Vol. 14(10), pp. 609-616, 7 March, 2019
DOI: 10.5897/AJAR2018.13671
Article Number: 87FEB5360464
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Analysis of factors affecting the demand for inorganic fertilizer in Boricha and Wondogenet Districts, Southern Ethiopia

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Received 24 October, 2018; Accepted 4 March, 2019

A study was undertaken to analyze factors affecting the demand for inorganic fertilizer in Boricha and Wondogenet farming Districts, Southern Ethiopia. Data on gender, educational level, farming experience, health status, soil fertility status, organic fertilizer used, access to inorganic fertilizer, ownership and size of cultivated farm, on-farm income, contact with DAs, availability of certified seed, and credit access were recorded using structured and semi-structured questionnaire on purposively selected one hundred eighty farmers. Descriptive statistics and econometric methods were employed to analyze the data using Statistical Package for Social Science (SPSS), version 19.0. The regression model revealed the number of oxen owned, cultivated farm size, access to certified seed, availability of fertilizer, contact with DAs, and on-farm income had a significant influence on the demand of inorganic fertilizer in the districts. The study suggested intensifying cultivated farms, sustaining extension services, strengthening fertilizer credit facility, providing improved seeds, and increasing on farm income of the farmers require immediate intervention in the study districts.

Key words: Factors, affecting, demand, inorganic fertilizer, South Ethiopia.

INTRODUCTION

Major economic and social measures have shown that agriculture is the dominant sector in the Ethiopian economy which contributes 55% of GDP, 80% of employment opportunity, 60% of export earnings and 70% of raw materials for domestic industries (World Bank, 2016). Despite its highest share in the country's economy, the performance of the sector cannot bridge the wide food demand of the increasing population (Eilittä, 2017; Anonymous, 2018). Projections showed the population will continue to grow at a faster pace and the urgency of maximizing crop production through adoption of improved agricultural technologies like fertilizer is of paramount importance (CSA, 2015; Freeman et al., 2016). In line with this, the government of Ethiopian has given top attention for fertilizer policy and strenuous efforts have been underway to adopt, promote and use it

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(FDRE, 2015). Although, the total consumption of chemical fertilizers has shown an increasing trend in the country in general, the demand for inorganic fertilizer in Borciha and Wondogenet districts, Southern Ethiopia are still below the expected due to various bottlenecks (Roberts, 2013; MoARD, 2015). This study was initiated to provide recent empirical evidences about the factors affecting the demand for inorganic fertilizer in the two districts so as to suggest policy implications for future intervention strategies of the region.

METHODOLOGY

Study area

This study was conducted in two major crop growing districts, Boricha and Wondogenet, Southern Ethiopia; both situated at about 270 km away from the capital Addis Ababa. Geographically, Boricha district has total area coverage of about 588.1 km^2 (CSA, 2015). It is located at 6°56' 30.8" North Latitude as well as 38° 25' 07.4" East Longitude. The district is characterized by lowland (Kola) and mid altitude (Woina dega) with a mean annual rain fall (mm) and temperature (°C): 801- 1000 and 17.6-22.5, respectively. The major crops growing include maize, banana, pepper, sweet potato, yam, enset, coffee, and haricot bean. Similarly, Wondogenet district has total area coverage of about 232 km^2 (CSA, 2015). It is located at 70°4' 55.7" N latitude and 38°36' 56.1" E longitude. The district is characterized by mid altitude (Woina dega) and Dega with a mean annual rain fall (mm) and temperature (°C): 1001-1400 and 15.1-22.5, respectively. The area is known in growing crops like maize, barley, kchat, sugarcane, potato, onion, enset, peas, and beans.

Sample size and sampling technique

One hundred and eighty respondent farmers, 90 from two kebeles, Konsore fulassa and Gesera kuwe in Boricha district and the rest 90 from Ado and Wosha Soyama kebeles of Wondogenet district were considered. The respondents were 45 farmers per kebele comprised both adopters and non-adopters of inorganic fertilizers. Data was collected using multi-stage purposive sampling technique through distribution of structured and semi structured questionnaire, interview and observation. In doing so, the respondents were classified based on their level of income, gender, education level, farming experience, health status, leadership position, farm ownership, number of family, oxen own, on-farm and non-farm income generate.

Data collected

Before conducting the actual survey of the study, pre-testing was carried out accounting for 50 randomly selected farmers (25 farmers/district) and some amendments were made on the final questionnaire. Data was collected from primary and secondary sources through distribution of questionnaire, interview of farmers at their slack time, and frequent observation of the districts.

Primary data

Structured questionnaire was distributed to those farmers who can read and write; otherwise interview was made through the direct translation of the questionnaire into their local language. Qualitative data about the patterns and types of activities of the people and their behavior was gathered informally through direct observation of the study areas and informal discussions with key Agriculture development agents, agriculture sector officers, administrators, and ethnic leaders.

Secondary data

Data about agricultural inputs supplied and consumed, physical characteristics, population size and crop yield were gathered through thorough reviewing and examination of reports as well as records of published and unpublished documents of the districts.

Data management and analysis

Questionnaires were coded, entered into Microsoft excel sheet and analyzed using Microsoft Excel programs. Descriptive analysis of the household characteristics were narrated and summarized into tables using sample mean and percentages to describe the factors that affect the rate of inorganic fertilizer. Econometric analysis method was also employed using Statistical Package for Social Sciences (SPSS) Version 19.0 and Multiple linear regression model was constructed to show which factor affects the demand for inorganic fertilizer by how much. Designation of the model was $Y = B_o + B_1X_1 + B_2X_2 + B_3X_3 \ldots B_nX_n + E$, where the independent variables X_1, X_2, $X_3 \ldots X_n$ denote factors affecting the rate of inorganic fertilizers use like the income of the farmer, price of fertilizer, size of the land, type of the soil, type of the crop, knowledge, farming experience, on time availability, and application of other organic fertilizers. The parameter B_o represents the constant coefficient value, B_1, B_2, $B_3 \ldots B_n$ denote the coefficient numbers that express the effect of factors (X_1, X_2, and $X_3 \ldots X_n$) on Y, Y denotes adoption level of inorganic fertilizer by the farmers, and E represents the error term.

Definition of variables in the model and hypothesis

In the study, the rate of inorganic fertilizer used was treated as dependent variable of the model (FERTILIZER) whereas those variables that are supposed to influence rate of inorganic fertilizer use were considered as independent variables and are explained as follows:

(i) Sex of the household head (SEX): This is a dummy variable which takes a value 1 if the household head was male and 0 for female. Therefore, it was assumed that male-headed households have more access to fertilizer use.
(ii) Age of the household head (AGE): Older farmers may accumulate more wealth than younger ones so as to finance fertilizer purchase. Hence, farmers who are older were assumed to adopt higher rate of fertilizer than the younger ones. Moreover, this variable was hypothesized as it positively influences fertilizer adoption and the intensity of use.
(iii) Farming experience (FAEXP): This represents the number of years that the farmers have passed on their farming work. Thus, a farmer with a long history of farming can adopt higher rate of fertilizer than the one who has short farming experience. Therefore, farming experience was hypothesized as it positively influences adoption level of fertilizer.
(iv) Educational level of the household head (EDUCN): This is a dummy variable, which takes a value 0, 1, 2, 3, 4 if the household head was illiterate, can read and write (basic education), primary school, secondary school and higher institution education, respectively. Farmers with ability to read and write and other education were expected to have an advantage in obtaining information and understand the benefit of fertilizer use. So,

educated farmers were assumed to adopt higher rate of fertilizer than illiterate ones. Therefore, education was hypothesized as it positively influences adoption level of fertilizer.

(v) Availability of family labor force (FAMLBR): New technologies such as fertilizer could increase the seasonal demand of labor so that adoption is more attractive to households with a large number of active labor forces. Hence, a farmer having large number of family labor force can adopt higher rate of fertilizer than a farmer with small number of family labor force. So, it was expected that this variable would have a positive impact on adoption and intensity of fertilizer use.

(vi) Health status of the household head (HEALTH): This is a dummy variable, which takes a value 0 if the household head was seriously ill (unable to perform main farm activities) and 1 if the household head was healthy during the main season. This variable can influence adoption and intensity of fertilizer use not only in physical availability of labor but also the management aspect of the farm household. Thus, households who have a healthy head are in a better situation to adopt new technology than those with sick ones. So, this variable was expected to positively influence adoption and intensity of fertilizer use.

(vii) Manure application (MANUAPP): This is a dummy variable, which takes a value 1 if the household uses manure and 0 if not. Farmers who have the culture of manure application can and/or not adopt small rate of inorganic fertilizer. Hence, this variable was expected to have negative impact on inorganic adoption.

(viii) Cultivated farm size (CFARMS): This refers to the total cultivated land that belongs under a particular farmer holding. A farmer with large farm size is assumed to be relatively wealthy, and then s/he can buy higher rate of inorganic fertilizer than a farmer with smaller farm size. Thus, this variable was hypothesized as it would have positive impact on farmers' demand for inorganic fertilizer adoption.

(ix) On-farm income (ONFI): This refers to the total amount of money farmers could earn from on-farm activities annually. It was the sum of current market value of output obtained from crop production, income from the sale of livestock and their products as well as by-products, and income from the sale of trees and their products. So, a farmer who earns higher on-farm income could purchase higher amount of inorganic fertilizer than the one who earn smaller amount. Thus, it was hypothesized as it would have a positive influence on farmers' adoption level of inorganic fertilizer.

(x) Non-farm income (NOFI): Some farmers in the study area may be engaged in non-farm activities such as handicraft, petty trade, office guarding and off-farm activities like working as daily laborer on government and private farms as well as the farm of others, which help them to earn additional income. The influence of this variable on the farmers demand for fertilizer can be positive or negative. Since this additional income sources increase the farmers' financial capacity, it increases the capacity of the farmers to invest in new technologies. In this aspect, availability of income from non-farm activities was hypothesized to be one of the factors that influence farmers' adoption for fertilizer positively. On the other hand, when farmers are engaged in non-farm activities, it shares the working force of the household that would be engaged in farming. Hence, this variable was hypothesized as it negatively influences the inorganic fertilizer adoption level of the farmers.

(xi) Number of oxen owned (OXEN): Defined in terms of number of oxen that the household head has for farm operations. A farmer with many oxen could rent the extra oxen to other farmers and fetch better wealth to purchase fertilizer and could also operate his/her farm properly as well as on time. Hence, a farmer having larger number of oxen could adopt higher rate of inorganic fertilizer than a farmer who have and/or do not have small number of oxen. Thus, this variable was expected to have positive influence on adoption and intensity of fertilizer use.

(xii) On time availability of fertilizer (ONTIME): This is a dummy variable, which takes a value 1 and 0 if the household head says yes and/or no on-time available of fertilizer, respectively. So, a farmer who can get on-time availability of inorganic fertilizer can adopt better than the one who cannot get on-time.

(xiii) Frequency of contact with DAs (FRCNT): A continuous variable which refers to the number of contacts that the households meet with DAs to get advice. A farmer who has frequent contact with DAs could adopt higher rate of inorganic fertilizer than a farmer who has less contact with DAs. Thus, this variable was hypothesized as it influences farm households' adoption level of fertilizer positively.

(xiv) Transportation access (TRANSPORT): This is a dummy variable, which takes a value 1 if the household has transportation access and 0 if not. Those households having transportation access are expected to adopt inorganic fertilizer in better than those farmers who have shortage of transport access. Therefore, this variable was hypothesized as it influences farm households' adoption level of fertilizer positively.

(xv) Soil fertility status (FERTILITY): This is a dummy variable, which takes a value 0, 1, and 2 if the soil fertility level is poor, medium and highly fertile, respectively. The more the fertile the soil is, the lower amount of inorganic fertilizer that would be required by the farmer. So, a farmer whose land is less fertile can adopt higher rate of inorganic fertilizer than those farmers whose lands are medium or highly fertile.

(xvi) Availability of certified seed (SEED): This refers to the total amount of seed that the households have given from the agricultural office. Therefore, this variable was hypothesized as it influences farm households' adoption level of fertilizer, positively.

(xvii) Leadership position (LEADRSP): This is a dummy variable, which takes a value 0 if the individual has not leadership poison and 1 if the individual has leadership poison. Therefore, this variable was hypothesized as it influences farm households' adoption level of fertilizer, positively.

(xviii) Credit access (CREDIT): This is a dummy variable, which takes a value 0 if the individual has no credit access and 1 if the individual has credit access. Therefore, this variable was hypothesized as it influences farm households' adoption level of fertilizer, positively.

RESULTS

Descriptive analysis of household characteristics

Sex of household head

Of the total respondents, 67.5 and 85.0% of the households were adopters while 32.5 and 15.0% were non adopters of inorganic fertilizers in Boricha and Wondogenet districts, respectively. Out of the adopters, female-headed accounted for 22.5% in Boricha and 37.5% in Wondogenet districts, while the rest 77.5 and 62.5% were male-headed in Boricha and Wondogenet districts, respectively (Table 1). In Boricha district, 55.6% of female-headed and 71.0% of male-headed households adopted inorganic fertilizer during the survey year. The corresponding figures in Wondogenet district were 73.3% for female-headed and 92.0% for male-headed households. The proportion of male-headed households who adopt inorganic fertilizer was greater than that of female-headed households in both districts which corroborates the finding of Akpan et al. (2013). This might be attributed to insecure the economic position of the female-headed households, shortage of labor, limited

Table 1. Sex category of respondent farmers in Boricha and Wondogenet Districts.

District	Farmers group	Sex				Total	
		Female		Male			
		N	%	N	%	N	%
Boricha	Adopter	22	55.6	119	71.0	141	67.5
	Non-adopter	18	44.4	21	29.0	39	32.5
	Total	40	100.0	140	100	180	100.0
	% of total	22.5		77.5		100	
Wondogenet	Adopter	42	73.3	23	92.0	34	85
	Non-adopter	15	26.7	2	8.0	6	15.0
	Total	67	100	113	100	180	100.0
	% of total	37.5		62.5		100.0	

% of total refers to the percentage calculated out of the total sample size of each district, N-number of respondent.

Table 2. The average family size by age category in Boricha and Wondogenet districts.

Age category	District					
	Boricha			Wondogenet		
	Male	Female	Total	Male	Female	Total
0-14 years	1	-	1	1	1	2
15-64 years	1	1	2	1	1	2
>64 years	1	-	1	-	1	1
Total	3	1	4	2	3	5

access to factors of production and social position of the household head as well as lack of awareness about new technologies. Again the proportion of both male-headed and female-headed sample respondents of Wondogenet district who adopt inorganic fertilizer was greater than that of Boricha district. This depicts that farmers in Wondogenet were better in adoption of inorganic fertilizer than those in Boricha district.

Family size by age category of the household head

The average family size of Boricha and Wondogenet district households were 4 and 5, respectively (Table 2). The average number of economically active labor age group (15 to 64 years) in both districts was similar (2) which directly agrees with Serge et al. (2017) and Mahmuda et al. (2018) estimation. On average, 50% family size of Boricha farmers observed actively engaged in an economic activity better than Wondogenet district farmers (40%).

Econometric analysis

The explanatory variables, viz: number of oxen owned, cultivated farm size, access to certified seed, price of fertilizer, on-time availability of fertilizer, access to fertilizer credit, frequency of contact with DAs, on-farm and off-farm income, as well as soil fertility status of the farmland in Boricha and number of family labor force, number of oxen owned, cultivated farm size, farming experience, access to certified seed, manure application, on time availability of fertilizer, access to fertilizer credit, frequency of contact with DAs, and on-farm income in Wondogent had direct influence on the rate of inorganic fertilizer use (Table 3).

Multi-collinearity test results

As shown in Table 4, variance inflation factor (VIF) values for all continuous variables in Boricha district were small (<10). This shows there is no serious multi-collinearity problem among the continuous variables when tested independently. Thus, all the continuous variables were included in the model. However, the VIF values of access to certified seed (30.095) and frequency of contact with DAs (18.056) in Wondogenet district showed serious multi-collinarity problem. This would bias the T-statistics and coefficient estimates unless remedial measures taken. To escape from such problem, dropping of all but one of the collinear variables from the analysis is one of the suggested methods (Bul Agric, 2016; Dillon and Barrett, 2017). Thus, access to certified seed with the highest VIF value (30.095) was omitted and the

Table 3. Pearson correlation values for the explanatory variables.

Explanatory variable	Pearson correlation value	
	Boricha	Wondogenet
Sex	0.248	0.118
Age	0.155	0.136
Educational level	-0.155	0.009
Health status	0.179	-0.009
Number of family labor force	-0.178	0.424**
Leadership position	0.054	0.245
Number of oxen owned	0.379*	0.459**
Cultivated farm size	0.822**	0.858**
Farming experience	0.225	0.448**
Access to certified seed variety	0.800**	0.964**
Manure application	-0.101	0.443**
Fertilizer input price	0.451**	0.217
On time availability of fertilizer	0.619**	0.415**
Transportation access	0.067	0.190
Access to fertilizer credit	0.565**	0.376*
Frequency of contact with Das	0.898**	0.973**
On-farm income	0.729**	0.880**
Off-Farm	0.324*	-0.013
Soil fertility status	0.696**	-0.204

** and *Correlation significant level at 1 and 5%, respectively.

Table 4. VIF of the continuous variables for Boricha and Wondogenet districts.

	Continuous variable	Boricha		Wondogenet	
		Tolerance (1-R_i^2)	VIF	Tolerance (1-R_i^2)	VIF
1	Number of Family labour force	0.833	1.201	0.405	2.468
	Number of oxen owned	0.584	1.713	0.367	2.722
	Cultivated Farm Size	0.192	5.214	0.106	9.428
	Farming experience	0.854	1.171	0.520	1.924
	Access to certified seed	0.367	2.723	0.033	30.095
	Frequency of contact with DAs	0.235	4.257	0.055	18.056
	Total on-farm Income	0.211	4.750	0.206	4.866
	Total off-farm Income	0.723	1.382	0.742	1.348

multicollinarity problem of Wondogenet district was corrected and all continuous variables had a VIF value of less than 10.

Similarly, the contingency coefficients were computed in order to check the degree of association among the remaining ten discrete variables and there was no serious problem of association among the variables in both districts when tested independently. This indicates no variable had a contingency coefficient value that approaches to 1 (perfect correlation). Thus, all the discrete variables were included in the model for further collinearity diagnosis and analysis.

In the study, number of oxen owned (OXEN), cultivated farm size (CFARMS), on time availability of fertilizer (ONTIME), frequency of contact with DAs (FRCNT), total on-farm income (ONFI) and access to certified seed (SEED) had significant ($P \leq 0.1$) effect on the adoption of inorganic fertilizer in Boricha district (Table 5). Likewise, with the exception of access to certified seed that has been dropped away from regression analysis for the correction of multi-collinearity problem, number of oxen owned (OXEN), cultivated farm size (CFARMS), on time availability of fertilizer supply (ONTIME), frequency of contact with DAs (FRCNT), and total on-farm income (ONFI) in Wondogenet district had significantly affect explanatory variables (Table 5).

Table 5. Regression result for significant explanatory variables.

Significant variable	Coefficients		t-value		VIF	
	Boricha	Wondogenet	Boricha	Wondogenet	Boricha	Wondogenet
(Constant)	-35.32	-32.98	-2.12	-2.37	-	-
Number of oxen owned	-5.99**	-9.73**	-2.51	-2.60	1.88	2.64
Cultivated farm size	15.87***	23.66**	3.08	2.44	5.41	5.83
On time availability of fertilizer	22.46***	20.17**	2.73	2.31	2.74	1.67
Frequency of contact with DAs	24.17***	41.73***	5.01	12.98	4.99	5.79
Total on-farm income	0.00***	0.00*	3.29	2.00	5.75	5.21
Access to certified seed	4.029***	****	4.647	****	6.736	*****

****Omitted from regression analysis for Wondogenet district due to multicollinarity problem. ***Significant at 1% probability level. **Significant at 5% probability level. *Significant at 10% probability level.

Table 6. Multiple linear regression coefficients after multicollinarity problem correction for Boricha.

Model		Unstandardized Coefficients		T	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	-35.32	16.674	-2.12	0.04	-69.42	-1.22	-	-
	Number of oxen owned	-5.99	2.39	-2.51	0.02	-10.88	-1.11	0.53	1.88
	Cultivated farm size	15.87	5.15	3.08	0.004	5.34	26.41	0.18	5.41
	Access to certified seed	4.03	.87	4.65	0.00	2.26	5.80	0.15	6.74
	Fertilizer input price	-5.33	4.77	-1.12	0.27	-15.09	4.42	0.46	2.15
	Availability of fertilizer	22.46	8.21	2.74	0.01	5.67	39.25	0.36	2.74
	Access to fertilizer credit	4.50	8.39	0.54	0.60	-12.65	21.65	0.48	2.08
	Contact with DAs	24.17	4.82	5.01	0.000	14.31	34.03	0.20	4.99
	Total on-farm Income	0.001	0.000	3.29	0.003	0.00	0.002	0.17	5.75
	Total off-farm	0.001	0.001	1.28	0.21	0.00	0.003	0.55	1.83
	Soil fertility status of farmland	2.81	5.89	0.48	0.64	-9.25	14.86	0.21	4.81

DISCUSSION

The effect of each significant explanatory variable on the rate of inorganic fertilizer use in the two districts is discussed in the following.

Ownership of oxen (OXEN)

It significantly ($P \leq 0.005$) affects the adoption of inorganic fertilizer in both districts and with each additional percent of oxen, the probability of fertilizer adoption decreased by 5.994% in Boricha and by 9.728% in Wondogenet districts (Tables 6 and 7). This implies that adoption of inorganic fertilizer was less attractive to farmers who had large number of oxen owned and an increase in the number of oxen could lead farmers to shift in fattening of animals that would discouraged them to use oxen for ploughing which in turn decrease the adoption of inorganic fertilizer. It might also be due to the fact that an increase in the number of oxen would increase the availability of animal dung for organic manure preparation as reported in Yara International (2014).

Cultivated farm size (CFARMS)

It depicted a 1 ha increase in the size of cultivated land increased the adoption level of inorganic fertilizer by 15.87 kg in Boricha and 23.665 kg in Wondogenet districts (Tables 6 and 7). This indicates a farmer owned larger cultivated farm lands mean more resources and greater capacity to purchase fertilizer as well as it increases readiness to take risk in case of crop failure. It corroborates the works of Stanfrod News (2018).

Amount of certified seed given in kilogram (SEED)

This shows that 1 kg increase in the quantity of certified seed demanded, can lead to an increase in the amount of

Table 7. Multiple linear regression coefficients after multicollinearity problem correction for Wondogenet.

Model		Unstandardized Coefficients		t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	-32.98	13.92	-2.37	0.02	-61.41	-4.55	-	-
	Family labour force	1.98	2.63	0.75	0.46	-3.39	7.35	0.48	2.08
	Number of oxen owned	-9.73	3.74	-2.60	0.01	-17.37	-2.08	0.38	2.64
	Cultivated Farm Size	23.66	9.71	2.44	0.02	3.82	43.50	0.17	5.83
	Farming experience	-0.73	0.47	-1.57	0.13	-1.69	.22	0.57	1.74
	Manure application	10.40	6.42	1.62	0.12	-2.71	23.51	0.57	1.76
	availability of fertilizer	20.17	8.72	2.31	0.03	2.36	37.98	0.60	1.67
	Access to fertilizer credit	-0.91	5.86	-0.16	0.88	-12.88	11.06	0.70	1.42
	Contact with DAs	41.73	3.21	13.9	0.00	35.16	48.30	0.17	5.79
	Total on-Farm Income	.002	.001	2.00	0.05	0.000	0.004	0.19	5.21

fertilizer adoption by 4.029 kg in Boricha district (Table 6). Thus, a farmer who owned relatively higher amount of certified seed has more demand for fertilizer adoption than the one who owned smaller one which agrees with finding of Minor (2015) and World Bank (2016). For Wondogenet district, this variable has been omitted from being regressed in the regression model due to the multicollinarity remedial measurement.

On-time availability of fertilizer supply (ONTIME)

The present result revealed that on time supply of inorganic fertilizer could increase its adoption by 22.46% in Boricha and 20.17% in Wondogenet districts (Tables 6 and 7). This shows that supply of fertilizers at the time when farmers are in demand increases its adoption; otherwise its adoption level could discouraged if not available on-time as reported by Stewart and Roberts (2014).

Frequency of contact with DAs (FRCNT)

It was observed that a one-time increase in the number of contact would increase the amount of inorganic fertilizer by 24.173 kg in Boricha and by 41.730 kg in Wondogenet districts (Tables 6 and 7). This shows a farmer who has more frequent contact with DAs is supposed to access for information that enables s/he to assess the advantages of adopting inorganic fertilizer than those who contact less frequently and is more likely to adopt which agrees with the report of Akpan et al. (2013) and Bul Agric (2016).

Total on-farm income (ONFI)

Tables 6 and 7 show an increase in the total on-farm income by 1 birr could increase the amount of inorganic fertilizer adoption by 0.001 kg in Boricha and 0.002 kg in Wondogenet districts. This indicates as total on-farm income of the farmer's increases, their demand for adoption also increases in both districts. The result was in conformity with the earlier study of Dillon and Barrett (2017).

In general, the model from this study for each district was: $Y= -35.32-5.99X_1 + 15.87X_2 + 4.03X_3 +22.46X_4 + 24.17X_5 + 0.001X_6 + E$ for Boricha district and $Y= -32.98 - 9.72x_1 + 23.66x_2 + 20.17x_3 + 41.73x_4 + 0.002x_5 + E$ for Wondogenet district. Where the capital letters X_1, X_2, X_3, X_4, X_5, and X_6 represent number of oxen owned (OXEN), cultivated farm size (CFARMS), access to certified seed variety (SEED), on time availability of fertilizer supply (ONTIME), frequency of contact with DAs (FRCNT), and total on-farm income (ONFI) were identified significant explanatory variables in Boricha district. While the small letters x_1, x_2, x_3, x_4, and x_5 represent number of oxen owned (OXEN), cultivated farm size (CFARMS), on time availability of fertilizer supply (ONTIME), frequency of contact with DAs (FRCNT), and total on-farm income (ONFI), were also significant explanatory variables in Wondogenet district. Y denotes amount of inorganic fertilizer needed to be adopted by the farmers in kilogram and E represents the error terms.

Conclusion

Generally, from this research, it was found that older farmers were more adopters than younger ones. Educated farmers were observed adopting more than uneducated ones. Farmers who owned larger farm size were more adopters than those who owned smaller farm size in both districts. Farmers with larger number of livestock holdings used inorganic fertilizers more than those with smaller holdings.

Conclusively, appropriate and adequate extension

services should be provided to promote the use of inorganic fertilizer to boost crop productivity to bridge the prevalent wide food deficit in the study districts. There should be well designed capacity building program to train additional DAs to reduce the existing higher ratio of farmers to DAs. The livestock ownership of the farmers shall be improved by capacitating the existing veterinary services as livestock holding is a proxy to wealth and has a positive effect on farmers demand for adopting technologies in the study area. Adequate rural finance institutions should also exist for better fertilizer credit facility as access to fertilizer credit has a positive influence on farmers' demand for inorganic fertilizer use.

In the study, the factors identified and analyzed were area specific and limited. Thus, understanding other and newly existing issues for the slow growth rate of inorganic fertilizer consumption should be further investigated in the future.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The author acknowledged the financial support from the Research and Technology Transfer Office, Hawassa University, Ethiopia.

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