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Determinants of Small Holder Farmers Bio Fertilizer Technology Adoption for Faba Bean Production in Tiyo Wereda, East Arsi Zone, Oromia National Regional State, Ethiopia

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Abstract

Bio-fertilizer is an eco-friendly and cost effective source ofnitrogen for crop production.However, its use in Ethiopian agriculture is very low in general and in TiyoWereda in particular. Thus, the main objective of this study was to assess the major determinant factors affecting smallholder farmers' adoption of bio-fertilizer forfaba bean production in TiyoWereda.The study applied stratified and random sampling techniques. A total of 120 sample respondents were used for primary data and secondary data collection. Out of these 120 respondents,72 were adopters while the rest 48 were non adopters. The data collected were subjectedto logistic regression model analyses in orderto find out the major factors that have contributed for adoption of bio-fertilizer.The econometric analysis result showed that, out of nine explanatory variables, four were found to have significant correlation with adoption of bio-fertilizer by smallholder farmers. From the total of four significantly independent variables, two of the continuous and two from dummy variables were found to be influencing adoption of bio fertilizer by small holder farmers in the study area. The other variables which were found to be significantly influencing the adoption of bio fertilizer for faba bean production were access to credit (ACFAC), education level ofhousehold head (ELHH), distance from household residence to all weather road (DMAINR), and access to information (AINFO;) while the remaining five explanatory variables: frequency of extension service, investment cost, family size, farm size and sex of house hold head were found to be less powerful in explaining variation in adoption of bio-fertilizer by smallholder farmer in the study area.

From this study it can be recommended that access to credit, access to information about bio fertilizer and extension service should get due attention so that farmers can adopt the use of this cost effective and environmentally friendly nitrogen sourcewhich can replace the chemical fertilizer currently used for faba bean production.

Key words: Bio-fertilizer, Adoption, Faba bean, Smallholder farmers, *TiyoWereda*, Ethiopia

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Introduction

Ethiopia is the center of crop diversity and one of the nine major agro-geographical production regions in the world of faba bean production (Asfaw et al., 1994). Faba beanis among the most important pulse crops in the highlands and mid-highlands of Ethiopia. Faba bean ranks firstamong the pulses grown in Ethiopia in terms of area coverage and volume of annual production by occupying about 443,107.88 hectares of land with an annual national production of 8,389,438.97 tones with an average yield of 18.93 kgha[1] (MOANR, 2016).According to CSA (2015), the crop is widely cultivated in mid and high altitude areas of the country characterized with elevations of 1800-3000 meters above sea level and receiving average annual rainfall of 700-1100mm. In spite of its enormous use, the productivity of faba bean in Ethiopia is about 18 $qtha^{-1}$ which is far below the crop's potential (>50 $qtha^{-1}$) (FAO, 2014). The low yield of faba bean in Ethiopia among other production factors is the low soil fertility (Asfaw et al, 1994).

Recently, there has been an interest to promote bio-fertilizers for eco-efficient intensification of agricultural systems in Sub-Saharan Africa (SSA) including Ethiopia. Bio-fertilizers are considered as cost-effective and environmentally friendly soil fertility amendments that boost crop productivity in many parts of the world. According to Nilabja(1964), bio-fertilizers make nutrients that are naturally abundant in the soil, or atmosphere available for use by plants and hold the promise to balance many shortcomings of conventional chemical based technology since they constitute products that are likely to be commercially promising in the long run, once information that enhance farmers' adoption becomes adequately available.

Bio fertilizer was introduced in 1994 to improve the productivity of legume crops in the study area.Regarding the future prospect of bio fertilizer, there is a need for large-scale utilization of this fertilizer as a potential input in Ethiopia. The study area can be taken as one ofthe exemplary areas in Ethiopia for using bio-fertilizer forfaba bean production.

In line with this, a study was conducted to assess the adoption status of bio-fertilizer andthe potential factors that determineits adoption by small-scale farmers in the study area.

Research Methodology

Description of the Study

The study was conducted in Tiyoworedawhich is located in Arsi Administrative Zone of Oromia Regional State, Ethiopia (Figure1) at a greed reference of (East $39^0$10' North $8^0$2'). It hasa population size of16,790 peopleliving in18 administrative units.

The topography of the Woreda varies from place to placecomposingplain lands, desiccated valleys, hills and mountain chains withan altitude ranging from 1780 to 4200 meters above sea level (m.a.s.l.).The climate varies according to the topography of the land from afro alpine humid to low land hot.The mean annual temperatureand annual rainfallof the study area ranges from 10^0C-22^0Cand 840 -900 mm, respectively(BANRTW, 2009).

The total area of the Woreda is 647km^2(65000 hectare) of which 33.49% is cultivated land, (3.1% perennial crop land), 14.8% grazing land,6% forest and shrubs, 9.2% settlement area while the remaining 30% is bare land.

The dominant soil type of the Woreda is clay soil whichin general has good potential to support cereals, pulses and tuber crop production.(OANRTW, 2006).

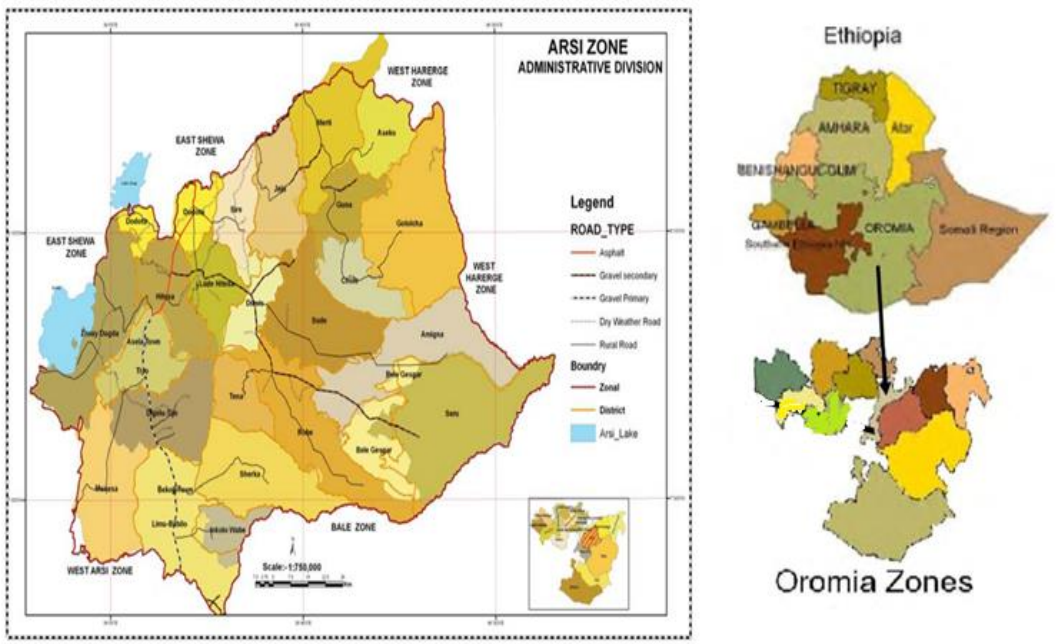

Figure1: Map of TeyoWoreda

Methods of Data Collection

The primary data was obtained by interviewing the sample respondents using open and closed questionnaires. Secondary data was collected from the Agricultural office, an international research organization and NGOs engaged in bio fertilizer distribution activities in Addis Ababa and Assela area. All questions were translated into the local language (Amharic). The questionnaires were pre-tested before conducting interviews with 15% of the whole sample. Besides, discussions with experts and faba bean seed distributing agentswereheld. The interview revealed formation that in the adoption literature, many social and economic factors are considered as determinants of farmers' adoption decision (Feder et al., 1985). Based on the literature and observations made in the area, it is envisioned that huge database was required. The data collected from both primary and secondary sources were qualitative and quantitative.

Sampling Techniques

Stratified sampling technique was used to select representative respondents/ faba bean producers in Tiyoworeda. By considering the kebeles , bio fertilizer technology was introduced in nine kebeles. The major kebeles that were randomly selectedwere from Dega and Woinadega. From these two climate zones, two kebeles- one from each- were selected in order to remove heterogeneity in production system, type of crop growth, amount of rain fall, temperature etc. In the sample kebeles, a total of one hundred twenty respondents were randomly selected from one thousand eight hundred sixty-four total household. Adopters and non-adopters of bio-fertilizer technology of Doshakebele from Dega zone and GoreSilingokebele from Weynadega zone were the two selected areas. Sampling methods are used for the purpose of accurate and detailed comparative analyses of the selected kebeles.

Table2.Number of bio-fertilizer user kebeles in dega and woinadega and sample kebeles

Agro-climatic zone	Total number of kebele	Bio-fertilizer user kebeles	Number of sample kebeles
Dega	4	2	1
Woinadega	9	4	1
Total	13	6	2

Source: BANRTW, 2010

The sample size determines using the following formulas.

$n= Z^2/e^2 (p*q*N/ (N-1) +Z^2 (p*q)$

N- Total population = 1864

e – Confidence level 95% margin error = 0.05

P—proportion and population containing the major interest

q—1-p,

z-- Number of standard deviation at a given confidence level (α=0.1) n — sample size

$n=0.1/0.05^2\,(.05*.05*1864/(1864-1)+0.1^2(0.05*0.05)=105.3\sim105$

And, adding 5% for possibility of un-returned questioners i.e. the sample size was (105 +105*0.05) = 120

The representative sample randomly selected kebeles and the farmers were selected with probability proportion size (PPS) random sampling technique to ensure representativeness of the population. Therefore, a total of 120 sample respondents, from the total sample 120, 72 adopters and 48 non-adoptersselected in the categorieswere selected to provide information.

Methods of Data Analysis and Econometric Model

Both quantitative and qualitative data analysis were employed to analyse the determinants of adoption of bio-fertilizer technologyamong the households in TiyoWereda. The collected data was analysed using the STATA software and statistical measures such as mean, ratio or percentage and standard deviation were generated.

Qualitative analysis was employed to identify constraints and opportunities with respect to adoption bio-fertilizer technology. The study used both descriptive statistics and econometric model to analyse the data. Farmers' adoption behaviour, especially in low-income countries, is influenced by a complex set of socio-economic, demographic, technical, institutional and biophysical factors (Feder et.al, 1985).

TheLogistic Regression model used to examine the relationships between adoption and factors influencing adoption involves a mixed set of qualitative and quantitative data. Logistic regression is a statistical technique where the probability of a dichotomous outcome- adoption and non-adoption is related to a set of explanatory variables (Idrisa et al., 2010).

The dependent variable is dichotomous, taking two values; 1 is when the event occurs, and 0 is when it does not. This type of relationship requires the use of qualitative response models. So, linear probability; logit and probit model are the possible alternatives.

The logit model based on cumulative logistic probability function was used in this study. Ignoring the minor differences between logit and probit models, Liao (1994) and Gujarati (1995) indicated that the probit and logit models are quite similar, so they usually generate predicted probabilities that are almost identical. The choice between logit and probit models is largely a matter of convenience (Green, 1991; Gujarati, 1995). But the logit model is computationally easier to use and leads itself to a meaningful interpretation than the other types (Pindyck and Rubinfeld, 1981; Green, 1991; Gujarati, 1995).

Maddala (1983), Green (1991) and Gujarati (1995) claim that the logistic distribution function for the adoption of bio-fertilizer can be specified as:

$P=1/(1+e^{-zi}) =e^{zi}/(1+e^{zi})$ --1

Where Pi - is a probability of adoption of bio-fertilizer for the i^{th} farmer and it ranges from 0-1. P is the observed response of the i^{th} farmer (i.e., the binary variable, P = 1 for a user, P = 0 for a non-user).

e^{-zi} stands for the irrational numbers e to the power of iZi
Zi - Is a function of n- explanatory variables (Xi) which is also expressed as
$Zi =\beta o + \Sigma \beta ixi +ui$

Zi is an underlying and unobserved stimulus index for the i^{th} farmer

i = 1, 2… m, are observations on variables for the adoption model, m being the number of explanatory variables in this study represents 9 independent variables.

$\beta 0$ = is the constant term and
βi=Are the unknown parameters to be estimated, and
Ut = is the disturbance term

The slope tells how the log-odds ratio in favor of adoption of bio-fertilizer changes as independent variables change. If Pi is the probability of adopting bio-fertilizer, then 1-Pi represents the probability of not adopting it.

$1-p =1/(1+e^{zi}) =1- e^{zi} / (1+e^{-zi})$
$e^{-zi} / (1+ e^{-zi}) =1/ (1+e^{zi})$ ---2

So, the odd ratio can be written as
$Pi /1-Pi=(1+e^{zi})/ (1+e^{-zi}) = e^{zi}$ ---3

Pi/ Pi −1 is simply the odds ratio in favor of adopting bio-fertilizer. It is the ratio of the probability that the farmer would adopt a bio-fertilizer to the farmer who does notadopt. Finally, taking the natural log of equation can be written as:-

$Li =\ln (Pi /1-Pi) = \ln (e^{\beta 0+ \Sigma \beta ixi})$

$Zi =\beta o + \Sigma \beta ixi +ui$ ---4

Where: = Li is log of the odds ratio in favor of bio-fertilizer adoption, which is not only linear in xi but also linear in the parameters.

Descriptive statistics (percentage, frequency and average) was employed in addition to the logit model mentioned above to address the first two objectives. The variables that were assumed to influence the adoption decision of bio fertilizer were tested for multicollinearity. The parameters (βi) of the model were estimated using the iterative MLE estimation procedure

Definition of Variables and Working Hypotheses

Different variables were expected to affect household adoption status in the study area. The variables hypothesized to affect adoption of bio-fertilizer were tested to see whether they were statistically significant or not using t-statistics and chi-square (χ 2) tests. The t-test was used to test the significance of the mean value of continuous variables of the two groups of adopters and non-adopters. The potential discrete (dummy) explanatory variables were tested using the chi-square (χ^2) distribution.

Accordingly, the major variables expected to have influence on the adoption status of household as well as the symbol to represent them are explained below:

The dependent variable of the model (BIOF): The dependent variable of the study, dichotomous in nature, represents the observed bio-fertilizer adoption status. It was represented in the model as BIOF=1 for the household that uses bio fertilizer in producingfaba bean, and BIOF = 0 for household that did not utilize it.

The adoption decision of bio fertilizer is the combined effects of some of the various factors of independent variables that are hypothesized to affect the farmersare: household characteristics, socioeconomic characteristics and institutional characteristics in which farmers work. During the review of adoption literature, past research findings and the researcher's knowledge of the farming system of the study area, reveals that among the large number of factors which were expected to relate to farmers' adoption behavior, 9 potential explanatory variables were considered in this study and examined for their effect in farmers' adoption decision of bio-fertilizer.

Results and Discussions

Results of Descriptive Analysis

The analysis of the socio-economic and institutional characteristics of the respondents:farm size, investment income, family size, sex of household head, level of education, access of credit, access of information, extension service and road distance of adopters and non-adopters of bio-fertilizer is shown on the table four and five below.

Table4.Descriptive statistics for continuous explanatory variables

Variable	**Adopters**		**Non-adopters**		**Total sample**		**T-value**
	Mean	**Standard deviation**	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**	
AMIANR	**2.06**	**1.23**	**5.06**	**1.26**	**3.56**	**1.245**	**-12.973****
ELHH	**6.69**	**4.95**	**3.83**	**4.91**	**5.82**	**4.83**	**3.11***
FES	**2.68**	**0.73**	**1.31**	**0.69**	**1.71**	**0.71**	**10.45**
FSIZ	**2.75**	**1.2**	**1.42**	**0.74**	**2.09**	**0.97**	**9.53**
FAMS	**3.01**	**0.96**	**2.85**	**0.81**	**2.93**	**0.89**	**8.12**

Table5. Descriptive statistics for descriptive explanatory variables

Variable	Response	Adopters		Non-adopters		Total sample		X^2-value
		F	Percent	F	Percent	F	Percent	
SHH	Male	58	80.6	27	56.25	85	70.83	8.235
	Female	14	19.4	21	43.75	35	29.2	
ACFAC	Yes	64	88.9	8	16.7	72	60	62.593***
	No	8	11.1	40	83.3	48	40	
AINFO	Yes	70	97.2	7	14.6	77	64.2	85.54***
	No	2	2.8	41	85.4	43	35.8	
IC	High	19	37.25	32	62.7	51	42.5	11.23
	Low	54	78.3	15	21.7	69	57.5	

F=frequency *, **, * =significant level at 1%, 5% and 10%**

Source: own survey result, 2010

Household Characteristics

Education Level of Sample Respondent of Household

The result presented on table-3 shows that out of 120 total sample respondents 63 (52.5%) of them are adopters, while 57(47.5%) of them are non-adopter with 6.99, 3.83 mean and 4.93, 4.91 standard deviation, respectively. The result also indicates that the distribution of respondent interims of literacy in the household is: 19.6% are illiterate, 7.5 % read and write, 27.5% are between 1-4 grade, 10% attended from 5-8, 10.8 % attended from 9-10,19.16% of the respondent completed 11&12, and 5.8% joined different technical college.From the total adopters, 57(87.3%) were educated from 1-12 grade, and 8(12.69%) were illiterate.On the other hand, from the total non-adopters 32(56.14%) were illiterate, 25(43.9%) covered 1-12 grade (table 6).Therefore, this study revealed that farmers who had higher education level understand new technology and try to use or adopt it to increase production. Hence, the data shows that significant difference was observed between adopters and non-adopters at 10% significant level. (Table 6).

Table6.Education Level of Sample Household Head Respondents

Education level	Adopter		Non adopter		Total sample		T-value
	N	%	N	%	N	%	3.11
Illiterate	3	2.5	20	16.7	23	19.16	
Read &write	5	4.16	4	3.33	9	7.5	
From 1-4	12	10	21	17.5	33	27.5	
5-8	11	9.16	1	0.8	12	10	
9-10	13	10.8	0	0	13	10.8	
11 &12	14	11.7	9	7.5	23	19.16	
>12	5	4.16	2	1.6	7	5.8	
Mean	6.69	3.83	5.26				

Source: own survey result, 2010

Distribution of Sample Respondent on Distance from All-weather Road of Households Head

According to the result shown on the (table 7), distance from the all-weather road had an impact on adoption of bio-fertilizer technology. From the total respondents, 68(56.7%) were adopters and 52(43.3%) were non-adopters, with average mean 2.06, 5.06 and standard deviation of 1.23, 1.26, respectively. Hence, the more the distance from the road increases,the number of adopting the technology decrease and the number of non-adopters increases. The data also indicates that 79.4% of the farmers living in the range of 1-3 km adopted the technology, while only 1.5% of the farmers accepted the technology from those respondents living in the range of 6-7 km from all-weather road (table 7). From this we can understand that farmers who are near to all weather roads have access to transportation facilities and information.

From this point of view, we can say that proximity to all weather roads is the major factor that affects farmers' adoption of new technology, and thus it is difficult for farmers who live far from all-weather roads to transport different inputs or new technology easily. Hence, the data shows that significant difference was observed between adopters and non-adopters at 1% significant level (table 7).

Table7. Distribution of sample respondent on distance from all-weather roads of households head

Distance from main road in km	Adopter		Non-adopter		Total sample		T-value
	N	%	N	%	N	%	
From 1-3	65	79.4	7	13.46	72	60	
4-5	2	2.9	29	55.8	31	25.8	
6-7	1	1.5	16	30.7	17	14.2	
mean	2.06		5.06		3.56		-12.973

Source: own survey result, 2010

Distribution of Sample Respondents in Terms of Sex of the Household

The total sample respondents of the distribution interims of sex of household of heads indicates that 70.8% are male headed and 29.2% female headed. These respondents were included in the interview. From the total respondents, 72(60 %) were adopters and 48(40%) are non-adopters (table 8). As the data shows or indicates from the adopters sample respondents, 80.6% were male and 19.4%, female respondents. Therefore, this study reveals that male farmers are more adopters than female farmers. This can be reasoned out that male household heads would have better strength and access to agricultural information regarding the new technologies as compared to female household heads. Most agricultural input decisions in Ethiopia are influenced by decision of the male household heads because they tend to use new technology or adopt new technology to increase productivity and production. Even though the number of male adopters are higher numerically, the data revealsthat the sex of household shows that nosignificant difference was observed between adopters and non-adopters.

Table8- Distribution of sample respondent's interims of Sex of the Household

Sex of household	Adopter		Non-adopter		Total sample		X^2-value
	F	%	F	%	F	%	8.235
Male	58	80.6.	27	56.25	85	70.8	
Female	14	19.4	21	43.75	35	29.2	
Total	72	100	48	100	120	100	

Source: own survey result, 2010

Distribution of Sample Respondent's in Terms of Farm Size of the Household

According to the result shown on the (table 9), distance from the all-weather road had an impact on adoption of bio-fertilizer technology. From the total respondent 75(62.5%) were adopters and 45(37.5%) were non-adopter with average mean 2.75, 1.42 and standard deviation of 1.2, 0.74 respectively. Hence, the farm size increases the number of adoption the technology has become increase. The data also indicated that 97% of the farmers have farm size of greater than 2ha adopted the technology while only 3% of the farmers accepted the technology from those respondents having farm size of range of 0.25-1ha (table 9). From this we can understand that farmers who have large farm size adopt the technology. Even though, the data showed difference in numerically there was no significant difference between adopters and non-adopters (table 9).

Table9 Distribution of Sample Respondent's Interims of Farm Size of the Household

Farm size of household	Adopter		Non-adopter		Total sample		T-value
	N	%	N	%	N	%	9.53
From 0.25-1	5	12.2	36	87.8	41	34.1	
From 1.1-2	6	40	9	60	15	12.5	
>2.1	64	97	2	3	66	55	

Source: own survey result, 2010

Distribution of Sample Respondent's in Terms of Family Size of the Household

According to the result shown on the (table 10), from the total respondents, 72(60%) were adopters and 48(40%) were non-adopters. Hence,when the family size increases, the number of adoption of the technology decreases. The data also indicates that 95% of the farmerswho adopted the technology have family size in the range of 1-3 persons, while only 5% of the farmers who are non-adopter of the technology have family size of 1-3persons (table 10). From this we can understand that farmers who have few family sizes adopt the technology. Even though, the data shows difference in numerically, there was no significant difference between adopters and non-adopters (table 10).

Table10 Distribution of Sample Respondent's Interims of family size of the Household

Family size of household	Adopter		Non-adopter		Total sample		T-value
	N	%	N	%	N	%	8.12
From 1-3	57	95	3	5	60	50	
From 4-6	13	33	26	66.7	39	32.5	
>7	2	9.5	19	90.5	21	17.5	

Source: own survey result, 2010

Distribution of Sample Respondent's in Terms of Investment Cost of the Household

According to the result shown on (table 11), investment cost has an impact on adoption of bio-fertilizer technology. From the total respondents 73(60.8%) were adopters and 47(39.2%) were non-adopters. Hence, when investment cost increases, the number of adopting the technology decreases. The data also indicates that 42.5% of the farmers said that bio fertilizersdemand high investment cost, while 57.5% said that bio fertilizers have low investment cost (table 11). Even though, the data showsdifference numerically, there was no significant difference between adopters and non-adopters (table 11).

Table11 Distribution of Sample Respondent's Interims of Investment Cost of the Household

Family size of household	Adopter		Non-adopter		Total sample		X^2-value
	N	%	N	%	N	%	11.23
High	19	37.25	32	62.7	51	42.5	
Low	54	78.3	15	21.7	69	57.5	

Institutional Characteristics

Distribution of Sample Respondent in Terms of Contact with Extension Service

Extension service is the main methods /technique of agricultural transformation for Ethiopian agriculture. Currently in Ethiopia there are 3 DAs in each kebele who are educating farmers in three departments i.e. crop, animal and soil science. Hence to increase the production in agricultural sector, extension agents (DAs) takethe majorshare. Usually the DAs educate farmers through training, demonstration, etc. by living near the farmers' residence. During data collecting, almost all farmers have contact with extension agents during cropping season.According to the differencein the frequency of contact per month, this study reveals that 70% were adopters and30% were non-adopters with mean and standard deviation of 2.68 and 1.31 mean, and 0.73, 0.69 of standard deviation, respectively. Farmers'contact with the extension agent 1, 2 and 3 times per month covers 13.1%, 1.2% and 85.7% by adopters and 77.8%, 5.5% and 16.7% by non-adopter farmers, respectively(table 12).The T-test of frequency of extension contact distribution between the two groups was run and the difference was found to be insignificant (T=10.45).

Table12. Distribution of Sample Respondents' in Term's Contact of Extension Service

Contact of extension service	Adopter		Non-adopter		Total sample	
	F	%	F	%	F	%
	84	70	36	30	120	100

Source: own survey result, 2010

Table13. Distribution of frequency of extension service in sample respondents

Frequency of contact forextension service	Adopter		Non-adopter		Total sample		T-value
	N	%	N	%	N	%	
1 Per month	11	13.1	28	77.8	39	32.5	10.45
2 Per month	1	1.2	2	5.5	4	2.5	
3 Per month	72	85.7	6	16.7	78	54.1	
Mean	2.68		1.31		1.995		

Source: own survey result, 2010

Distribution of Sample Respondents in Terms of Access to Credit Facility

Credit is an important institutional service to farmers for input purchase and ultimately to adopt new technology. However, some farmers have access to credit while others may not have due to different problems related to repayment. In this respect, the survey result shows that 64(88.9%) of the adopters, and 8(16.7%) of the non-adopters had access to credit service from different institutions in 2009/2010 cropping season (table-14). This implies that adopters had better access to credit compared to non-adopters. Out of the 48 non-adopters, 40(89%) of them had no access to credit, while out of 72 adopters only 8(11%) had no access to credit. From this it can be concluded that access to credit helps farmers to adopt new technology. This was statistically significant at 1% level of significance ($\chi2$=62.593) (Table14).

According to the result shown in the (table 14) below, the sources ofcredit input, 72.5% got credit from cooperatives, 21.7% from NGO and 5.8% from GTZ.

Table14 - Distribution of Sample Respondents in Terms of Access toCredit Facility

Access to credit service			Adopter		Non –adopter		X^2
	F	%	F	%	F	%	62.593
Access to credit	72	60	64	88.9	8	16.7	
No- access to credit	48	40	8	11.1	40	83.3	
Credit source							
NGO	15	21.7	15	23.4	0	0	
cooperatives	50	72.5	45	70.3	5	100	
GTZ	4	5.8	4	6.3	0	0	

Source: own survey result, 2010

Distribution of Sample Respondents in Terms of Access to Information

The result presented on (table 15) is highly significant and shows that out of 120 total respondents, 77(64.2%) of them had access to the information, while 43(35.8%) of them had no access. The result also indicates that because of accessto information 70 (97.2%) of them have adopted the technology, while 7(14.6%) of them did not. Out of the 43who had no access, 41(85.4%) of the non-adopters and 2(2.8%) of them adopted the technology. Hence, it is clearly shown on the table that those farmers who had access to the information had adopted the technology more than those who had no access to information. This was statistically significant at 1% level of significance (χ2=85.539) (Table 15).

Table15. Distribution of sample respondents' interims of access to information

Access to information			Adopter		Non –adopter		X^2
	F	%	F	%	F	%	
Access to information	77	64.2	70	97.2	7	14.6	
No- access to information	43	35.8	2	2.8	41	85.4	
Total	120	100	72	100	48	100	85.539

Source: own survey result, 2010

Distribution of Sample Respondents Reasons why Non-adoptersDo not Use Bio-fertilizer

Reasons not use bio-fertilizer	Numbers respondents/frequency	Percent of respondents
Lack of fertilizer supplier	15	31.25
Lack of awareness about bio- fertilizer	33	67.75

Source: own survey result, 2010

Farmers gave many reasons why they did not use bio-fertilizer. From the reasons that farmers raised 15(31.25%) lack of fertilizer supplier, and 33(67.75%) lack of awareness about bio- fertilizer,as shown below on(table16).

Econometric Results and Discussion of Factors Influencing Adoption of Bio-fertilizer

Model Diagnostics Test Result

Test for Multicollinearity

In order to identify variables thatdetermine the determinant variables on farmers' adoption of bio-fertilizer, the binary logistic regression econometric model was estimated using maximum likelihood estimation technique. Prior to the analysis of the data, it was found important to look into the problem of multicollinearity or linear association among the hypothesized explanatory variables. Variance inflation factors (VIF) were used to check the multicollinearity problem in continuous variables and, similarly, contingency coefficient was used for dummy variables. Thus, the value of VIF is less than 10.

Test of Hetroscedasticicity

Hetroscedasticicity occurs when variance of the error varies across the observation. It can be tested using Breusch-Pagan /Cooke-Weisberg test. The STATA test shows the variance of error is not constant. Hence, there is hetroscedasticicity. Thus, it was necessary to take remedies ofvariables that have showed high degree of hetroscedasticicity. Among these remedy systems is dropping one or more of the variables. But hetroscedasticicity problem was not removed. After these trials, robust remedies method of hetroscedasticicity correction was used. So, the hetroscedasticicity problem was solved (annex 3).

Goodness of Fit the Model

Finally the total of nine independent variables out of which five continuous and four discrete variables were entered into binary logistic regression model analysis to determine the best subset of independent variables that are predictors of the dependent variable. Hence, (table 17) shows that education level, use of credit service, access to information of the household and road distance were variables and should be considered significant. The result indicates that the model chi-square value, the parameters included in the model taken, were significantly different between zero and 1 percent level of significance. Thus, the model predicted both adopters and non-adopters groups of bio-fertilizer accurately. The value of **Pseudo R^2=84.02** indicates also the goodness of fitted model. The result is significant at less than 1% probability level indicating that the hypothesis that the coefficients (βs) except the interpretation is equal to zero. Thus the null hypothesis is not tenable. Likewise the log likelihood value (-12.82) was significant at 1% level of significant (Table17).

Table17:-Result of maximum likelihood estimate binary logit model (n =120)

BIOF | odd ration	Coef.	Std. Err.	Wald value	P-value|
ACFAC | 96.66643	4.571266	1.629216	7.87	0.005***
FES | 1.314798	.273683	.7365108	0.138	0.710
ELHH | 2.7309638	.3133914	.1623839	3.72	0.054*
SHH | 0.2022172	-1.598413	1.33557	1.43	0.231
DMAINR | 0.4732617	-.7481063	.3507954	0.2	0.033**
AINFO | 88.65429	6.78733	2.141253	10.05	0.002***
IC | 0.966047	-.9616033	1.022694	1.13	0.347

FAMS |	.386097	.2816093	0.54	0.891	1.5905538
FSIZ |	.4255425	. 7442057	3.06	0.567	1.884159
_cons |	-1.46582	2.298122	0.41	0.524	0.2308887

LR chi2 (6)   134.85 (0.0000)

Pseudo R2   =   0.8402

Over all model predication = 81.91

Over all prediction of adopters = 91%

Over all prediction of non-adopters = 83%

Note: ***, **, * significant level at 1%, 5% and 10% probability level, respectively.

Source: own compositional result, 2010

Significant Variables of Determinants of Bio-fertilizer Adoption

The main use of maximum likelihood was estimating the parameters of the variables that are expected to determine the adoption of bio-fertilizer (Table 17). Hence, 5 continuous and 4 discrete variables were entered. From the total of nine independent variables, 2 of the continuous and2 from the dummy variables were found to be significantly influencing adoption of bio fertilizer. Variables found to be significant included: access to credit (ACFAC) which was found to be significant at 1%, education level household head (ELHH) which was found to be significant at 10%, and distance from household residence to main road (DMAINR) which was found to be significant at 5%, and access to information (AINFO) which was found to be significant at 1% probability level (Table 17). With the above brief background, the influence of the significant independent variables on the adoption of bio-fertilizer was explained below.

Distance of farmer's residence from all-weather roads (DMAINR):- As the distance between household’s home and road increases by 1.0 km, the probability of adoption of bio-fertilizer declines by the odds ratio of 96.7 at 5% significance level. Thus this variable is found to affect the adoption of bio-fertilizer negatively.The possible explanation is that less distance of all-weather roads from farmers’ residence adds the tendency to increase adoption or use of bio-fertilizer. The proximity of road can reflect access to get inputs and information easily and quickly.The odd ratio for this variable indicated that a one kilo meter increase of road distance from farmers’ residence decreases the adoption level of bio-fertilizer by 0.473 (47.3 %), assuming all other factors kept constant. This result also agrees with the finding of Wolday (1999) who conducted a study to understand the major factors which dictate the use of improved seeds in Ethiopia and reported that infrastructure developments are the principal negatively determinants of the adoption of improved seed. Hence, in this study it can be concluded that the odd ratio in service of adopting bio-fertilizer increases with decrease to proximity ofthe all-weather roads to farmer’s residence.

Education level of the sample respondent (ELHH):-The result revealed that formal educational qualification of the household head had positive and significant influence on the probability of farmers’ adoption of bio-fertilizer at 10% significant level. The reason is that this can change the outlook of farmers to willinglyaccept newly introduced technology. The odd ration for this variable indicated that a one-year schooling (a one grade) increase in education level of farmers also increases the adoption level of bio-fertilizer by 0.73 (73 %), assuming all other factors kept constant. This result is in agreement with the finding of Nkonya et al (1997), H.B. Bodake (2009), Admassie and Ayele (2004), Beshire et al (2012) and Kebede, et al (1990), who observed that educated farmers can get information and their ability to secure the necessary information to have the desired objectives. This indicates that more educated farmers are more likely to enhance the ability to analyze, and use relevantinformationfor newly innovative technology. The result of education on these study farmers who had higher education level has higher adoption level than low educated farmers.

Access to credit services of the sampled respondents (ACFAC): the result revealed that formal access to credit service of the household head had positive and significant influence on the probability of farmers' adoption of bio-fertilizer at 1% significant level. The reason is that access to and use of credit services from formal organizations have more probability to accept and use new technology than not accessaccess from these. The odd ratio for this variable indicated that unit increase of credit service increases the possibility to adopt bio-fertilizer by .666 (66.7 %), assuming all other factors kept constant. This result is in agreement with the finding of Sarup and vesisht (1994),Green Ng'ong'ola (1993) , TeressaandHeidhues (1996) and Asfaw et al (1997),who indicated that the lack of access and use of credit services significantly help to incorporate newly innovation technology to improve production. The need of institution support to farmers that can access credit in financial servicesenhanced adoption of bio-fertilizer in the study area.

Access to information services of the sampled respondents (AINFO): According to the result reveals that access to information about every new technology that increase production of the household head has positive and significant influence on the probability of farmers' adoption of bio-fertilizer at 1% significant level. The reason is that access and getting of information services from different NGOs, extension agents, agricultural experts and through different communication media have more probability to accept and use new technology than absent of access. The odd ratio for this variable indicates that increase of availability of information service increases the possibility to adopt bio-fertilizer by .542 (54.2 %), assuming all other factors kept constant. This result is in line with the finding of Admassie and Ayele (2004), Beshire et al (2012) and Kebede ,et al (1990), Beshire, et al (2012), Feder et al (1985) and NilabiaGhosa (2007),who indicated that the farmer getting information services significantly enhances the adoption of innovative technology for improved production. The need of institutional support for farmers who can access information is vitaltoadopt bio-fertilizer in the study area.

Conclusion and Recommendation

Conclusion

This study tried to identify determinant factors that affectthe adoption of bio-fertilizer technology by smallholder farmers in TiyoWoreda,EastArsi Zone. It investigated the determinants for the adoption bio-fertilizers by comparing the users and non-users of this fertilizer, and identified various factors associated with adoption of bio-fertilizer.

The descriptive statistics analysis to the socio-economic factors revealed that the adopters of bio-fertilizer increase by male household heads. Moreover, the frequency contact of extension agent was more with adopters than non-adopters of bio-fertilizer. The result of the study revealed that adopters of bio-fertilizer have relatively more access to information than non-adopters.

A totals of nine explanatory variables were included into the model of which four of them had shown statistically significant influence on adoption determinantsfor bio-fertilizer at significant level. Therefore, access to credit, access to information, and education level were found to be positive and significant determinantsforthe adoption of bio-fertilizer at 1%, 1% and 10% level, respectively. Contrary to this, distance from all-weather roads was shown as negative and significant determinant for the adoption of bio-fertilizer at 5%. On the other hand, farm size, investment income, family size, frequency contact of farmers with extension agents, and sex of household head had no significant influence on determining bio-fertilizer adoption by smallholder farmers. Hence, this might show no statistically significant difference between adopters and non-adopters of these variables.

Therefore, from this finding it is concluded that increasing the facility of credit service, designing farmer training center program, construction of roads to access information to the farmers in order to improve the adoption of bio-fertilizer in smallholder farmers.

Recommendations

The study revealed that farmers' access to information about bio-fertilizer had positively and significantly affected the adoption of bio-fertilizers.

Farmers’ information on bio-fertilizer isan important factorto spread the technology. Hence, further work is required to access information to farmers who live far from farmer training centers, DAs residence and the media.

This study revealed that distance of farmer residence from all-weather roadsis negatively significant on adoption decision of bio-fertilizer. This is similar with the report of various studies that revealed access to all weather road is very important in the adoption of newly introduced technology. Hence, construction of roads in the locality to connect to the main road should be given proper attention to improve adoption of bio-fertilizers.

This study also revealed that availability of credit service is positively significant on adoption decision of bio-fertilizer for smallholder farmers. Hence, credit service should get attention to enhance the participation. Therefore, increasing the facility of credit service is recommended to adopt technology for increased production.

Moreover, the study revealed that literacy hadinfluenced farmers' adoption decision of bio-fertilizer positively and significantly. Therefore, in order to solve illiteracy and educate smallholder farmers in rural areas, farmer training centers should design training programs on agricultural developmental activities based on training assessment.

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