	1.06	0.0200
Log likelihood	-52.60			
Probability of χ^2	26.48			
Probability of χ^2	0.0092			
Pseudo R^2	2011			
N	208			

* Significant at α = .05; Marginal effect refers to the marginal measured effect of the variable on the probability of adoption