Gender specific determinants of inorganic fertilizer adoption in the semi-arid region of Ghana

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Abstract

Poor soil fertility is a major challenge in food production in Ghana especially in the upper east region. Fertilizer which is known to increase soil fertility is not widely adopted especially by female headed households. This research is aimed at investigating the influence of gender on inorganic fertilizer adoption in the Upper East Region of Ghana. A total of 300 households comprising 150 male and 150 female headed households were interviewed. A separate model was used to determine if the factors of adoption of fertilizer differ by gender. Results show that household size, area of land allocated for maize production and area for rice production were common factors that influence fertilizer adoption by both gender groups. However additional factors such as marital status and perception about soil fertility status positively and significantly influenced fertilizer adoption by male headed households while farming experience, dependency ratio, and family remittance were additional factors that significantly influenced fertilizer adoption by female headed households. Similarly factors such as age of farmers, access to extension services, access to credit, access to market, livestock holdings, slope of the land and group membership were not statistically significant to fertilizer adoption for both gender groups. Male headed households had additional factors such as education, farming experience, dependency ratio, slope of the land and remittance that were not statistically significant. Factors such as, marital status, non-farm income, soil fertility status, and access to climate information were not statistically significant for female headed households. Policies which target large scale maize and rice farmers will be relevant in increasing fertilizer adoption among male and female headed households. In addition government policies should target farmers with long farming experience and female headed households with large family sizes.

Introduction

Agriculture is the backbone of Ghana's economy, employing about 70% of the work force in the country, contributes about 30% of the Gross Domestic Product (GDP) and accounts for about 60% of the country's foreign exchange earnings through export (Ayisu, 2008; ISSER, 2010). The semi-arid region of Ghana which comprises the Northern, Upper West and Upper East regions is the most intensely agrarian part of the country. These three regions together are considered the food basket of the country as it accounts for more than 40% of agricultural lands (MoFA, 2010). However, over the years, crop productivity has declined partly due to lose in soil fertility. According to MoFA (2010), about 80% of the population in this area depends on subsistence agriculture which is marked with low productivity and income. Over reliance on rain-fed agriculture and traditional methods of production in addition to low use of inputs are key causes of low productivity, and high poverty in this area.

Generally, there has been much research and demonstrated efforts on the need to increase or boost productivity in the semi-arid region of Ghana but less has been achieved. To meet expected rising demands for food, increasing agricultural productivity through the adoption of modern agricultural technologies such as fertilizer use and improved seeds among others are crucial. Inorganic fertilizers when properly applied to soils have the potential to increases soil fertility, improve crop productivity and enhance household income and food security. For example, various studies have shown that fertilizer use improves crop yields in Africa (Duflo et al., 2008; Fosu-Mensah, 2012; Beaman et al., 2013). Though inorganic fertilizer has been identified as the main source of nutrients to replenish depleted soil nutrients for crop production, its use has not been widely adopted in the semi-arid region of Ghana. Several reasons have been reported in literature for low fertilizer adoption by farmers in general. Some identified reasons include: accessibility, availability, high cost, poor transportation network, lack of adequate knowledge and skills in using fertilizer on the part of farmers, lack of extension service to enhance farmers technological awareness, climatic condition, risk, liquidity or credit constraints and high incidence of poverty in the farming communities (Fosu et al., 2004; Fufa and Hassan 2006; Morris et al., 2007; Duflo et al., 2008; Yamano and Arai, 2010; Akpan et al., 2012; Dar et al., 2013; McIntosh et al., 2013; Karlan et al., 2014; Yu and Nin-Pratt 2014).

Although various studies have analysed farmer's adoption and use of fertilizer in several developing nations including Ghana, works on the effects of gender differentials on fertilizer adoption in Ghana and most especially in the semi-arid region of Ghana is scarce. Several studies for instance have established that lower yields are associated with female farmers than the males (Larson et al., 2015; Cadzow, 2016). This has been attributed to limited access to resources such as farm lands, credit, information about modern technologies, extension services and education on the part of women (Doss, 2015; Bravo-monroy et al., 2016). According to Oseni et al., (2015) women are most likely to be constrained and intimidated in their quest for productive inputs, resulting in lower levels of fertilizer application. Doss and Morris (2001) found that female famers in female headed households in Ghana were more unlikely to adopt new crop varieties and fertilizers than male farmers in male headed households. In most part of the semi-arid regions of Ghana, socio-cultural norms and practices forbid women to inherit productive resources such as land, and credit among others. It has been noticed that little has been done or documented on studies considering the gender differentials in decision to use or adopt fertilizer in the study area. The aim of this research is to investigate the gender differentials in the adoption of fertilizers among farmers in the semi-arid region of Ghana. The objectives of this paper are to: (1) determine factors influencing gender specific decision to adopt fertilizer and (2) investigate gender specific knowledge on soil conservation practices by local farmers.

Materials and methods

A household survey was conducted between August and December 2014 using a pre-tested questionnaire where 150 male and 150 female headed households were randomly sampled from Bolgatanga Municipality and Bongo district (Vea catchment) of the Upper East Region of Ghana. A total of 14 communities were randomly selected out of which seven (Sumbrungru, Sherigu, Yikene, Zaare, Nyarega and Gowrie) were from Bolgatanga municipality and seven (Lungu, Bongo, Balungu, Bongo Soe, Amanga, Feo and Boko) from the Bongo district. The two districts were purposely selected to represent agricultural activities in the catchment given the presence of Vea dam that allows farmers to produce crops all year round. Data on male and female headed households were obtained from the Ministry of Food and Agriculture offices at both Bolgatanga Municipality and Bongo District. Structured and unstructured questionnaire were employed for the survey. Farmers were interviewed by trained research assistants under supervision to guarantee accuracy of information gathered. Data collected during the survey covered farmers' socio-economic and demographic attributes, cropping and livestock production as well as their accessibility to climate information. The temperature and rainfall data were obtained from Ghana Meteorological Agency in the region.

Furthermore, soils were randomly sampled at two depth (0-15 cm and 15 – 30 cm) from farmers' fields for laboratory analysis. Farmers' fields where organic fertilizer, inorganic fertilizer and fields where no fertilizer were applied during the research period were purposely selected for the following physical and chemical analysis (parameters): total N (%), available P (ppm), available K (mg kg-1), pH, (Mg (cmol (+) kg^{-1}), CEC (cmol (+) kg^{-1}), Organic C (%), EC (µS/cm, OM (%), Sand (%), Silt (%) and Clay (%). Farmers' knowledge on soil conservation practices were also assessed through interviews.

Analytical framework and empirical model

Binary probit model

Linear regression models with binary dependent variables poses some basic challenges such as heteroscedasticity of the error term, non-normality, low efficient of determination and the probability of the outcome falling outside 0 – 1 range (Gujarati 2003 and Tesfaye et al, 2014). The probit model, however, ensures that the estimated probability falls within the logical limit of 0 and 1 (Tesfaye et al, 2014). Having an s-shaped relationship between the independent variables and the probability of an event helps address one of the problems with functional forms in linear probability model (Pindyck and Rubinfeld 1991).

The probit model was used to analyse the farmers' choice of adoption decision given the binary nature of the dependent variable. The model assumes that there is a latent unobserved continuous variable Y_i^* that determines the value of Y_i whiles only the value 0 and 1 for the dependent variable Y_i are observed (Sebopetji and Belete 2009). Assuming the response variable Y_i is binary with only two possible outcomes (1 = adoption and 0 = no adoption). Suppose also that a dependent variable Y_i is influenced by a vector of independent variable

$$Pr(Y_i = 1|x_i) = F(\beta' x_i) = \Phi(\beta' x_i) \quad (1)$$

x_i, the model can be specified as follows:

Where, Pr represents probability, Y_i is the binary choice variable denoting willingness to adopt and Φ represents the cumulative distribution function (CDF) of the standard normal distribution. β denote a vector of unknown parameter.

$$Y_i^* = \beta_0 + \sum_{n=1}^{N} \beta_n x_{ni} + u_i \quad (2)$$

The latent variable Y* is specified as follows:

$$Y_i = \begin{cases} 1 & if\ Y_i^* > 0 \\ 0 & otherwise \end{cases} \quad (3)$$

And

Where, x_i denotes a vector of explanatory variables, u_i represents random distance term, N total sample size, and β is a vector of unknown parameters to be estimated by the maximum likelihood method. The parameters do not necessarily represent the marginal effects of the independent variables due to the non-linearity of the probit model. The coefficients of the marginal effects are very useful for policy decision-making. The marginal effect is estimated by differentiating

$$\frac{\delta Y_i}{\delta x_i} = \emptyset(\beta' x_i)\beta_i \quad (4)$$

equation (1) with respect to x_i (Greene 2008). Where, ϕ is the probability density function of the standard normal distribution. The empirical specification for the Vea catchment

$$y_i = \beta_0 + \sum_{n=1}^{N} \beta_n x_{ni} + v_i \quad (5)$$

is specified as follows:

Where, Y_i = adoption of fertilizer (1 if a farmer adopted fertilizer, 0 otherwise); X_1 = gender; X_2 = age; X_3 = education; X_4 = household size; X_5 = farming experience; X_6 = marital status; X_7 = dependency ration; X_8 = percent income from non-farm income sources; X_9 = group membership; X_{10} = remittance; X_{11} = land ownership; X_{12} = access to agriculture extension; X_{13} = access to credit; X_{14} = access to climate information; X_{15} = access to market; X_{16} = soil fertility; X_{17} = maize area; X_{18} = rice area; X_{19} = slope; X_{20} = livestock holding.

Results

Descriptive statistics of respondents

Table 1 presents the demographic information of the respondents. Out of the 150 male-headed and 150 female-headed households

TABLE 1
Gender specific description of model variables for fertilizer adaptation

Variables	**Unit**	**Male**		**Female**		**Male and female combine**	
		Mean	**St Dev.**	**Mean**	**St Dev.**	**Mean**	**St Dev.**
Dependent variable							
Fertilizer application	Dummy=1 if yes, 0 otherwise	0.55	0.50	0.21	0.41	0.38	0.49
Explanatory variables							
Household characteristics							
Gender	Dummy=1 if yes, 0 otherwise	1.00	0	0	0	0.5	0.50
Age	Years	55.31	17.97	53.00	14.88	54.34	16.50
Education	Years	2.78	3.28	1.36	3.59	2.07	3.51
Household size	Count	7.83	3.06	7.65	3.07	7.74	3.06
Farming experience	Years	25	5.38	23.72	4.58	24.36	5.03
Marital status	Dummy=1 if yes, 0 otherwise	0.90	0.30	0.047	0.212	0.47	0.50
Dependency ratio		0.62	0.52	0.78	0.71	0.70	0.63
Percent income from non-farm sources	(%)	2.02	4.67	8.87	10.45	5.45	8.78
Social capital							
Group membership (Agric. union/ cooperative)	Dummy=1 if yes, 0 otherwise	0.267	0.44	0.31	0.47	0.29	0.46
Remittance	Dummy=1 if yes, 0 otherwise	0.63	0.49	0.40	0.50	0.56	0.50
Institutional and infrastructural variables							
Land ownership	Dummy=1 if yes, 0 otherwise	0.29	0.46	0.22	0.45	0.26	0.45
Access to Agric. Extension services	Dummy=1 if yes, 0 otherwise	0.47	0.50	0.35	0.48	0.41	0.49
Access to credit	Dummy=1 if yes, 0 otherwise	0.17	0.37	0.23	0.42	0.20	0.40
Access to climate information	Dummy=1 if yes, 0 otherwise	0.94	0.26	0.93	0.26	0.93	0.26
Access to market	Dummy=1 if yes, 0 otherwise	0.93	0.26	0.91	0.28	0.92	0.27

TABLE 1 *cont.*
Gender specific description of model variables for fertilizer adaptation

Variables	Unit	Male		Female		Male and female combine	
		Mean	St Dev.	Mean	St Dev.	Mean	St Dev.
Plot characteristics							
Soil fertility	Dummy=1 if yes, 0 otherwise	0.15	0.35	0.33	0.47	0.24	0.43
Maize area	Hectares	0.11	0.19	0.31	0.09	0.07	0.16
Rice area	Hectares	0.18	0.23	0.42	0.10	0.11	0.19
Slope	Dummy=1 if yes, 0 otherwise	0.91	0.29	0.89	0.31	0.9	0.30
Physical and financial assets							
Livestock holding	Tropical livestock unit	5.40	4.02	1.01	1.28	3.20	3.70

interviewed during the survey, approximately 55% of the former and 21% of the latter reportedly applied fertilizer to their crops. The average age of the household head in the study area was between 55 years (for male head) and 53 (for female head), while the number of family members per household on average was 8 people for both male and female headed households. Majority of the respondents have no access to credit and extension services, less educated, and extremely depend on agriculture for their livelihood. Only 2.02% and 8.87% of household income for male-headed and female-headed households respectively, earned from non-farm sources. While only 15% and 33% of farmers perceive that their

TABLE 2
Determinants of fertilizer adoption by both male and female headed households

Explanatory variables	Marginal effect	St. Err	P - Value	(95 % confidence interval)	
Age	0.002	0.001	0.110	-0.000	0.004
Education	-0.009	0.006	0.099	-0.021	0.002
Farming experience	0.006	0.004	0.067*	-0.000	0.013
Household size	0.010	0.006	0.124	-0.003	0.022
Marital status	-0.134	0.052	0.011*	-0.236	-0.031
Access to Agric. Extension	-0.020	0.38	0.597	-0.094	0.054
Access to credit	0.021	0.054	0.705	-0.086	0.127
Gender	0.005	0.003	0.046*	-0.014	0.001
Dependency ratio	0.036	0.030	0.233	-0.023	0.095
Maize area	1.111	0.128	0.000***	0.861	1.361
Rice area	1.115	0.098	0.000***	0.923	1.307
Market access	0.009	0.053	0.867	-0.096	0.114
Land ownership	-0.121	0.045	0.007**	-0.209	-0.033
Livestock holding	-0.011	0.006	0.076*	-0.022	0.001
Non-farm income	-0.004	0.003	0.151	-0.009	0.001
Slope	-0.021	0.070	0.762	-0.158	0.116
Soil fertility	0.034	0.049	0.487	-0.158	0.116
Group membership	-0.033	0.043	0.438	-0.118	0.051
Remittance	0.021	0.038	0.583	-0.054	0.0963
Access to climate information	0.111	0.064	0.086*	-0.016	0.237

NB: significance level, ***1%, **5%,*10%. Prob> chi^2 = 0.0000; Log pseudo likelihood = -102.488; Pseudo R^2= 0.481; Number of obs. =300 soils are fertile for male and female headed households respectively. As shown in Table 1, livestock holding by male-headed households in the study area is about 5 times that for female-headed households and is estimated at 5.40 TLU (tropical livestock unit) for male heads and 1.01 TLU for female heads.

Probit regression for fertilizer adoption

Table 2 present results of pooled data of both gender adoptions to fertilizer application. From the Table, farming experience, gender difference, access to climate information, size of rice and maize farms positively and significantly influenced farmers' likelihood to adopt fertilizer application. However marital status, land and livestock ownership negatively and significantly influence adoption of fertilizer application.

Table 3 presents results on determinants of chemical fertilizer adoption by male headed households. The results show that household size, marital status, area of land allocated to maize production, rice area and perception about fertility status of soil, positively and significantly influenced male adoption to fertilizer application. In contrast, the results show that land ownership, non-farm income, and access to climate information negatively and significantly influenced fertilizer application by male farmers. However age of farmers, education, farming experience, access to extension services, access to credit, dependency ratio, access to market, livestock holding, slope of the land, group membership and remittance were not statistically significant.

Table 4 presents summary results of factors that influence female decision to apply chemical fertilizer to their farms. The results

TABLE 3
Determinants of fertilizer adoption by male headed households

Explanatory variables	**Marginal effect**	**St. Err**	**P - Value**	**(95 % confidence interval)**	
Age	0.0004	0.0009	0.649	-0.0014	0.0023
Education	-0.0076	0.0062	0.216	-0.0197	0.0045
Farming experience	-0.0007	0.0035	0.851	-0.0075	0.0062
Household size	0.0141	0.0069	0.041**	0.0006	0.0276
Marital status	0.1880	0.0719	0.009***	0.0479	0.3281
Access to Agric. Extension	-0.0219	0.0379	0.564	-0.0963	0.0525
Access to credit	-0.0532	0.0717	0.458	-0.1936	0.0873
Dependency ratio	0.0484	0.0316	0.125	-0.0135	0.1103
Maize area	0.9593	0.1682	0.000***	0.6297	1.2890
Rice area	1.2577	0.1694	0.000***	0.9257	1.5897
Market access	-0.0108	0.0592	0.855	-0.1268	0.1052
Land ownership	-0.0880	0.0464	0.058*	-0.1790	0.0031
Livestock holding	-0.0041	0.0030	0.176	-0.0101	0.0018
Non-farm income	-0.0162	0.0078	0.038**	-0.0314	-0.0009
Slope	0.0462	0.0482	0.338	-0.0483	0.1406
Soil fertility	0.1364	0.0458	0.003***	0.0466	0.2261
Group membership	0.0011	0.0369	0.976	-0.0713	0.0735
Remittance	-0.0543	0.0349	0.119	-0.1224	0.0139
Access to climate information	-0.1220	0.0560	0.029**	-0.2317	-0.0123

NB: significance level,***1%, **5%,*10%. .Prob> chi^2 = 0.0000; Log pseudo likelihood = -23.08; Pseudo R^2= 0.7766; Number of observation=150 indicate that there is a positive association between fertilizer application by female headed households and farming experience, household size, dependency ratio, farm area allocated for maize production, rice area and family remittance while negative association were observed between fertilizer application by female farmers and education and non-farm income. The age of female farmers, marital status, access to extension services, access to credit, access to market, land ownership, livestock holding, non-farm income, slope, soil fertility, group membership and access to climate information were not statistically significant.

Gender specific knowledge on soil conservation practices

The results of farmers knowledge on soil conservation practices is presented in Table 5, which shows that both gender groups have sound knowledge on soil conservation practices. Approximately 95 % and 97 % of male and female headed households are respectively aware of soil conservation practices in terms of crop residue retention, soil fertility management using organic matter, zero tillage, seed bed preparation, crop rotation and the use of cover crops. However, the main challenge been faced by farmers is lack of financial resources as shown in the adoption rate of chemical fertilizer. Farmers were however of the view that interest rates on credits were so high that the probability of default was high hence their inability to take credits.

Soil chemical and physical characteristics of farmers` field

The results of chemical and physical analyses of the soil from farmer's fields are presented in Table 6. The result indicates that soils are

TABLE 4
Determinants of fertilizer adoption by female headed households

Explanatory variables	Marginal effect	St. Err	P - Value	(95 % confidence interval)	
Age	0.0025	0.0019	0.194	-0.0013	0.0062
Education	-0.0262	0.0124	0.034**	-0.0505	-0.0019
Farming experience	0.0141	0.0055	0.010**	0.0034	0.0249
Household size	0.0187	0.0088	0.034**	0.0014	0.0361
Marital status	0.2651	0.1621	0.102	-0.0525	0.5827
Access to Extension	-0.0044	0.0586	0.940	-0.1193	0.1105
Access to credit	0.0289	0.0701	0.680	-0.1084	0.1662
Dependency ratio	0.0710	0.0361	0.050*	0.0001	0.1418
Maize area	0.8900	0.2774	0.001***	0.3463	1.4338
Rice area	0.5007	0.2451	0.041**	0.0203	0.9811
Market access	0.0008	0.0885	0.993	-0.1727	0.1743
Land ownership	-0.0958	0.0712	0.178	-0.2353	0.0437
Livestock holding	-0.0064	0.0279	0.819	-0.0611	0.0483
Non-farm income	-0.0052	0.0030	0.085*	-0.0111	0.0007
Slope	-0.0298	0.1192	0.802	-0.2634	0.2037
Soil fertility	-0.0436	0.0673	0.517	-0.1755	0.0883
Group membership	-0.0676	0.0625	0.280	-0.1901	0.0549
Remittance	0.1113	0.0569	0.051*	-0.0002	0.2228
Access to climate information	0.0562	0.1433	0.695	-0.2247	0.3372

NB: significance level, ***1%, **5%,*10%. Prob> chi2 = 0.0000; Log pseudo likelihood = -58.11; Pseudo R2= 0.2526; Number of observation=150

TABLE 5
Gender specific knowledge on soil conservation practices

Variable	Male (%)		Female (%)		Average true total
	True	False	True	False	(%)
Residue retention					
Crop residues are sources of soil organic matter	98	2	99	1	98
Soil organic matter improves water capacity	88	12	89	11	89
Soil fertility management					
Organic manure is as strong as chemical fertilizer	98	2	99	1	98
Manure improves water holding capacity of the soil	71	29	87	13	79
Tillage					
Planting can be done without ploughing	100	0	99	1	99
Tillage improves water infiltration	98	2	98	2	98
Seed bed					
Improves water holding capacity	99	1	100	0	99
Improves soil aeration	99	1	99	1	99
Rotation					
Rotating cereals and legumes improve soil fertility	99	1	99	1	99
Rotation prevent some plant disease	99	1	99	1	99
Cover crops					
Reduce soil erosion	95	5	99	1	97
Increase soil microbes	93	7	93	7	93

TABLE 6
Soil characteristics of the study area as at 2014

Parameters	Organic Fertilizer (farms)		No Fertilizer application		Inorganic Fertilizer	
Soil depth (cm)	**0 - 15**	**15 - 30**	**0 - 15**	**15 - 30**	**0 - 15**	**15 - 30**
Total N (%)	0.48	0.33	0.15	0.16	0.21	0.19
Available P (ppm)	9.54	7.50	5.96	5.53	7.36	6.97
Available K (mg kg^{-1})	2.47	2.90	1.77	1.91	1.61	2.08
pH	7.23	7.0	6.67	6.45	6.12	6.39
Mg (cmol (+) kg^{-1})	0.60	0.98	1.22	0.86	0.91	0.97
CEC (cmol (+) kg^{-1})	12.74	10.62	9.23	7.10	10.80	9.87
Organic C (%)	4.08	2.20	1.53	0.47	2.69	1.73
EC (µS/cm)	96.2	113	68.89	74.43	62.75	81.25
Sand (%)	65.6	65.4	66.43	63.57	58.25	66.00
Silt (%)	11	12.8	11.43	12.86	15.75	11.25
Clay (%)	23.40	21.8	22.14	23.57	25.00	22.75

slightly acidic at farms where some fertilizers were applied than farms where no fertilizers were applied. Similarly, soil phosphorus was higher in farms where organic manure was applied compared to farms which received chemical fertilizer and farms where no fertilizer was applied. In addition, CEC and soil organic carbon (SOC) were generally high in soils where organic manure was applied compared to fields which did not receive any fertilizer.

Discussion

Probit regression for fertilizer adoption

Majority of studies conducted on the determinants of fertilizer adoption and rate of application by farmers used a pooled data without emphasizing gender differentials in adoption. The study placed emphasis on gender differences based on the presumption that male and female headed households are subjected to different binding constraints with females presumably worse off in this regards (emphasizing access to information, land tenure security and finance). Based on the results for the respective probit specifications, as shown in Table 2, farming experience was significant which confirms the finding of Diiro (2015) in Uganda, Nkonya et al., (2005) in Tanzania and Abdoulaye and Sanders (2005) in Niger. Gender was significant which confirms the finding that different factors influenced gender decision to adopt fertilizer application. This finding is in line with the finding of Diiro (2015). The positive influence of climate information on fertilizer adoption is because this informs farmers of the availability of moisture for their crops as such the risk of crop failure due to drought is eliminated. Climate information is important in the face of climate change as farmers are informed of the onset, amount and duration of the season hence crop loss is minimised (Fosu-Mensah et al., 2012). The negative and significant influence of land and livestock ownership on fertilizer adoption is due to the fact that owners of livestock use the droppings of their animals as manure on their farms. Even though the build-up of plant nutrients from manure is a gradual process, the ownership of the land makes the farmer benefit from the long term build-up of nutrients through manure application. Hence they are less likely to adopt fertilizer considering the fact that fertilizer is expensive. This finding is in contrasts to the findings of Beshir et al., (2012) in Ethiopia who found a positive association between livestock ownership and fertilizer adoption.

The positive association between fertilizer adoption by male-headed households and household size was probably due to the fact that farmers who had more family members to feed must increase their crop yield hence are more likely to adopt fertilizer to increase crop productivity . This is in contrast to Diiro (2015) where family size did not influence fertilizer adoption. Similarly, marital status, area of land allocated for maize production, rice area, and perception about fertility status of fields did influence fertilizer adoption. Generally, maize and rice crops are fast growing crops and need nutrients for proper growth hence farmers who have large acres of maize and rice fields are more likely to adopt fertilizer to boost crop yields. In addition, farm size is an indication of wealth and social status in society. This result is in line with the findings of Doss and Morris (2001) and Beshir et al., (2012). The positive perception about fertility status of crop fields however contrasts our a priori expectation and documented evidence in literature (Odendo et al., 2011).

Female headed households with many years of farming experience, larger household size, high dependency ratio, large area of maize and rice, and those with access to remittance are more likely to apply fertilizer. Female-headed households who earn relatively more income from non-farm sources are less likely to apply fertilizer. While fertilizer adoption in general requires sound financial capacity, earning relatively high percentage of household income from non-farm sources in general has a potential to induce a less-risk averse behaviour in farmers, and make them less likely to adopt and invest in fertilizer. A percentage point increase in the share of household income from non-farm sources leads to a 1.62% decrease in the probability of fertilizer application by male-headed households and 0.52% decrease by female-headed households.

More educated female heads are less likely to apply fertilizer. This could be attributed to increased access to alternative employment avenues with higher level of education, which consequently make these farmers less reliant on agriculture and demotivate them from investing in fertilizer. A year increase in the level of education of a female-head leads to a 2.62% decrease in the probability of fertilizer application by the household she heads. This is contrary to the finding of Desalew and Taye (2017) who reported positive and significant correlation of farmer's educational level with the decision to use soil and water conservational technologies.

The significant positive effect of maize and rice area in both probit specifications indicates that targeting maize and rice farmers under initiatives to promote fertilizer adoption could prove more successful in the study area, and the rate of adoption could influence, to a greater extent, the scale of production, with large scale producers being more likely to apply fertilizer. Given the limited degree of mechanization in the study area, fertilizer application is likely to be more labour-intensive, and increased availability of labour in a household is likely to enhance fertilizer adoption. This is in line with the positive association observed between fertilizer and household size in the respective probit regressions. While we find no significant effect of experience on fertilizer application by male-headed households, a year increase in experience leads to a 1.41% increase in the probability of fertilizer adoption by female-headed households. In addition, whereas we find no significant effect of marital status on fertilizer application by female-headed households, married male-heads are 18.80% more likely to apply fertilizer compared to their non-married (single) counterparts.

Gender specific knowledge on soil conservation practices

Despite the high level of awareness regarding soil conservation practices to ameliorate soil productivity to boost crop yields by both genders, only few farmers adopted inorganic fertilizer irrespective of gender. Fertilizer application by female farmers was very low (less than a quarter of total respondents) probably due to the patrilineal system of inheritance and succession which bequeath land to only male children. The low level of fertilizer adoption could also be attributed to lack of capital to purchase it.

Soil chemical and physical characteristic at the Vea catchment

Chemical and physical analyses of the soil from farmer's fields indicate that soils are slightly acidic in farms where some amount of fertilizer was applied compared to farms which received no fertilizer and farms which received organic manure. The low pH value recorded in farms which receive some fertilizer could be attributed to the amount of acidic cations present as a result of the leaching of basic cations. A similar low value was reported by Fosu-Mensah (2012) in Ejura and Arthur (2009) for soils in Kwadaso, Ghana. The application of organic matter, however, raised the pH level to neutral. Crop residues and farmyard manure are reported to increase soil organic carbon content (SOC) Kpongor (2007). Generally the soils of the study area are sandy in nature with sand composition ranging from 58.25 – 66.45%. The recorded total N values within the top soil 15 cm layer are low ranging from 0.15 in fields without fertilizer application to 0.48 (where organic manure was applied). There was some significant difference in total soil N between soils which received organic fertilizer application compared to that which did not receive any fertilizer application. This might be due to the build-up of nutrients in farms where manure were applied. These farms are mostly cultivated close to the homes where households' organic waste and manure are applied. Nitrogen is one of the most essential components of organic matter. The decomposition of organic matter leads to the release of nutrients including N. Similarly, the percent organic carbon is rated low according to Landon (1996). Plant available P can be rated as medium and K as rather low according to Page et al., (1982).

Conclusion

The study assessed how gender differences influence farmers' adoption of inorganic fertilizer. The results revealed that factors that influence male and female farmers' decision to apply inorganic fertilizer are different and varied. From the study, it was revealed that male headed households are more likely to adopt fertilizer application than female headed households. The factors that significantly influenced male headed households to adopt inorganic fertilizer application positively are household size, marital status, area of land allocated for maize production, rice area and perception about fertility status of soil. In contrast, the results show that land ownership, non-farm income, and access to climate information negatively but significantly influenced fertilizer application by male farmers.

For female headed households the factors that influenced their adoption of inorganic fertilizer are farming experience, household size, dependency ratio, farm area allocated for maize production, rice area and family remittance while negative association were observed between fertilizer application by female farmers and education and non-farm income. From the findings, different policy instruments are required to increase the adoption of inorganic fertilizer application for both gender groups. Policies which target large scale maize and rice producers will be relevant to increase fertilizer adoption by male and female headed households. In addition, policies that target experience farmers, farmers with large household size among female headed households will be relevant to adoption of fertilizer. It is evident from the chemical and physical soil results that the fertility status of farmers' fields are poor irrespective of gender and calls for institutional support in the form of fertilizer subsidy to improve fertilizer adoption in the catchment. Recommending more education while the educated female-headed households are less likely to apply fertilizer.

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Competing interests

All authors declare no competing interests.

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