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Factors Influencing Application of Fertilizer by Smallholder Farmers of Northern Ethiopia

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Abstract
It has been said that Ethiopia's agriculture, a mainstay of the economy of the country, is dominated by smallholder farmers and the productivity of the sector is low. Low level of productivity due to low level of use of improved technologies is among the most frequently mentioned major causes of the country's food insecurity problem. In order to meet the food requirements of the growing population, food grains and other agricultural products have to be increased through widespread and intensified use of improved technologies enhancing agricultural productivity. Hence; the major focus of this study was to examine socioeconomic factors influencing use of chemical fertilizer by smallholder farmers in the study area. Tobit model was used to analyze factors influencing use of fertilizer econometrically. A total of twelve explanatory variables were included in the model. From the result of the analysis six variables (family size, sex of household head, distance from market, perception of household about cost of fertilizer, access to credit facility and total land size) were found to be the significant factor affecting the use of fertilizer by smallholder farmers. Implication of results of this study is that any development intervention through improved agricultural technologies should consider the aforementioned socioeconomic characteristics and determinants of adoption for success.
Keywords: Fertilizer, Adwa, Smallholder farmers, Topit model

1. INTRODUCTION

Agriculture is the mainstay of the Ethiopian economy. It employs 80% of the population and contributes about 41% of GDP and 86% of exports (Bingxin *et al*., 2011). Besides its contribution as the main income-generating sector for the majority of the rural population, it serves as the main source of household food consumption (Samia, 2002).

The agricultural sector in Ethiopia is dominated by subsistence, low input-low output and rain-fed farming system. The use of chemical fertilizer is quite limited despite Government efforts to encourage the adoption of modern agricultural system and intensive agricultural practices (FDRE/MoARD, 2010). Improving the productivity, profitability, and sustainability of smallholder farming is the main pathway out of poverty in using agriculture for development (World Bank, 2008). Achieving agricultural productivity growth will not be possible without developing and disseminating yield-increasing technologies because it is no longer possible to meet the needs of increasing numbers of people by expanding areas under cultivation (Solomon and Bekele, 2010).

Clearly, increasing agricultural productivity is critical to economic growth and development. One important way to increase agricultural productivity is through the introduction of improved agricultural technologies and management systems (World Bank, 2008).

The productivity of Ethiopian agriculture has been low and a number of yield improving technologies like use of fertilizer have been recommended to use by smallholder farmers of the country. However, the level of use of the chemical fertilizer is not as expected. Farmers of the study area suffered from low productivity of the agriculture as a result of traditional method of farming system, limited use of chemical fertilizer and they have serious land scarcity problem.

Study conducted in Yelmana Densa and Farta Districts of Northwestern Ethiopia (Tesfaye *et al.,* 2001) indicate that socioeconomic, institutional and technical factors are accountable for determining use of new technology. However, these recommendations are location specific and would justify the need for research elsewhere. It is expected that geographical and climatic differences would affect decision of farmers to use fertilizer and studies done elsewhere may not be of direct relevance to address the problems and opportunities of the present study area. It is therefore relevant to assess factors affect decision of farmers to use chemical fertilizer in study area. The overall objective of this study was to analyze factors affecting use of chemical fertilizer by smallholder farmers of the study area.

2. METHODOLOGY

2.1. Description of the Study Area

This study was conducted in rural Adwa district, central zone of Tigray northern part of Ethiopia. Adwa is found about 223kilometers away from Mekelle and 1006 kilometers from Addis Ababa. The district has total area coverage of 66,618 hectares of which 13,714 hectares are cultivated land. The geographical structure of the

district is both low land and semi-low land. About 32.2% and 67.8% of the cultivated land is found in the low land and semi-low land respectively. The district has a total household of 24,692 and has a total population of 108,647, out of which 54,659 were females and the rest of 53,988 were males. The average temperature of the area is 27^{oc} and average annual rainfall ranges from 600 to 850 mm. The main economic activity of the study area includes both crop and livestock production. Some of the major crops grown in the area include teff, wheat, barley, finger millet, sorghum and maize and the major livestock production includes cattle, sheep, goat, donkey and poultry.

2.2. Method of Data Collection

The study utilized both primary and secondary sources of data. The primary data was collected through individual interviews of the selected respondents whereas the secondary data was gathered from different reports of the district and from the district Agricultural Office. During sampling process two-stage sampling procedure was used to select sample farmers that were included in the study. In the first stage, out of the total 18 *peasant associations* of the district four *peasant associations* were selected randomly. In the second stage, from the selected *peasant associations,* 160 respondents were identified based on probability proportional to size of households of each *peasant associations* and the subsequent application of random sampling technique. After the sampling process was completed data were collected by using formal and informal survey methods of data collection.

2.3. Methods of Data Analysis

In this study Tobit model was used to analyze factors affecting the application of recommended level of fertilizer by farmers of the study area. In Tobit model, decisions whether to use or not and how much to use were assumed to be made jointly and hence the factors affecting the two level decisions were taken simultaneously (Solomon *et al.,* 2010).

As stated in Gujarati (2004) the Tobit model to estimate the factor affecting the use of fertilizer was defined as:

$$\begin{cases} y_i = y* = X_i\beta + u_i \quad \text{if} \quad y_i^* > 0 \quad u_i \approx n(0, \sigma^2) \\ y_i = 0 \quad \text{otherwise} \end{cases} \tag{1}$$

Where: y_i = the expected amount of fertilizer in kilogram per hectare of land at a given level of *Xi*; y^*=unobserved latent variable, *n* = number of observations; *Xi* = vector of explanatory variables; β = vector of unknown coefficients (parameter to be estimated); and U_i = independently and normally distributed error term with zero mean and constant variance σ^2.

The model parameter was estimated by maximizing the Tobit likelihood function of the following,

$$L = \prod_{Y_i^*>0} \frac{1}{\sigma} f\left(\frac{Y_i - \beta_i X_i}{\sigma}\right) \prod_{Y_i^* \le 0} F\left(\frac{-\beta_i X_i}{\sigma}\right) \tag{2}$$

Where; *f* and *F* are respectively, the density function and cumulative distribution function (Maddala, 2005).

The marginal effect of an explanatory variable on the expected value (mean proportion) of the dependent variable was estimate by:

$$\frac{\partial E(Y_i)}{\partial Xi} = F(z)\beta_i \tag{3}$$

Where z is defined by $\frac{\beta ixi}{\sigma}$

The change in the probability of using fertilizer as independent variable X_i changes was estimate by:

$$\frac{\partial F(z)}{\partial X_i} = f(z)\frac{\beta_i}{\sigma} \tag{4}$$

Where, $z = X\frac{\beta}{\sigma}$, F (z) is the cumulative distribution function, f (z) is the value of derivative of the normal curve at a given point, z is the Z-score for the area under normal curve, ß is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error terms.

Similarly, the change in intensity of use with respect to change in an explanatory variable among users was estimated by:

$$\frac{\partial E(Y|Y_i^* > 0)}{\partial X_i} = \beta\left[1 - z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^2\right] \quad (5)$$

In this study the dependent variable was the amount of fertilizer used by sample households per hectare. Whereas the independent variables that were expected to affect the dependent variable with their unit of measurement and expected sign are presented in the table below.

Table 1: Description of independent variables

Variables	Nature of the variable	Unit of Measurement	Expected sign
Age of household head	Continuous	Years	+
Education level of household heads	Continuous	Year of formal schooling	+
Sex of household head	Dummy	Male/female	Male adopt more than female
Sizes of land holding of household	Continuous	Hectare	+
Frequency of contact with extension agents	Continuous	Number of visit farmer's farm by development agents per month	+
Access to credit facility	Dummy	Yes/no	+
Distance from market	Continuous	Kilometer	-
Distance to the main road	Continuous	Kilometer	-
Family size in adult-equivalent	Continuous	Number of adult-equivalent	+
Livestock holding (TLU):	Continuous	Number of TLU	+
Perception of farmers about cost of technology	Dummy	Ordinal variable	-
Participation of the household head in leadership position	Dummy	Yes/no	+

3. RESULTS AND DISCUSSION

3.1. Amount of Fertilizer Used by Sample Households per Hectare

Fertilizer is one of the agricultural technologies provided to the farmers of the study area by the agricultural bureau of the district. Most farmers of the study area, almost greater than 98% used fertilizer. Even though they used fertilizer, there was a great difference in application of fertilizer per hectare from farmer to farmer. Out of the total respondents about 149 were user of chemical fertilizer. But the gap of application of fertilizer per hectare between users ranges from below 100k.g/ha up to the recommended level which is 200k.g per hectare.

Table 2: Classification of sample respondents based on amount of fertilizer used per hectare

Description	Number of respondents	%
Use of Fertilizer (k.g/ha)		
<100	28	17.5
100-150	58	36.25
>150	74	46.25
Mean of fertilizer/ha	165	-
Std.dev	54	-

Sources; own computational result

3.2. Determinants of use of fertilizer

A total of twelve variables (4 dummy and 8 continuous) were tested for their influence on the use of fertilizer by farmers of the study area (table 3). Out of these total variables six of them (sex of household head, size of cultivated land owned by households, distance from the nearest market, family size in man equivalent, perception of household towards the cost of the technology and access to credit facility) were found to affect use of fertilizer by farmers significantly. On the other hand the remaining seven variables didn't have a significant effect on use of fertilizer.

Sex of household head: From table 3; Sex of household head affects use of fertilizer by farmers positively and significantly at 5% significance level (t=2.37). According to Namwata *et al.* (2010) sex of household head was affected adoption of improved agricultural technology for Irish potatoes positively and significantly. And also the study by Rafael (2001) on determinants of adoption of Agricultural Technology in Mozambique confirmed similar result. From the results of marginal effect (table 4); being male headed household increase the probability of being user of chemical fertilizer by 5.25% and level of use by 14.21 among users and by 14.44 among the total sample. This implies that being male headed household increases the probability of using fertilizer as

compared to female headed households. In most of the rural areas males have access to updated information than females, because male participates in different activities than females; this makes male headed households to have updated information about the use of fertilizer and they have an exposure to use it; in addition to this male can participate in different non-farm income as compared to females and have better income sources than females; hence male headed household has the exposure to buy and use chemical fertilizer than female headed households.

Family size in adult-equivalent: This is the demographic factor which affects use of chemical fertilizer by farmers of the study area positively and significantly at 5% (t=2.44). A unit increase in the family size in man equivalent increases the probability of use of fertilizer by 2.73% and it increases the level of use of fertilizer by 7.39 and 7.51 among users and the total sample size respectively (table 4). The studies by Bekele *et al*. (2000) and Haji (2003) confirmed the same result.

Land size owned by household: This is the economic factor which affects use of fertilizer by households of the study area positively and it was statistically significant at significance level of 1% (t=6.17). From the results of marginal effect (table 4) a unit increase in land measured in hectare increases the probability of use of fertilizer by 24.67% and it increases the level of use of fertilizer by 66.71 and 67.79 among users of fertilizer and among the total sample, respectively. This implies that a farmer with large farm land uses more fertilizer than farmers with small land size. A study by Shimelis (2004) confirmed this result.

Access to credit facility: This is the institutional factor which affects the use of chemical fertilizer positively and significantly at significance level of 1% (table 3). Studies by Motuma *et al*. (2010), John *et al* (2009) and Odoemenem and Obinne (2010) were consistent with this result. And the same result was found by (Namwata *et al.*, 2010); the study indicates that credit affect adoption of improved agricultural technology for Irish potatoes significantly and positively. From Table 4, having access to credit service increases the probability of being a user of chemical fertilizer by 13.13% and it increases level of use of fertilizer by 35.50 and 36.07 among user and among the whole sample respectively. Most farmers of the study area suffers from shortage of money during the sowing season and if fertilizer is provided to them on credit base their level of use of fertilizer increases or if they get credit facility from different micro-finance institutions they might be able to purchase the fertilizer and use it. Due to this reason use of chemical fertilizer and access to credit service had positive relationship.

Perception of household towards the cost of fertilizer: From the econometric result (table 3) perception of household towards the cost of fertilizer affects use of chemical fertilizer negatively and significantly at 1% (t=-2.80). From the analysis of marginal effects (table 4), perceiving of high cost of fertilizer decreases the probability of use of chemical fertilizer by 3.25% in favour of users and it decreases the level of use of fertilizer by 8.79 among the users and by 8.94 among entire sample. According to Fufa and Hassan (2006) perception of household to cost of fertilizer had negative and significant effect on use of fertilizer. If farmer perception for cost of the fertilizer is high which means the price of the fertilizer is beyond their capacity to purchase as compared with the natural manure; it forces them to purchase less amount of fertilizer. On the other hand if the price of the fertilizer is low every farmer can purchase it. So there is negative association between cost of fertilizer and level of use of fertilizer.

Distance from the nearest market in kilometer: This variable affects use of fertilizer by farmers negatively and significantly at significance level of 1% (t=-2.73). The results of marginal effect in table 4; showed that a unit increase in distance from the nearest market decreases probability of use of fertilizer by 1% and it decreases level of use of fertilizer by 2.64 and 2.68 among users and among the whole sample respectively. Mesfin (2005) found out that distance to market centers was negatively and significantly releated to adoption of triticale (*x-triticosecale wittmack)*. Decreasing the distance from the market decreases transportation cost of transporting agricultural inputs from the market. Hence market distance and use of chemical fertilizer had negative relationship.

Table **3**: Maximum Likelihood Estimates of Tobit model of use of fertilizer (in k.g/ha)

FERTILIZER	Coefficient	Robust Std. Err.	*t*-value
Sex of household head	14.51	6.13	2.37**
Education level of household head	1.54	1.14	1.35
Participation of HH head in leadership activity	2.67	4.94	0.54
Farming experience in year	0.06	0.22	0.26
Family size in adult-equivalent	7.55	3.09	2.44**
Sizes of land holding of HH	68.13	11.039	6.17***
Distance to main road	-1.35	1.93.	-0.70
TLU	5.13	5.07	1.01
Access to credit facility	36.26	9.45	3.84***
Frequency of contact with extension agents/month	1.34	3.31.	0.41
Perception of HH about cost of the technology	-8.98	3.21	-2.80***
Distance from market	-2.70	0.98	-2.73***
CONSTANT	2.56	28.89	0.09
Numbers considered=160 Log likelihood function= -729.93606 Lift censored=0 Right censored=+infinity ***,** indicate significant at 1% and 5% respectively			

Source: Computed from the field survey data

Table 4: Marginal effect of explanatory variable on the use of fertilizer (in k.g/ha)

variable	Change in Probabilities as independent variable changes $\frac{\partial F(z)}{\partial X_i}$	Change among entire sample $\frac{\partial E(Y_i)}{\partial Xi}$	Change among adopters $\frac{\partial E(Y \mid Y_i^* > 0)}{\partial X_i}$
Sex of household head	0.053	14.44	14.21
Family size in adult-equivalent	0.027	7.51	7.39
Sizes of land holding of HH	0.247	67.79	66.71
Distance to main road	0.131	36.08	35.50
Perception of HH about cost of the technology	-0.033	-8.94	-8.79
Distance from market	-0.01	-2.68	-2.63

Source: Computed from the field survey data

4. CONCLUSION

Agricultural production and productivity in Ethiopia is low to feed the ever increasing population of the country. This is mainly due to low use of new agricultural technologies like fertilizers and use of less productive agricultural inputs resulting from high price of inputs, weak research and extension linkage, poor infrastructural and institutional services and shortage of land for cultivation.

The present study was conducted to identify the major demographic, economic, social and institutional factors that could influence the decision to use fertilizer at farm level by farmers of the study area. Topit model was used to analyze factors influencing use of fertilizer.

From the survey result, out of the total respondent farmers, 149 (93.13%) of them used chemical fertilizer and 11(6.87%) of them were non-user. However, there was variability in the amount of fertilizer used by the farmers and only few (36 %) of them applied the recommended level of fertilizer which is 200 kg per hectare (100 kg of DAP and 100 kg of urea) while the rest applied much below the recommended rate.

Tobit regression model was estimated using maximum likelihood estimation procedure to examine explanatory variables that influence use fertilizer by farmers'. From the results of Tobit regression access to credit facility, increases in size of cultivated land, sex of household head and family size in adult-equivalent affect use of chemical fertilizer positively and significantly. Distance from nearest market and perception to cost of technology affect use of chemical fertilizer negatively and significantly.

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REFERENCES

Bekele Hundie, Verkuijl H, Mwangi W, Tanner D, 2000. Adoption of Improved Wheat Technologies in Adaba and Dodola Districts of the Bale Highlands, Ethiopia. International Maize and Wheat Improvement Center, Addis Ababa, Ethiopia. 22p.

Bingxin Yu, José Funes, Sinafikeh Asrat, 2011. Cereal Production and Technology Adoption in Ethiopia. Development Strategy and Governance Division. International Food Policy Research Institute. IFPRI Discussion Paper 01131. 36p.

FDRE/MoARD, (Federal Democratic Republic of Ethiopia/Ministry of Agriculture and Rural Development). 2010. Ethiopia's Agricultural Sector Policy and Investment Framework (PIF) 2010-2020. Draft Final Report 15 September. 39p.

Fufa B, Hassan RM, 2006. Determinants of Fertilizer Use on Maize in Eastern Ethiopia: A Weighted Endogenous Sampling Analysis of the Extent and Intensity of Adoption. Agrekon, 45(1): (March 2006). 12p.

Gujarati, 2004. Basic Econometrics, 4rd edition. McGraw-Hill, Companies, New York.1002p.

Haji Biru, 2003. Adoption of Crossbred Dairy Cows in Arsi Zone: The Case of Tiyo and Lemu- Bilbilo Districts. An M.Sc. Thesis Presented to the School of Graduate Studies Haramaya University. 105p.

John O, Geophrey S, Mary M, 2009. Agricultural Technology Adoption: A Panel Analysis of Smallholder Farmers' Fertilizer Use in Kenya. Contributed Paper Prepared for Presentation at the African Economic Research Consortium Conference on Agriculture for Development, May 28th and 29th, Mombasa, Kenya. 30p.

Maddala, GS, 2005. Introduction to Econometrics.3rd edition. Formerly of Ohio State University Press, New York.

Mesfin Astatkie, 2005. Analysis of Factors Influencing Adoption of Triticale (*X -Triticosecale Wittmack*) and Its Impact: The Case of Farta District. An M.Sc. Thesis Presented to the School of Graduate Studies of Haramaya University. 112p.

Motuma Tura, Dejene Aredo, Wondwossen Tsegaye, Roberto LR, Girma Tesfahun, Germano M, 2010. Adoption and Continued Use of Improved Maize Seeds: Case Study of Central Ethiopia. *African Journal of Agricultural Research.* 5(17), 2350-2358.

Namwata BML, Lwelamira J, Mzirai OB, 2010. Adoption of Improved Agricultural Technologies for Irish Potatoes (Solanum Tuberosum) Among Farmers in Mbeya Rural District, Tanzania: a Case of Ilungu Ward. *Journal of Animal & Plant Sciences*. 8(1): 927- 935. Publication Date: 27/08/2010.

Odoemenem IU, Obinne CPO, 2010. Assessing the Factors Influencing the Utilization of Improved Cereal Crop Production Technologies by Smallscale Farmers in Nigeria. *Indian Journal of Science and technology.* 3 (1) Edu. Sust. Devpt. "*Agriculture in Nigerian. Indian Society for Education and Environment. http://www.indjst.org Indian J.Sci.Technol.*

Rafael N, 2001. Determinants of Agricultural Technology Adoption in Mozambique. Post-Doctoral Research Fellow. International Food Policy Research Institute. 30p.

Samia Zekaria, 2002. Innovative and Successful Technical Experience in the Production of Agricultural Statistics and Food Security of Ethiopia. Contributing Paper Presented at a Seminar on a New Partnership to Strengthen Agricultural and Rural Statistics in Africa for Poverty Reduction and Food Security, Paris, France 16-17. Central Statistics Authority. Addis Ababa, Ethiopia.

Shimelis Kebede, (2004). Demand for Fertilizer in Oromiya: The Case of Two Districts in North Shewa zone. An M.Sc. Thesis Presented to the School of Graduate Studies of Haramaya University, Ethiopia. 120p.

Solomon Asfaw, Bekele Shiferaw, 2010. Agricultural Technology Adoption and Rural Poverty: Application of an Endogenous Switching Regression for Selected East African Countries. Poster presented at the Joint 3rd African Association of Agricultural Economists and 48th *Agricultural Economists Association of South Africa Conference*, Cape Town, South Africa, September 19-23. 30p.

Solomon Asfaw, Bekele Shiferaw, Franklin S, 2010. Does Technology Adoption Promote Commercialization? Evidence from Chickpea Technologies in Ethiopia. 27p.

Tesfaye Zegeye, Girma Taye, Tanner D, Verkuijl H, Aklilu Agidie, Wilfred M, 2001. Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer by Small-scale Farmers in Yelmana Densa and Farta Districts of Northwestern Ethiopia. Ethiopian Agricultural Research Organization.42p.

World Bank, 2008. Agriculture for Development, World Development Report, Washington, DC. www.worldbank.org

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