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Adoption determinants of row planting for wheat production in Munesa District of Oromia Region, Ethiopia

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Agriculture takes the lion's share in the economic development of many developing countries, including Ethiopia. Agricultural policy of the years has focused on supporting the introduction of improved technologies to boost production and reduce food insecurity. However, outcomes of such agricultural policies have been influenced by different factors of which low adoption of improved agricultural technology is a major constraint. The objective of this study was therefore, to analyze the determinants of adoption and intensity of use of row planting for wheat production. Data were obtained from both primary and secondary sources. Multi-stage sampling technique was used to select 140 wheat producer household heads from the Munesa district of Oromia region, Ethiopia. Data were collected through the administration of semi-structured questionnaires. Data were analyzed using both descriptive statistics and the Tobit econometric model. Descriptive result shows that, from 140 sampled households 97 are adopters of wheat row planting while the remaining are non-adopters. The model was used in estimating the determinants of adoption and intensity of use of row planting for wheat production. The model results revealed that education level, labor availability, extension contact, credit use, participation in training and access to improved seed had positively and significantly influenced adoption and intensity of use of row planting for wheat production. Based on the results of this study, it can be concluded that, policy and development interventions should focus on improving economic and institutional support system for high rates of adoption and intensity leading to improved productivity and income among smallholder farmers.

Key words: Adoption, row planting, Tobit model, Munesa, wheat.

INTRODUCTION

Reducing poverty in developing countries like Ethiopia depends on the growth and development of the agricultural

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sector (World Bank, 2008). Wheat is a strategic food security crop grown for food and cash by smallholder farmers in Ethiopia and occupies about 17% of the total cereal crop area (Central Statistical Agency of Ethiopia, 2013).

The demand for the crop has been on the increase due to rapid population growth, urbanization and upsurge of food processing industries (Dorosh and Rashid, 2013). The country produces 75% and imports 25% to make up for the shortfall(Global Agricultural Information Network, 2014).The country is thus unable to meet the high demand and remains a net importer despite the potential to increase production (Rashid, 2010). According to Ethiopian Ministry of Agriculture, farm level productivity is 2.1 t/ha using traditional broadcasting while potential yield stands at 2.45t/ha (MoA, 2012). Farm productivity in 2012, was 29, 13 and 32% below that of Kenya, African as a continent and world at large, respectively (Food and Agricultural Organization, 2014b). The research systems together with other stakeholders have played a major role in delivering improved technologies for increasing productivity in the country (Biftu et al., 2016). Efforts have also being underway by the national agricultural research system through which a number of technologies have been released for the farming community. In spite of these efforts, a productivity gain has not been impressive. One major factor contributing to low productivity in the country is the low adoption rate of improved technologies (Hassen et al., 2012; Ahmed et al., 2014). Among these is the low adoption of row planting despite its ability to contribute to high yields (Joachim et al., 2013).

Recent studies in Ethiopia have shown that yields are very responsive to row planting for wheat production. Tolosa et al. (2014) reported average yield of 2.8t/ha (19.7%) in the highland areas using row planting which is above national average yield of 2.45t/ha in the country. Vandercasteelen et al. (2014) also found an increase in *teff* yields between 12 and 13% in farmers' experimental plots and 22% in demonstration plots managed by extension agents by using row planting.

In addition, in the United States, planting wheat in wide rows in combination with inter-row cultivation reduced weed density by 62% and increased yield by 16% (Lauren et al., 2012). Furthermore, according to the Ministry of Agriculture and Rural Development (MoARD, 2012) row planting on average increases production by 30% and reduces the amount of seed consumption to one-fifth of existing seed use. Despite the advantages of row planting, it is not widely accepted in the study area. Studies on adoption of row planting are scanty and less focused on intensity. The main objective of this study was therefore to estimate and evaluate determinants of adoption and intensity of use of row planting for wheat production among smallholder farmers. This is expected to provide information to stakeholders in their quest to formulate policies and programs to upscale row planting for sustainable crop production.

MATERIALS AND METHODS

Description of the study area

This study was conducted in the Munesa district located in the East Arsi zone of Oromia region, Ethiopia. The district is situated at latitudes 7°12' to 45 N and longitude 52° to 39°03'E in central Ethiopia. Munesa is located at 57 km away from the southern part of zonal town called Asella and 232 km south west of Addis Ababa. The total land area covered by the district is 1031 km^2 and altitude of the area ranges from 2080-3700 m.a.s.l and characterized by mid sub-tropical temperature ranging from 5 to20°C. Munesa is organized into 32 rural kebeles and 3 rural towns with a total population of 211,762 (MDAO, 2015). Crop-livestock integration is the dominant farming system within the district. Major cereal crops cultivated include; wheat, barley, and maize. Among cereal crop produced, the district is well known by wheat production. Major livestock reared in the district include cattle, sheep, goats and hoarse (Figure 1).

Sampling techniques and sample size determination

Respondents for this study were sampled using the multi-stage sampling technique. In the first stage, major wheat producing districts was purposively selected. The selected districts were Munesa district. The main reason for purposive selection was due to its high potential for wheat production, and introduction and application of row planting level of wheat production. There are also strong research and extension intervention programs embracing wheat producers in the district. Moreover, newly released improved wheat varieties and wheat row planting practices were relatively more disseminated and practiced in this district. Hence, it was plausible to assess the adoption intensity of wheat row planting in the district. In the second stage, of the probability sampling, a list of major wheat growing lower administrative divisions (kebeles) within the selected district was prepared. Taking in to account the resources available, four kebeles were selected from the district, based on their high potential in wheat production and wheat row planting practice compared to the remaining kebeles of the district. In the third and final stage, a list of wheat farmers was prepared for each selected kebele. Sample farmers were selected by simple random sampling technique. The sample size was determined based on the formula given by Yamane (1967), and allocation of sample size to each kebele was made proportionate to the size of farm household heads population of each kebele.

$$n = \frac{\mathrm{N}}{1 + \mathrm{N}(e)^2}$$

Where n is the sample size, N is the population size (total households in the four kebeles which is 1,880) and e is the level of precision. After calculating by formula, 140 households were selected. See proportion of sample respondent from each sample kebele (Table 1). Accordingly, from a total of randomly selected 140-sample size, 43 were non-participant farmers and 97 were participant farmers in row planting of wheat in 2016/2017 cropping season.

Data collection methods

Primary and secondary data were collected for the study using both formal and informal methods. For the primary data, a household level survey was conducted between Nov 2016–Jun 2017 using semi-structured questionnaire. Prior to the field data collection,

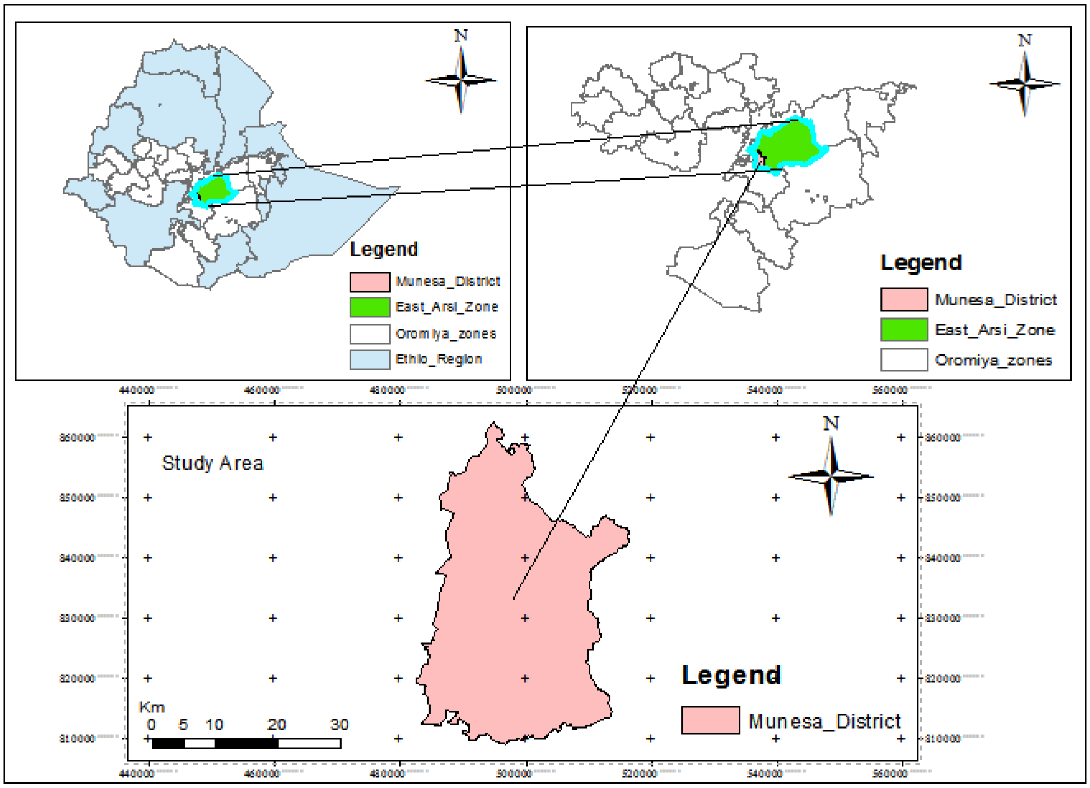

Figure 1. Map of the study area.
Source: Author, 2016.

Table 1. Number of respondents in each selected kebeles and selected respondents.

Name of Kebeles	Total number of households	Sample household
Didibe Yadola	439	33
Oda Lenca	520	39
Garambota Lole	513	38
Shumbulo	410	30
Total	1,880	140

Source: own computation, 2016/2017 from Munesa district administration office.

testing was done to validate the data collection tool. The semi-structured questionnaire was used to collect data on household demographic, socio-economic structure, institutional factors and production activities. Besides, a checklist was prepared and used for group discussion and key informants with wheat grower farmers and purposively selected knowledgeable respondents regarding wheat row planting to elicit data that cannot be collected from individual respondents, respectively. Secondary data were also collected from relevant governmental and non-governmental offices, published and unpolished sources to consolidate the primary data.

Method of data analysis

In order to achieve the stated objectives of the study, the survey data were sorted out, edited, coded, organized, summarized and analyzed using descriptive and Tobit model using STATA version 13. Descriptive statistical tools such as mean, standard deviation, frequency, and percentage were applied to describe the characteristics of the respondents. Results are presented in the form of tables. Test of hypothesis was done using Chi-square test and F- test. In the econometric part, Tobit model was used to identify the determinants of adoption and intensity of use of row planting for wheat production.

Econometric estimation of adoption and intensity of use of row planting

The adoption and intensity of use of wheat row planting was estimated based on the approach by Roger (1962) and Feder et al. (1985) using the Tobit model. The Tobit model was used since the proportion of area under row planting had a censored distribution. The use of linear programming models, logistics and probit models were therefore inappropriate (Tobin, 1958). Solomon et al. (2011)

viewed that the decision to adopt and intensity of use are assumed to be made jointly and factors affecting them are assumed to be the same. These were the basis for the use of the Tobit model instead of other adoption models. Following Johnston and Dinardo (1997), the Tobit model was specified as:

$$AIi^*=B_O + B_iX_i+U_i, \text{ where } i=1, 2\ldots\ldots\ldots\ldots n$$

$$AI = AIi^*, \text{ if } AIi^*>0$$

$$=0 \text{ if } AIi^* \leq 0 \quad (1)$$

Where,

AI_i = adoption intensity of wheat row planting of i^{th} farmer measured by dividing area under wheat row planting for total area allocated for wheat production.
AI* = the latent variable and the solution to utility maximization problem of intensity of adoption subject to a set of constraints per household and conditional on being above a certain limit,
X_i= Vector of factors affecting adoption and intensity of use of wheat row planting,
B_i= Vector of unknown parameters, and
U_i= is the error term normally distributed with mean 0 and varianceσ^2.
Equation (1) represents a censored distribution of intensity of adoption since the value of AI for all non-adopters equals zero. According to Maddala (1992), the model parameters of a censored distribution are estimated by maximizing the Tobit likelihood function of the following form:

$$L = \prod_{AIi>0} \frac{1}{\sigma} f\left(\frac{AIi - \beta Xi}{\sigma}\right) \prod_{AIi\leq 0} F\left(\frac{-\beta iXi}{\sigma}\right)$$

(2)

Where, *f* and F are respectively the density function and cumulative distribution function AIi^*. $\prod_{AIi\leq 0}$ Means the product over those i for which $AIi^* \leq 0$, and $\prod_{AIi>0}$ means the product over those i for which$AIi^* > 0$.

Coefficients of a Tobit model do not directly represent the marginal effects of the associated independent variables on the dependent variable. However, their signs show the direction of change in probability of adoption and the marginal intensity of adoption as the respective explanatory variable changes. It is therefore not appropriate to interpret the coefficients of a Tobit model in the same way that of uncensored linear model (Johnston and Dandiro, 1997). To interpret the coefficients as marginal effect, derivatives of the model has to be computed. Johnston and Dandiro (1997) proposed the decomposition of explanatory variable effects into adoption and intensity of usage. A change in X_i (explanatory variables) affect the conditional mean of AIi* in the positive part of the distribution and the probability that the observation will fall in that part of the distribution. Marginal effects of explanatory variables for this study were therefore estimated as follows:

1). The marginal effect of an explanatory variable on the expected value of the dependent variable was:

$$\frac{\partial E(AIi)}{\partial Xi} = F(z)\beta i \quad (3)$$

$\frac{\beta iXi}{\sigma}$ is denoted by z, following Maddala (1997).

2). The change in probability of adopting of wheat row planting as independent variable Xi changes is:

$$\frac{\partial F(z)}{\partial Xi} = f(z)\frac{\beta i}{\sigma} \quad (4)$$

3). The change in the intensity of use of wheat row planting with respect to a change in an explanatory variable among user is:

$$\frac{\partial E(^{AIi}/_{AIi^*>0})}{\partial Xi} = \beta i\left[1 - Z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^2\right] \quad (5)$$

Where: F (z) is the cumulative normal distribution of Z,
f(z) is the value of the derivative of the normal curve at a given point (that is, unit normal density),
Z is the Z score for the area under normal curve,
β is a vector of Tobit maximum likelihood estimates and
∂ is the standard error of the error term.

Prior to the econometric model estimation, multicollinearity was tested using the Variance Inflation Factor (VIF) and Contingency Coefficient (CC), simultaneously.VIF for continuous explanatory variables (Xi) were estimated such that:

$$VIF = \frac{1}{1-R^2} \quad (6)$$

Where, R^2 is the coefficient of correlation among explanatory variable. Variables with VIF exceeding 10 were deem to be highly collinear (Gujarati, 2004). Dummy variables with CC values greater than 0.75 were deem to be collinear (Healy, 1984). CC was specified as:

$$CC = \sqrt{\frac{x2}{n+x2}} \quad (7)$$

Where n= sample size and x^2= chi-square value.

Estimation of adoption index

The adoption index was used to measure the level of adoption under row planting for each sample households at the time of the survey. The adoption index score was calculated by dividing area allocated for wheat production using row planting to total cultivated area for wheat production by the i^{th} farmer. The rational for calculating the adoption index was to know the level of adoption of row planting for wheat production in the study area following the work of Alemitu (2011), Abreham and Tewodros (2014), and Rahmeto (2007). The adoption index for each respondent farmer was calculated as:

$$AI_i = \frac{\text{Area under wheat row planting technology (AWi)}}{\text{Total area allocated for wheat production (ATi)}}$$

Where: AI_i is adoption index of the i^{th} farmer, and i represent respondents (farmers).

Once the AI scores was calculated, respondents were classified into non- adopter, low, medium and high adopter depending on their AI value. The actual adoption index score ranges from 0 to 1. Adoption index score of zero point implies non-adoption of the row planting for wheat production and greater than zero (>0 and ≤ 1) implies adopters with three category; namely low adopters, medium adopters and high adopters. The mean adoption index scores of non-adopters, low, medium and high adopters groups were 0.00, 0.20, 0.48 and 0.85, respectively (Table 2).

Table 2. Summary of variables and their expected signs.

S/N	Dependant variable	Description	
	Area under row planting	**Non-negative continuous variable**	
	Independent variable	**Description**	**Expected sign**
1.	Age of household head	Continuous variable measured by years	-
2.	Sex of household head	Dummy variable (1=Female, 0 =Male)	+
3.	Education	Education level of household head (years of schooling)	+
4.	Farm size	Continues variable measured in hectare	+
5.	Labor availability	Continuous variable measured by ME	+
6.	Access to improved seed	Dummy variable (1, if available, 0 otherwise)	+
7.	Extension contact	Continuous variable measured by number	+
8.	Access to credit	Dummy variable(1, users, 0 otherwise)	+
9.	Participation in row planting training	Continuous variable measured by number	+
10.	Perception on row planting	Dummy variable (1, if perceived as superior, 0 otherwise)	+
11.	Membership to social association/group	Dummy variable (1, if membership, 0 otherwise)	+

RESULTS AND DISCUSSION

Here, presents findings and discussions on row planting adoption rate, and intensity. It also looks at socio-economic, demographic and institutional determinants of wheat farmers in the study area.

Status of adoption and intensity of use of wheat row planting technology

In this study, farmers who did not grow wheat through row planting were considered as non adopters and while the farmers who grow wheat with row planting were taken as adopters. The adoption index of sample households indicated that 43 of the sample respondents (30.7%) had adoption index score of 0, which shows they are non adopters, 26 respondents (18.6%) had adoption index ranging from 0.01 to 0.33. This indicates low adopters, while 40 respondents (28.6%) had adoption index score stretching from 0.34 to 0.66 indicating medium adopters, and 31 respondents (22.1%) had adoption index score ranging from 0.67 to 1.00, which show high level of adoption (Table 3). The difference in area coverage under wheat row planting may be attributed to varying land holding and stage of an individual in the adoption process. One way analysis of variance revealed the existence of significant mean difference (F=628.19, P=0.000) among the adoption index score of the four adoption categories at 1% significance level, implying the existence of variation in level of adoption among sample households.

Descriptive results

As observed in the Table 4, the mean age of the non-adopter sample respondents were about 45.88 years, while the mean age of low, medium and high adopter categories were 42.88, 43.6, and 39.61, respectively. The mean test using one-way ANOVA show the significant mean difference at 10% probability level among adoption categories. The mean labor availability of the sample households measured in Man Equivalent (ME) was 3.41. The mean of sample household contact with extension agents and participate in training regarding wheat row planting was 5.72 and 2.41, respectively in survey year. The mean test of analysis of variance (ANOVA) also shows the significant mean difference among adoption categories of wheat row planting interims of labor availability, extension contacts and frequency of participation in training at 1% probability level. The average size of land owned by the sample respondents were 4.27 ha.

As indicated in Table 5, the descriptive analysis indicated that (121)86.43% of the sample households are male and the rest (19)13.57% are women, who are single, widowed or divorced. Among the respondents, 33.57% (47) of them were obtained and used the credit from different sources and the remaining 66.43% (93) have not received and used the credit. The Chi-square test ($\chi 2$=2.944, P=0.400; and $\chi 2$=1.622, P=0.654) revealed that there is no significant difference between sex of household head and credit uses with respect to adoption categories of wheat row planting in the study area. Out of 140 sample respondents, 45.71%(64) were reported availability of improved wheat seed on time with required quantity and the remaining 54.29%(76)of farmers were reported unavailability of improved wheat seed on time with required quantity during production period. And also, 92.86% (130) of sample respondents had participated in social group while 7.14 %(10) did not participate in social group/ association. The result of chi-square test ($\chi 2$=22.791, P=0.000; and $\chi 2$=8.734 and

Table 3. Distribution of sample respondents by level of adoption of wheat row planting technology.

Adopter category	N	%	Adoption index(AI)	Mean of AI	STD	Min	Max
Non-adopt	43	30.7	0.00	0.000	0.0	0.00	0.00
Low	26	18.6	0.01-0.33	0.200	0.07	0.05	0.33
Medium	40	28.6	0.34-0.66	0.480	0.05	0.34	0.63
High	31	22.1	0.67-1.00	0.850	0.17	0.67	1.00
Total	140	100%	0.00-1.00	0.360	0.33	0.00	1.00
F-value			628.19***				

Source: Own survey data (2017); *** indicates at 1% significant mean difference.

Table 4. Characteristics of wheat grower farmers by adoption levels of wheat row planting: Continuous variables.

	Adopter category					
	Non	Low	Medium	High	Total	F-value
AGE EDUCL	45.88	42.88	43.6	39.61	43.29	2.32*
LABOUR	2.55	3.68	3.65	4.05	3.41	15.946***
LANDSIZE	4.64	3.93	4.13	4.23	4.27	1.209(NS)
EXTENCONT	4.65	6.31	5.93	6.45	5.72	4.706***
TRAINING	0.51	2.81	3.33	3.52	2.41	45.97***

Source: Field Survey (2017); NS= indicate non-significant mean difference; and ***, *****indicates the mean difference is significant at 5% and 1% level, respectively.

Table 5. Characteristics of wheat grower farmers by adoption levels of wheat row planting: Dummy variables.

Variable		Adoption categories					
		Non	Low	Medium	High	Total	
		%	%	%	%	%	χ2- value
SEX	Male	(39)32.2	(23)19	(35)28.9	(24)19.83	(121)86.43	2.944(NS)
	Female	(4)21.1	(3)15.8	(5)26.3	(7) 36.84	(19) 13.57	
CREDTUSE	No	(14)31.2	(11)16.1	(11)31.2	(11)21.51	(47)66.43	1.622(NS)
	Yes	(29)29.8	(15)23.4	(29)23.4	(20)23.40	(93)33.57	
SOCIALPART	No	(7)70	(0)0.0	(1)10	(2)20	(10)7.14	8.734**
	Yes	(36)27.7	(26)20	(29)30	(29)22.3	(130)92.9	
ACCIMPSEED	No	(36)47.4	(9)11.8	(16)21.1	(15)19.74	(76)54.29	22.791***
	Yes	(7)10.9	(17)26.6	(24)37.5	(16)25.00	(64)45.71	

Source: Field survey (2017); NS=indicate non-significant mean difference; and **, ***indicates the mean difference is significant at 5 and 1% level, respectively.

P=0.033) also shows statistically significant difference between adoption categories of wheat row planting with respect to availability of improved wheat seed and participation in social group/association in the study area.

Econometric results

Tobit econometric model was used to analyze factor affecting adoption and intensity of use of row planting on wheat production. The model was selected based on theoretical background and review literature on related studies and previous justification point up in methodology part. The R^2 value of 0.6784 implies that the variable included in the model accounted for 67.84% of variation in adopting and intensity of use of wheat row planting. The log likelihood function indicates a Chi-square value of 136.50 significant at 1% significance level. This means the model as a whole fits significantly (P≤0.001). On the

Table 6. Determinants of adoption and intensity of row planting in wheat production.

Variable	Estimated coefficients	Standard error	t-ratio
SEX	-0.017	0.089	-0.19
AGE	-0.003	0.003	-0.91
LABOR	0.098***	0.029	3.35
EDUCT	0.022**	0.01	2.27
LANDSIZE	-0.011	0.018	-1.11
EXTCONT	0.030*	0.016	1.87
CRDITUSE	0.112*	0.061	1.84
PARTSOCIALG	0.085	0.117	0.73
ACCSEED	0.232***	0.076	3.054.00
PARTTRA	0.084***	0.021	-0.94
HHPRPTECH	-0.029	0.031	-1.5
CONST	-0.406	0.271	
Sigma	0.281	0.021	

Note: *, ** and *** represents significance at 10%, 5% and 1% probability levels, respectively.
Log likelihood = -32.35428; Pseudo R2 = 0.6784; Prob > Chi2 = 0.0000;
LRCh2 (15) =136.50
Source: Model output (2017).

other hand, it implies that all explanatory variables included in the model jointly influence the adoption and intensity of use of row planting for wheat production in the study area. The result of maximum likelihood estimates of Tobit model are summarized in Table 6.

Education level of household head (EDUCT)

The result of the Tobit regression model analysis shows that education had positively and significantly influenced the household adoption and intensity of use of row planting for wheat production at 5% probability level of significance. This was because educated household heads understood the importance of row planting and why the needed to adopted it. The high number of farmers who had accessed education could independently make adoption decision with effect on adoption rate and intensity. Leake and Adam (2015) and Abrhaley (2016) also reported the positive influence of farmer's education on agricultural technology adoption. They explained that farmers with higher education level can easily process information and search for appropriate agricultural technologies to alleviate their production constraints.

Labor availability (LABOR)

Labor availability was measured in Man equivalent. The availability of economically active labor force in the household is found to be among the most influential variables in the model. It has a positive significant influenced on adoption and intensity of use of row planting for wheat production at 1% significance level. The result indicates that when labor availability increases, the area under row planting also increases. The reason for this positive effect was that row planting was labor intensive and hence its availability could increase area under cultivation. This finding is consistent with findings of Hailu (2008), Motuma et al. (2010), and Leake and Adam (2015). They argued that farmers who have more family labor could supply the required labor for different operations and undertake the agricultural activity in time and effectively manage the wheat fields.

Extension contact (EXTCONT)

As the model result indicates, extension contact had a positive significant effect on adoption and intensity of use of row planting for wheat production at 10% significance level. This implies an increase in the frequency of visits by extension officers during the production will lead to an increase in the size of land for wheat productions using row planting. This result also indicates that, the households who frequently contact with extension agent are more likely to expose to updated information about the importance and application of row planting for wheat production through counseling and field demonstrations on a regular basis. The effect of extension visit for this study is consistent with the findings of Tolosa et al. (2014) which indicate that frequency of extension contact was positively related to adoption of row planting for wheat production.

Credit use (CRDITUSE)

Credit use was one of institutional variable, which was

Table 7. Effect of change in significant explanatory variable on probability of adoption and intensity of use of wheat row planting.

Variable description	Change in probability of adoption	Change in intensity of use	Overall change
EDUCT	0.0209	0.0134	0.0181
LABOR	0.092	0.05890.0181	0.071
EXTCONT	0.0283	0.0672	0.0246
CRDUSES	0.1049	0.1337	0.0912
ACCISEED	0.2347	0.0505	0.1824
PARTTRA	0.0789		0.0686

Source: Model output (2017).

found to have positive and significant influence on the probability of adoption and intensity of use of wheat row planting at 10% significance level. The result is in line with the hypothesis set forth. The probable reason for positive result is that, credit use is one way of improving financial constraints for purchasing different agricultural inputs like improved seed, modern fertilizer, weed chemicals and hiring labor/row planting machine from private owner farmer has to improve labor constraints in the study areas. As a liquidity factor, the more farmers have received and used the credit, the more likely to adopt row planting that could possibly increase their yield. Thus, credit use facilitates the uptake of improved agricultural technologies. The result is consistent with the finding of Simtowe et al. (2016) and Frank et al. (2016) indicated that the availability of credit enables households to pay for external hired labor and other expenses incurred in the process of technology adoption.

Access to improved seed (ACCISEED)

Availability of improved wheat seed at the right time with required quantity has the expected positive and significant influence on adoption and intensity of use of row planting for wheat production at 1% significant level. The positive influence of this variable implies that supplying improved seed at the right time with required quantity increases the farmer's probabilities of being adopter of row planting for wheat production. This is because improved seed gives high yield at harvesting period than old seeds especially when used with row planting. Quite often improved seed are in short supply in the study area and hence adoption becomes a question of timely availability and provision of the enough quantities for farming households. The result is in line with the finding of Tolesa (2014) and Tolesa et al. (2014) which indicated that availability and access to improved wheat seed have a positive effect on adoption of row planting for wheat production.

Participation in training (PARTTRA)

Training is one of the extension events and the means of teaching and learning process where farmers get practical skill and technical information for adoption of new agricultural technologies. As expected, this variable were influenced the probability of adoption and intensity of use of row planting for wheat production positively and significantly at 1% significance level. This may be explained by the fact that farmers who have an opportunity to participate frequently in training regarding row planting given at farmer training center (FTC) and attend training at demonstration site of wheat row planting gain better knowledge and technical skill on the application of row planting. They are therefore more likely to adopt and use the row planting for wheat production than others. The result is agreed with the findings of Beyan (2016), and Alemitu (2011).

Effects of change in significant explanatory variables on adoption and intensity of use of wheat row planting

Not all variables that were found to influence the adoption and intensity of use of wheat row planting might have similar contribution in influencing the decision of farm households. Therefore, change in explanatory variables from a Tobit model could be decomposed in to changes due to probability of adoption and changes due to intensity of use as suggested by McDonald and Moffit (1980). Accordingly, the marginal effect of significant explanatory variables in explaining adoption and intensity of use of wheat row planting are listed in Table 7.

The marginal effect result computed in Table 7, revealed that an intervention ensuring the availability and provision of improved wheat seed to farmers in required quantity and at the right time increases the probability of adoption and increases the intensity of use of wheat row planting by 23.47 and 13.37%. The overall effect of this variable on adoption and intensity of use of wheat row planting was 0.1824. Labor availability was found statistically significant at 1% probability level and positively related with adoption and intensity of use of wheat row planting. The model result revealed that, a unit increase in man equivalent increases the probability of change on adoption and intensity of use of wheat row planting by 9.20 and 5.89%, respectively. Moreover, the overall effects of a unit increase in man equivalent on adoption and intensity of use of wheat row planting was 0.071.

Credit uses and frequency of participation in training regarding row planting are other positive and significant explanatory variables, which have profound effect on adoption decision and intensity of use of wheat row planting. Marginal effect result (Table 7) reveals that creating awareness among farmers on credit uses and improving credit supply institution increase the probability of change on adoption and intensity of use of wheat row planting by 10.49 and 6.72%, respectively. The overall effect of this variable on adoption and intensity of use of wheat row planting was 0.0912. The marginal effect result in the Table 7 also indicated that a unit increase in farmer's frequency of participation in training given at FTC and demonstration center of wheat row planting increases the probability of change on adoption and intensity of use of wheat row planting by 7.89 and respectively. The overall effect of the variable was 0.0686.

The model result also showed the positive and significant influence of frequency of extension contact and household education on adoption and intensity of use of wheat row planting at 10 and 5% significance level. The marginal effect result (Table 7) confirms that as a frequency of extension contact increase by one, the probability of change on adoption and intensity of use of wheat row planting was 2.83 and 1.81%, respectively. The overall effect from this variable was 0.0246. In addition, increasing education level of household by one increases the probability of change on adoption and the intensity of use of wheat row planting by 2.09 and 1.34%, respectively. The overall effect of this variable on adoption and intensity of wheat row planting was 0.0181.

CONCLUSION AND RECOMMENDATIONS

Generally, in Ethiopia particularly in the study area wheat is an important food security crop and an economically important cash crop, which serves as a major means of income for the livelihood of wheat producer households. Besides, the wheat crop plays a vital role in the economy of the country, which is used as a means of input for different food industries. Therefore, institutional support service should be given to this sub-sector to improve production and productivity, such as credit service, extension and research service, which there service provision, is not at expected level. These factors together with other household personal, demographic, socio-economic and psychological factors highly affected the adoption and intensity of use of wheat row planting and consequently production and productivity of the crops.

As shown above, in this research the Tobit model indicated that education level of household head, farm positive and significant effect on adoption and intensity of use of wheat row planting.

The study suggested that participation of farmers in different training regarding wheat row planting prepare for them either at FTC or technology demonstration cite or peasant association has to be strengthened so as to improve farmers' indigenous knowledge, and technical skill on the application of wheat row planting. In addition, farmers' frequent contact with extension agent should be strengthened to improve farmers' access to update information and get advice regarding improved agricultural technology available to them. Since manual wheat row planting is labor intensive, agricultural machinery/ equipment with relatively less labor requirement should be designed and made available to farmers. Moreover, education campaigns and adult education strategies should be designed and implemented by local governments to improve farmer's education level.

Finally, organizing and strengthening wheat producers' to form a cooperative will alleviate procurement on inputs like improved seed and sale of outputs in collective basis, which will help to overcome market barrier to some extent. Barrier on the supply side of credit (high interest rate, high bureaucracy on credit service) should be overcome if a valid major means of income for the livelihood of wheat producing farmers' is to be achieved in the study area. The concerned bodies should formulate a strategy for rewarding and recognizing the model farmers through giving certificate and material support for those who adopt and use the row planting intensively on wheat production.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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