# Fertilizer Adoption and Use Intensity Among Smallholder Farmers in Northern Ghana: A Case Study of the AGRA Soil Health Project

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## Abstract

Northern Ghana is characterized by food insecurity largely due to over reliance on rain-fed agriculture under low farm input conditions. The present study investigated the effect of factors influencing mineral fertilizer adoption and use intensity among smallholder farmers in Northern Ghana. A total of 330 smallholder farmers selected through multi-stage sampling technique were interviewed. Adoption of fertilizer technology was determined by age, nativity, farm size, access to credit, and distance to agricultural office. The result of the truncated regression estimates indicated that income of household head, membership of farmer association, distance to agricultural office, access to input shop, income earning household that do not participate in agricultural development project and income-earning male-headed household were the significant factors influencing fertilizer use intensity. Distance to agricultural office was a key positive determinant of fertilizer adoption and use intensity. The study recommends improvement in road infrastructure and technical training of agricultural extension agents. Farmer based organizations must be trained on regular basis to enhance their productive skills and technology uptake.

**Keywords:** fertilizer, adoption, soil health project, probit, truncated

## 1. Introduction

### 1.1 Background and Problem Statement

Agriculture in Ghana is predominantly on a smallholder basis. About 90% of farm holdings are less than two hectares in size, although there are some large farms and plantations, particularly for rubber, oil palm and coconut and to a lesser extent, rice, maize and pineapples (Chamberlin, 2007). The smallholder farmers are dispersed, and this makes provision of support services expensive and ineffective. Production is also largely rain-fed with limited mechanization and inadequate use of improved technologies such as high and stable yielding crop varieties, good agricultural practices, fertilizers, and other agro-inputs. These among many other things have contributed to the observed low levels of productivity in the agricultural sector (Chamberlin, 2007).

Cereals are major crops of importance to the agricultural sector of Ghana. Northern Ghana, which comprises - Northern, Upper East and Upper West regions - accounts for over 40 percent of agricultural land in Ghana and is considered the breadbasket of the country (MoFA, 2010). The most important food crops in northern Ghana are maize, rice, sorghum, pearl millet, cassava, groundnut, cowpea and soybean. For most farm families, cereals are the most important staples. The importance of maize is demonstrated in its expansion to even the drier areas of northern Ghana where it has virtually replaced sorghum and millet which were traditional food security crops in the region. Northern Ghana produced about 350,000 metric tons of maize in 2011 over an area of 245,000 ha (SRID, MoFA, 2012). Nearly all production of cowpea (95%) and soybean (97%) in the country emanates from northern Ghana (SRID, MoFA, 2012).

The area is however inundated with high levels of food insecurity and poverty. Nearly one million people amounting to about half of the population of the area face annual food deficit and are net buyers of food (GSS, 2008) which is a major concern to the government and its development partners. About 80 percent of the population depends on subsistence agriculture with very low productivity and low farm income (MoFA, 2010). Per

capita income of the area is about US$200.0 per annum, which is less than 50 percent of Ghana's per capita income of approximately US$600.0 per annum (GSS, 2008). The main reason for the extreme poverty and high food insecurity is the over reliance on rain-fed agriculture under low farm input conditions.

Low soil fertility has also been identified as a major contributor to the low yields recorded by the agricultural sector (MoFA, 2010). The soils of the major maize growing areas in northern Ghana in particular are low in organic carbon (< 1.5%), total nitrogen (< 0.2%), exchangeable potassium (< 100 ppm) and available phosphorus (< 10 ppm, Bray 1) (Adu, 1995; Benneh et al., 1990). A large proportion of the soils are also shallow with iron and magnesium concretions (Adu, 1969).

Soil fertility management in Ghana is sub-optimal thus affecting yields. Fertilizer nutrient application in Ghana is approximately 8 kg per ha while depletion rates, which are among the highest in Africa, range from about 40 to 60 kg of nitrogen (N), phosphorus (P), and potassium (K) per hectare per year. Estimates show negative nutrient balance for all crops in Ghana (FAO, 2005). The escalating rates of soil nutrient mining are a serious threat to sustainability of agriculture and poverty reduction in Ghana. There are also inefficiencies and bottlenecks in fertilizer distribution networks which limit access, and add to the cost of fertilizer in farming communities. Agro-input marketing is rudimentary and farmer-based organizations are also weak and therefore unable to acquire credit, fertilizer and other inputs in bulk to reduce cost (FAO, 2005). These are likely to affect decisions on the use of fertilizers and other agro-inputs in the country.

Integrated Soil Fertility Management (ISFM) is the approach advocated by Alliance for a Green Revolution in Africa (AGRA) to improve the soil fertility and soil health status of African soils. AGRA has demonstrated its commitment to improving the health of the soils in northern Ghana by funding the Soil Health Project 005 which is being implemented by CSIR-Savanna Agricultural Research Institute between 2009 and 2013. Most studies on soil fertility management focused on quantifying the socio-economic, institutional and production factors which influence adoption and fertilizer use intensity among smallholder farmers (Akpani, Udoh, & Nkanta, 2012; Ariga, Kibaara, & Nyoro, 2009; Tchale & Wobst, 2004; Waithaka, Thornton, Shepherd, & Ndiwa, 2005). According to MSU (1998), fertilizer use intensity is constrained by both external and internal factors which include access to credit, access to input and output markets, access to complementary inputs which have "thin" markets like manure and lack of appropriate knowledge base, erratic rainfall pattern, transport cost, access to irrigation and storage facilities. In addition to these factors, this study investigated other important factors within the context of the AGRA Soil Health Project that have the potential to influence fertilizer adoption among smallholder farmers in northern Ghana.

There are myriads of models ranging from binary to multinomial that have been proposed to study the adoption behaviours of farmers as well as the fundamental determinants of technology adoption. Normally, the econometric specification depends largely on the objective of the study and the type of data available (Shiferawa, Kebede, & You, 2008). Studies on adoption of technology employ the logit and probit models where the dependent variable is dichotomous whereas Tobit model measures the intensity of use of a technology (Adesina & Zinnah, 1993; Kristjanson et al., 2005; Maddala, 1983; Shiyani et al., 2002; Tobin, 1958) given the restrictive assumption that the probability of adoption and use intensity are jointly determined.

This study examined this assumption and employed the Double Hurdle Model (DHM) as developed by Cragg (1971) to empirically determine fertilizer adoption and use intensity in northern Ghana. The model employed in this study is appropriate since fertilizer adoption and intensity of use are two distinctive choices. The DHM is a parametric generalization of the Tobit model in which two separate stochastic processes determine the decision to adopt fertilizer technology and the intensity of fertilizer use. The model assumes that farm household heads make two consecutive decisions with respect to adoption and intensity of use of fertilizer. The first hurdle involves the fertilizer adoption equation estimated by employing the probit model whereas the second hurdle involves an outcome equation, which uses a truncated model to determine the extent of optimum use of fertilizer. According to Coady (1995) and Croppenstedt et al. (2003), the DHM has been used in modeling constrained adoption and intensity of use of new technologies mainly because it accounts for the existence of a significant number of farmers with positive desired demand for modern inputs but are too constrained to adopt them.

### 1.2 Concept and Justification of the AGRA Soil Health Project

The Soil Health Project (SHP) aims at improving smallholder farmer productivity, through increasing access to locally appropriate soil nutrients and promoting ISFM. The objectives of the programme were to (1) create in five years, physical and financial access to appropriate fertilizers for around 4.1million African smallholder farmers in an efficient, equitable and sustainable manner (2) create in five years, access to appropriate ISFM knowledge, agronomic practice and technology packages, for around 4.1 million African smallholder farmers

and (3) create a policy environment for investment in fertilizer and ISFM in African countries.

In a bid to translate the above objectives into implementable actions, three sub-programs were established, which constitute major strategic levers of the SHP. These include:

(i) Research and Extension: It seeks to facilitate the adoption of improved ISFM technology packages that promote the use of both mineral and organic fertilizers and conservation agriculture production practices. It also provided funding to soil scientists to test various ISFM technology options to identify and promote those that enhance smallholder farmer productivity.

(ii) Fertilizer Value Chain Development: Fertilizer sub-program aims at catalyzing local production of fertilizer through support to local companies that are providing appropriate blends using local phosphate rocks.

(iii) Capacity building in the form of training: The aim is to maintain a supply of soil scientists to provide research and extension support to farmers. Soil laboratory technicians were also trained to improve the quality of laboratory management and outputs. Training was also provided to extension staffs who worked directly with farmers.

## 2. Method

### 2.1 Study Area

The study covered smallholder farmers in northern Ghana consisting of Northern, Upper East and Upper West Regions. The three regions share borders with Republic of Togo to the east, Ivory Coast to the west and Burkina Faso to the north. Within the country, the northern Ghana is bordered by Volta Region on the south east and Brong-Ahafo Region on the south west (Figure 1). Geographically, the three regions are between longitude $8^{o}46'01.88''$ N and $10^{o}58'34''$ N and latitude $2^{o}45'45.40''$ W and $0^{o}32'59.95''$ E and cover a total land area of 97,666 km² with an estimated population of 3,317,478. The vegetation is a typical Guinea Savannah type; which is characterized by drought-resistant grasses and trees. Northern Ghana plays an important role in agriculture and is normally referred to as the grain basket of the country. More than 80 percent of the inhabitants of northern Ghana are full-time farmers (MoFA/SRID, 2011). Most smallholder farmers in these regions have benefited from a lot of development projects aimed at increasing productivity and improving livelihoods. However, poverty is rated high in the region.



Figure 1. Administrative map of Ghana

### 2.2 Data and Sampling Technique

The study was conducted between October and November, 2012. The basic information for the analysis was

obtained from primary data collected with the aid of a structured questionnaire. In addition to the survey, key informants interviews and focus group discussion were conducted to augment the household survey.

A total of 330 smallholder farmers were systematically and randomly selected and interviewed. The sample frame for the study was the AGRA Soil Health Project 005 (AGRA SHP005) targeted districts in the three regions. The sampling process combined purposive, stratified and random procedures in 3 stages. At the first stage, 11 districts (five from Northern Region; three from Upper East Region; and three from Upper West region) were purposively selected to include project districts. Within each district, the list of beneficiary communities were stratified into three groups namely project community, non-project communities within 5 km away from a project community, and non-project communities located 5 km away from a project communitys. Two communities were selected randomly from each group making a total of 6 communities per district. At the community level five households were further randomly selected from a list of farm households. In all, 330 farmers from 66 communities drawn from 11 districts were involved in the study (Table 1).

Table 1. Sampling frame

| Region | Districts | Communities (6 per district) | Household (5 per community) |
|---|---|---|---|
| Northern | 5 | 30 | 150 |
| Upper East | 3 | 18 | 90 |
| Upper West | 3 | 18 | 90 |
| Total | 11 | 66 | 330 |

*2.3 Estimation of Fertilizer Adoption and Use Intensity*

2.3.1 Introduction

The Double Hurdle model was used for the analysis with the assumption that the adoption decision and the intensity use were independently determined. In order to justify the use of the Double Hurdle model, a restriction test was carried out where the log likelihood values were obtained from a separate estimation of Tobit, Probit and Truncated regression models. Based on the values obtained, the following likelihood ratio statistic was computed using the formula below:

$$\lambda = 2(LL_{Probit} + LL_{Truncreg} - LL_{Tobit}) \tag{1}$$

The test statistic has a chi-square distribution with degrees of freedom equal to the number of independent variables (including the intercept). The Tobit model is rejected in favour of the Double Hurdle model if $\lambda$ exceeds the appropriate chi-square critical value (Burke, 2009).

2.3.2 Double Hurdle Model

*First Hurdle - Fertilizer Technology Adoption*

The individual's adoption decision of fertilizer technology is dichotomous, involving two mutually exclusive alternatives. The individual either adopts or does not. The framework for such analysis has its root in the threshold theory of decision making in which a reaction occurs only after the strength of a stimulus increases beyond the individual's reaction threshold (Hill & Kau, 1981). This implies that every individual when faced with a choice has a reaction threshold influenced by several factors.

The present study adopted the Probit regression model to quantify the factors influencing the probability of fertilizer technology adoption among smallholder farmers in northern Ghana. The fact that the dependent variable is a dichotomous justifies the use of a binary model (i.e. Probit model). The Probit model was ideal because of its ability to constrain the utility value of the decision to adopt variable to lie within zero and one, and its ability to resolve the problem of heteroscedasticity (Asante et al., 2011). Accordingly, the dependent variable, adoption of fertilizer technology (Y) assumes only two values: one if the farmer adopts fertilizer technology and zero if a farmer does not adopt.

According to Akinola and Owombo (2012), given the assumption of normality, the probability that $y_i^*$ is less than or equal to $y_i$ can be computed from the normal cumulative normal distribution as follows:

$$P_i = P\left(Y = \frac{1}{X}\right) \tag{2}$$

$$P_i = P(y_i^* < y_i) \tag{3}$$

$$P_i = P(Z_i < \beta_0 + \beta_j X_{ij}) = F(Y_i) \tag{4}$$

$$P\left(Y = \frac{1}{X}\right) = F(XB) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{XB} e^{\frac{-(XB)^2}{2}} dx \tag{5}$$

$$X = (1, x_{1i}, x_{2i}, \ldots \ldots, x_{ki}) \tag{6}$$

$$\beta' = (\beta_0, \beta_1, \ldots \ldots \ldots \ldots, \beta_k) \tag{7}$$

Where $y_i^*$ is the critical or threshold level of the index, such that if $y_i$ exceeds $y_i^*$, the farmer adopts fertilizer technology, otherwise the farmer does not. $P\left(Y = \frac{1}{X}\right)$ is taken as the probability that the farmer adopts fertilizer technology given the values of explanatory variables X, and where $Z_i$ is a random variable normally distributed with mean zero and unit variance, $Z_i \sim N(0, \sigma^2)$. The relative effect of each explanatory variable on the likelihood that a farmer will adopt fertilizer technology is specified as follows:

$$\frac{\partial P_i}{\partial X_{ij}} = \beta_{ij} * f(Z_i) \tag{8}$$

Where $f(Z_i)$ is the inverse of the cumulative normal function and $\beta_{ij}$ are the estimated parameters. The elasticity of the predicted probability is then computed as:

$$\frac{\partial P_i}{\partial X_{ij}} = \beta_{ij} * f(Z_i) * \frac{\bar{X}}{P_i} \tag{9}$$

The empirical model employed to determine the fertilizer adoption is given as:

$$Y_i = \beta_0 + \beta_1 Age + \beta_2 Gend + \beta_3 Mar + \beta_4 Edu + \beta_5 Fmexp + \beta_6 Natv + \beta_7 Income + \beta_8 Area +$$
$$\beta_9 Fertsta + \beta_{10} Crdt + \beta_{11} Lvstk + \beta_{12} FmOrg + \beta_{13} DstAg + \beta_{14} Acsinpt + \beta_{15} DstInp + \mu_i \tag{10}$$

Where, $\beta_0$ is the constant term $\beta_1, \beta_2, \beta_3, \ldots \ldots, \beta_{15}$ are the parameters of the respective explanatory variables in the model, and $\mu_i$ is the error term.

*Second Hurdle - Fertilizer Use Intensity*

The second level of the analysis involved the determination of the factors that influences fertilizer use intensity. The second hurdle model uses the truncated regression model to determine the extent of fertilizer use intensity. Observations on positive and greater than the optimum fertilizer use intensity are only used in the analysis. The intensity of fertilizer use ($Y_i$) is specified as:

$$Y_i = \frac{Quantity\ of\ Fertilizer\ Use\ (Kg)}{Total\ Area\ of\ Land\ (Ha)} \tag{11}$$

The decision to intensify fertilizer use is modeled as a regression truncated below the average fertilizer use intensity as expressed below:

$$Y_i^* = X_i\beta + \mu_i, \ \ \mu_i \sim N(0, \sigma^2) \tag{12}$$

$$Y_i = \begin{cases} Y_i^* \ if\ Y_i^* > 0\ and\ d_i = 1 \\ 0\ if\ Y_i^* \leq Y_0\ and\ d_i \leq 1 \end{cases} \tag{13}$$

Where $Y_i$ is the fertilizer use intensity which depends on the latent variable $Y_i^*$ being greater than zero and conditional to the decision to adopt fertilizer ($d_i$), $X_i$ is the vector of explanatory variables hypothesized to influence fertilizer use intensity, $Y_0$ is the threshold fertilizer use intensity in the study area.

The empirical model employed to determine the fertilizer use intensity is given as:

$$Y_i = \beta_0 + \beta_1 Age + \beta_2 Gend + \beta_3 Mar + \beta_4 Edu + \beta_5 Fmexp + \beta_6 Nat + \beta_7 Income + \beta_8 Fertsta$$
$$+\beta_9 Lvstk + \beta_{10} FmOrg + \beta_{11} DstAgr + \beta_{12} Acsinpt + \beta_{13} DstInp + \beta_{14} Occu + \beta_{15} DstMkt$$
$$+\beta_{16} IncGend + \beta_{17} IncHcat + \mu_i \tag{14}$$

where, $\beta_0$ is the constant term $\beta_1, \beta_2, \beta_3, \ldots \ldots, \beta_{22}$ are the parameters of the respective explanatory variables in the model, and $\mu_i$ is the error term. The estimates for these parameters were obtained using the STATA SE software version 11. Appendix 1 shows the host of explanatory variables that are potentially expected to explain variation in adoption and fertilizer use intensity and their *a priori* expectations.

*2.4 Description of Explanatory Variables*

Age is expected to influence fertilizer use intensity positively (Adesina & Forson, 1995; Chinu & Tsujii, 2004; Fufu et al., 2006; Gbetibouo, 2009; Olwande et al., 2009). Older household head are more risk averse and are assess the attributes of a technology than younger household heads (Ayamga, 2006). Resource constraint may also be a limiting factor among younger household heads in terms of fertilizer use intensity though they are more dynamic with regards to adoption of innovations (Enete & Igbokwe, 2009). Gender (Gend) of household head affects adoption and fertilizer use intensity positively. Females are normally occupied with domestic activities and are also resource (financial and human) and these negatively impact on both adoption decision and the extent of fertilizer use. It is expected that households head that are married will have a higher probability of fertilizer adoption and use intensity. Married household heads (Mar) are normally assisted by their spouses in production, processing and marketing decision-making. Marriage also increases a farmer's concern for household welfare and food security which is therefore likely to have a positive effect on their decision to adopt and increase fertilizer use intensity (Nnadi & Akwiwu, 2008).

Education (Edu) is expected to have a positive effect on both fertilizer adoption and intensity of use. It enables an individual to make independent choices and to act on the basis of the decision, as well as increase the tendency to co-operate with other people. (Enete & Igbokwe, 2009; Ofori, 1973; Southworth & Johnston, 1967; Schultz, 1945). It is also possible that education could increase the chances of the household head earning non-farm income which could reduce the household dependency on agriculture and thus the intensity of fertilizer use. Experienced (Fmexp) farmers are more likely to adopt fertilizer technology. The opposite holds true for hertilizer use intensity. Some agricultural extension programmes use experienced farmers in the demonstration of new technologies to increase adoption. Agricultural activities are more risky especially where a new technology is introduced which negatively affects the extent of use of that technology. Nativity of household head determines access to communal resource like land and irrigation facility for farming and access to these facilities enhance adoption and fertilizer use intensity negatively (Amanze et al., 2010; Olawale, Arega, & Arega, 2009; Coady, 1995)

Participation in agricultural development projects is expected to influence farmers' fertilizer adoption and fertilizer use intensity either positively or negatively. Agricultural projects usually providecrucial information to enhance the productive skills of farmers. It is also possible that a farmer may participate in a developmental project for other technical supports thus impacting negatively on fertilizer adoption and use intensity. Household heads that are engaged in farming as their main occupation are more likely to adopt any fertilizer technology. Income (Inc) of household head is positively related to both adoption and fertilizer use intensity. High transaction cost in terms of transportation normally limits the extent of fertilizer use. Income earning farm households are able to overcome the financial constraint with respect to technology adoption and purchase. Farmers' perception of soil fertility status (Fertsta) affects the adoption and extent of use both positively and negatively. Farm size is expected to positively influence fertilizer adoption. A higher farm size may normally be accompanied with a corresponding increase in complementary technologies *ceteris paribus*. Agricultural credit (Crdt) is one of the major institutional factors limiting technology uptake by most smallholder farmers. Household heads with access to credit are more likely to adopt fertilizer technology. Intensity of fertilizer use is high especially among household heads with access to input credit. Livestock ownership status (Lvstk) is used as a proxy for availability of household resource endowment (Heyi & Mberengwa, 2012). Farmers who are resource endowed will have a higher propensity of adoption and intensity of fertilizer use. Household head membership of an association/group (FmOrg) increases access to information which is important to production and marketing decisions (Olwande, 2010). Most farmer groups engage in group marketing, bulk purchasing of inputs and credit provision for its members. It is therefore expected that household head membership of association/group will positively affect adoption as well as intensity of fertilizer use.

Household heads with access to inputs (Acsinpt) are more likely to adopt fertilizer but may not necessarily determine the extent of use of fertilizer. Distance to input market (DstInp) is one of the major limiting factors for inputs purchase as it imposes a high transaction cost to producers. The adoption and fertilizer use intensity decreases with an increase in the distance to the nearest input market (Amanze & Eze, 2010; Zhou, Yang, Mosler, & Abbaspor, 2010; Olayide, Arega, & Ikpi, 2009). Agriculture officers play a crucial role in the demonstration and dissemination of agricultural technology therefore distance to an agricultural office (DstAgr) impacts negatively on the adoption and extent of fertilizer use due to the limitation in terms of information access.

The interactive term, income and participation in agricultural development project (Inc*PatAgra) is posited to influence the intensity of fertilizer use positively. Fertilizer use intensity is positively affected by the interactive term, age and agricultural development project (Age*PatAgra). Participation in agricultural development

projectby older farm household heads will enhance their information access and as well as productive skills to guide their production activities. Finally, income and gender of household head (Inc*Gend) is expected to influence both adoption and intensity of fertilizer use both positively and negatively. Male-headed household who earn income is more likely to adopt and intensify fertilizer use relative to the female headed household who earn income. Females are generally constraint in terms of resources and will use income to enhance household food and nutritional requirement.

## 3. Results and Discussion

### 3.1 Determinants of Fertilizer Adoption and Use Intensity

The double hurdle was best suited for the data based on the restriction test as specified in Equation (1). The Tobit model was rejected in favour of the Double-hurdle model because the computed lambda from the likelihood ratios exceeded the critical chi2 value. The probit model was used to estimate the parameters of the determinants of fertilizer technology adoption by smallholder farmers in northern Ghana. The significant Wald chi-square value of 100.90 indicates that the explanatory variables jointly influence the farmers' decision to adopt fertilizer technology (Table 2). Adoption of fertilizer technology was significantly determined by age, nativity, farm size occupational status, access to credit, and distance to agricultural office. Farm size was the most influential determinant of adoption of fertilizer technology in northern Ghana.

The extent of fertilizer use was significantly determined by income of household head, membership of farmer association, distance to agricultural office, access to input shop, income earning household that do not participate in agricultural development project and income earning male headed household. Access to input shop was the most influential determinant of fertilizer use intensity both statistically and numerically. The significant Wald chi-square value of 70.59 indicates that the explanatory variables jointly influence the fertilizer use intensity (Table 2).

The probability of fertilizer technology adoption was influenced negatively by age of household head. The result implied that older household heads were less likely to adopt fertilizer. A unit increase in the age of the household head decreases the probability of fertilizer adoption by 0.005. Normally younger household heads are more dynamic and innovative in terms of technology adoption (Enete & Igbokwe, 2009). The opposite is true for fertilizer use intensity.

Nativity influenced the adoption of fertilizer technology negatively. The result indicated that native household heads are less likely to adopt the fertilizer technology relative to the non-native household heads. The probability of fertilizer technology adoption among native household heads was lower than non-native household heads by 0.229. Nativity guarantees access to communal agricultural resources as well as security of the resources. Non-native household heads usually have informal agreement with land owners with regard to the share of farm produce after harvest. The demand on these household heads influence their decision to adopt and use of technology (improved seed, fertilizer and good agricultural practices) that guarantee higher yields.

Contrary to expectation, income of households head had a negative effect on fertilizer use intensity. A unit increase in household income led to a 0.254 kg/ha decrease in fertilizer use intensity. The result contradicted the findings of Feder et al. (1985) and Freeman and Omiti (2003). They observed that wealthier farmers are capable of taking risks due to their additional resources to fall on in case of any unforeseen circumstances. Investment of financial resource in interest earning assets and high demand on food and other social responsibilities are likely to explain the result of low fertilizer use with increase in income.

Area under cultivation was negatively related to fertilizer adoption. The implication of the result was that as farm size increases, farmers were more likely not to adopt fertilizer. The marginal effect showed that a unit increase in the area under cultivation reduced the probability of fertilizer adoption by 0.355. The result confirmed the findings by Olayide (2009) and Coady (1995). Adoption of fertilizer in northern Ghana is low especially among smallholder farmers largely due to financial constraint. The present finding explicate the reasons for advocacy by agricultural projects for farmers to own relatively manageable plots of farm lands.

Credit access was negatively associated with probability of fertilizer adoption. Household heads with access to credit are less likely to adopt fertilizer technology. The probability of adoption of fertilizer among household heads without credit access was 0.139 more than those with credit access. Access to farm credit is one of the major challenges facing smallholder farmers in the study area. It is possible that farmers with credit will be more likely to divert part of their financial resource to other productive ventures that yield profit. Farm credit may also be used to pay for land preparation, purchase of other farm inputs and support for household food requirement. The result implies that farmers in the study area must be supported with input credit rather than cash credit.

Fertilizer use intensity was positively influenced by membership of association. The fertilizer use intensity among household heads that belong to farmer association was 37.12kg/ha more than household heads that do not belong to farmer organization. Farmer association served as platform for accessing and dissemination of information and technology. Most agricultural development projects in northern Ghana (such as Northern Rural Growth Programme, Millennium Challenge Account Programme, Rice Sector Support Project, AGRA Soil Health Project, Fertilizer Subsidy Programme, Agricultural Value Chain Mentorship Project, AfricaRISING Project, etc.) target farmer groups to enhance and build their business and technical capacity respectively and subsequently support them with input credit and market opportunities. Farmers belonging to associations and cooperative have easy access to fertilizer technology, fertilizer coupon, and credit which has a positive effect on fertilizer use. The outcome of the study implies commitment on both governmnent and non-governmental organizations to work towards the sustainability of farmer associations.

Distance to agricultural office had a positive outcome on fertilizer adoption and intensity of use. The result indicated that increase in the distance to agricultural office was likely to increase adoption and fertilizer use intensity. A unit increase in the distance to the agricultural office leads to a 0.008 and 1.98 kg/ha increases in fertilizer adoption and intensity of use respectively. The agricultural office serves as proxy for access to agricultural extension agents. Access to extension agents will increase farmers' awareness and information on the importance of technology adoption (Akpan et al., 2012). However, the result contradicts literature as distance serves as a barrier for technology adoption. It is also likely that farmers depend more on neighbouring farmers for useful information on fertilizer use relative to most of the agricultural extension agents that are not accessible to farmers.

Furthermore, household heads that have access to input shops were not likely to intensify fertilizer use. The intensity of fertilizer use among household heads with access to input shop is 64.29 kg/ha lower than household heads that do not have access to input shops. It can be deduced from the result that access to input shop is not a guarantee for increase in intensity of fertilizer use. Studies by Akpan et al. (2012), Amanze et al. (2010), Olawale et al. (2009), Olayide et al. (2009), and Wanyama et al. (2009), have suggested distance to the sale of fertilizer as influential determinant of fertilizer use intensity rather than access to input shop. However, the present study has shown that access to input shop may not necessarily translate to fertilizer use intensity by smallholder farmers in northern Ghana. Access to input shop must be complemented by willingness to pay and education.

Income earning male-headed household were more likely to intensify fertilizer use. For income earning male-headed households, the extent of fertilizer use was 0.026 kg/ha more than income earning female-headed household. Income earning male headed household have access to resources such as productive land and credit facilities relative to their female counterparts. Wanyama et al. (2010) found a similar result though the component of the income was not captured in the analysis. Inaccessibility to production credit limits female-headed household with respect to fertilizer use.

Finally, the intensity of fertilizer use by income earning households that participated in agricultural development project was lower than non-participant income earning household heads. For household heads that earn income and participate in agricultural development project, the extent of fertilizer use is 0.022 kg/ha lower than income earning non-participant household heads. The relatively lower use of fertilizer among these farmers may be attributed to high dependency on household heads coupled with attitudinal behavior which requires continuous sensitization and education. The AGRA SHP005 was implemented to promote the use of ISFM practices among farmers in Northern Ghana to boost productivity. Myriads of approaches have been used to reach out to the farmers. Notably among these interventions include demonstrations, Farmer Based Organization (FBO) capacity building and facilitation of input credit to farmers. Farmers normally have wide-ranging intentions for participating in any agricultural development projects rather than aligning themselves to the objectives of the project. In situations where project is not able to meet the expectation of these farmers, they tend to abandon the project concept and follow their old practices of farming. The project may be contributing towards the adoption of fertilizer technology but not intensity of fertilizer use. The AGRA SHP005 must be sustained to increase the level of farmers' awareness on fertilizer use.

Table 2. Double hurdle estimates of adoption and fertilizer use intensity

| Variable | 1st Hurdle (Probit) | | 2nd Hurdle (Truncated) | |
|---|---|---|---|---|
| | Marginal Effect | Robust Std. Error | Marginal Effect | Robust Std. Error |
| Gender of household head | -0.05042 | 0.45971 | 30.8741 | 54.9118 |
| Age of household head | -0.00525** | 0.00564 | -0.3936 | 0.6299 |
| Marital status of household head | 0.02951 | 0.36064 | -70.4662 | 45.6083 |
| Educational status of household head | 0.09868 | 0.24456 | 15.3738 | 24.2752 |
| Years of Farming experience | 0.00054 | 0.00209 | 0.0213 | 0.0461 |
| Nativity of household heads | -0.22993* | 0.41617 | -54.4339 | 65.6421 |
| Income level of household head | 0.00000 | 0.00000 | -0.2539*** | 0.0072 |
| Farm Size | -0.35519*** | 0.10259 | - | - |
| Perception of soil fertility | -0.09954 | 0.19551 | -3.9396 | 21.2442 |
| Access to credit | -0.13927** | 0.18812 | - | - |
| Ownership of livestock | -0.04386 | 0.24523 | -17.2508 | 14.9231 |
| Membership of farmer organization | 0.02468 | 0.19749 | 37.1189* | 21.8678 |
| Distance to agricultural office | 0.00816* | 0.01197 | 1.9865** | 0.9444 |
| Access to input shop | -0.08342 | 0.23439 | -64.2922*** | 23.5930 |
| Distance to input shop | -0.00449 | 0.02143 | -1.0316 | 1.5039 |
| Occupational Status | - | - | -41.3162 | 32.6127 |
| Distance to market | - | - | 0.0789 | 0.0777 |
| Income*Gender | - | - | 0.0257*** | 0.0072 |
| Income*Participation in project | - | - | -0.0219*** | 0.0067 |
| No. of Observation | 319 | | 311 | |
| Wald Chi2 (15) | 100.9 | | 70.59 | |
| Prob> Chi2 | 0.0000 | | 0.0000 | |
| Pseudo R-Squared | 0.3927 | | - | |
| Log Pseudolikelihood | -125.18171 | | -1903.4343 | |

Source: Regression Estimation from Author's Household Survey Data (2012).

***$p < 0.01$, **$p < 0.05$ and *$p < 0.10$.

## 4. Conclusion

Soil fertility management is a critical issue in northern Ghana and has attracted the attention of several programmes that promotes ISFM practices among smallholder farmers. The study revealed that adoption of fertilizer technology was significantly determined by age, nativity, farm size, access to credit, and distance to agricultural office. Fertilizer use intensity was significantly determined by income of household head, membership of farmer association, distance to agricultural office, access to input shop, income earning household that do not participate in agricultural development project and income earning male headed household. Participation in agricultural development project does not necessarily lead to increase in adoption and fertilizer use intensity. Distance to agricultural office also plays a major role in fertilizer adoption and use intensity in the study area.

Based on the findings of the study, it is recommended that agricultural development programmes should target FBOs as well as support them with technical training to enhance their technology uptake. Secondly, government policy should aim at supporting farmers with input credit to increase the use of fertilizer as well as sustaining the fertilizer subsidy programme. Improvement in infrastructure such as road is crucial in influencing the use of

fertilizer. Finally, the AGRA Soil Health Project 005should intensively engage the agricultural extension agents in training on fertilizer use to ensure that quality information is disseminated to farmers.

**Acknowledgement**

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Appendix 1. List of explanatory variables

| Variable | Description | A priori |
|---|---|---|
| Age | Age of household head in years | +/- |
| Gender of household head (Gend) | 1 if male and 0 other wise | + |
| Marital status (Mar) | 1 if married and 0 otherwise | + |
| Education (Educ) | 1 if educated and 0 otherwise | + |
| Years of farming experience (Fmexp) | Number of years | +/- |
| Participation in AGRA SHP (PatAgra) | 1 if participates and 0 otherwise | +/- |
| Occupational status (Occ) | 1 if farmer and 0 otherwise | +/- |
| Income (Inc) | Amount in GH | + |
| Perception on soil fertility status (Fertsta) | 1 if soil is rich and 0 otherwise | +/- |
| Access to credit (Credit) | 1 if household receive credit and 0 otherwise | + |
| Livestock ownership (Lvstk) | 1 if owns livestock and 0 otherwise | + |
| Membership of farmer association (FmOrg) | 1 if member of farmer association and 0 otherwise | + |
| Distance to market (Dstmkt) | Distance in Km from house to market | - |
| Distance to agricultural office (DstAgr) | Distance in Km from house to agricultural office | - |
| Distance to agricultural shop (DstAgr) | Distance in Km from house to input shop | - |
| Access to input (Acsinpt) | 1 if household have access and 0 otherwise | +/- |
| Nativity (Nat) | 1 if native and 0 otherwise | +/- |
| **Interactive Term** | | |
| Income & Participation in project (IncPatAgra) | Income*Participation in AGRA SHP | + |
| Age & Participation in project (AgePatAgra) | Age*Participation in AGRA SHP | - |
| Income and Gender (IncGend) | Income * Gender | +/- |

Appendix 2. Tobit regression estimates of fertilizer use intensity

```
Tobit regression                                  Number of obs   =        319
                                                  F( 17,   302)   =       8.91
                                                  Prob > F        =     0.0000
Log pseudolikelihood = -1951.9572                 Pseudo R2       =     0.0076

                              Robust
        fui      Coef.      Std. Err.       t     P>|t|      [95% Conf. Interval]
       sex    18.15604     31.00652      0.59    0.559    -42.86015    79.17224
       age    -.4493931     .4608267    -0.98    0.330    -1.356231    .4574448
      mari   -58.09983     37.33334     -1.56    0.121    -131.5663    15.36659
       edu    18.94203     17.68164      1.07    0.285    -15.85278    53.73685
      yexp     .0347828     .0383238     0.91    0.365    -.0406326    .1101982
      natv   -53.10735     55.00061     -0.97    0.335    -161.3403    55.12562
  incomegh    -.0113596     .0030368    -3.74    0.000    -.0173355   -.0053837
 fetstatus    -6.644802    15.41937     -0.43    0.667    -36.98782    23.69822
 livestock   -11.46319      7.928887    -1.45    0.149    -27.06606     4.139669
       mem    19.20034     14.66785      1.31    0.192    -9.663795    48.06448
    dstagri     1.357123     .7186293    1.89    0.060    -.0570318     2.771278
   shpaces   -36.40478     17.84527     -2.04    0.042    -71.52161    -1.287959
    dstshp     -.6264142    1.275903    -0.49    0.624    -3.137199     1.884371
      occu   -24.55744     28.63528     -0.86    0.392    -80.90738    31.79251
    dstmkt     .0477413     .0540432     0.88    0.378    -.0586077     .1540902
   IncGend     .0115887     .00304       3.81    0.000     .0056065     .0175709
   IncHcat    -.0085992     .0035235    -2.44    0.015    -.0155329    -.0016656
     _cons   329.3901      79.0021       4.17    0.000    173.9258     484.8544

    /sigma   124.6663       8.03429                        108.856     140.4766

  Obs. summary:         8   left-censored observations at fui<=0
                      311       uncensored observations
                        0 right-censored observations

. mfx

Marginal effects after tobit
      y  = Linear prediction (predict)
         =   201.89558

variable      dy/dx      Std. Err.      z      P>|z|   [      95% C.I.      ]         X
      sex*   18.15604     31.007       0.59    0.558   -42.6156    78.9277    .968652
      age    -.4493931     .46083     -0.98    0.329   -1.3526     .453811    49.1348
     mari*  -58.09983     37.333      -1.56    0.120   -131.272    15.0722    .949843
      edu*   18.94203     17.682       1.07    0.284   -15.7133    53.5974    .22884
     yexp     .0347828     .03832      0.91    0.364    -.04033    .109896    32.3762
     natv*  -53.10735     55.001      -0.97    0.334   -160.907    54.6919    .971787
 incomegh    -.0113596     .00304     -3.74    0.000   -.017312   -.005408   3843.27
 fetsta~s*   -6.644802    15.419      -0.43    0.667   -36.8662    23.5766    .429467
 livest~k   -11.46319      7.92889    -1.45    0.148   -27.0035     4.07714    .191223
      mem*   19.20034     14.668       1.31    0.191   -9.54812    47.9488    .670846
   dstagri    1.357123     .71863      1.89    0.059   -.051365     2.76561   13.6038
  shpaces*  -36.40478     17.845      -2.04    0.041   -71.3809   -1.42869    .470219
    dstshp   -.6264142     1.2759     -0.49    0.623   -3.12714     1.87431   3.29436
     occu*  -24.55744     28.635      -0.86    0.391   -80.6816    31.5667    .943574
    dstmkt     .0477413     .05404     0.88    0.377   -.058181    .153664    22.3234
   IncGend     .0115887     .00304     3.81    0.000     .00563    .017547    3755.48
   IncHcat    -.0085992     .00352    -2.44    0.015   -.015505   -.001693   760.387

(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

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