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Adoption of Improved Lentil Varieties among Smallholder's farmers in Gimbichu District, East Shewa Zone, Oromia Region, Ethiopia

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ABSTRACT

Adoption of improved technologies is one of the most promising ways to ensure food security and alleviate poverty in Ethiopia. However, the adoption and dissemination of lentil technology is constrained by various factors. To this end, the aim of this study was to empirically identify the determinants of adoption and intensity of adoption of improved lentil varieties. In this study, two stage sampling procedure was followed to select the sample respondents. First four lentil growing kebeles were randomly selected from 26 lentil producing kebeles. In the second stage: 166 sample respondents were randomly selected based on probability proportional to size for the interview purpose. Semi-structured interview schedule was developed and used for data collection, the study from the sampled households. Both primary and secondary data were used for this study. The collected data was analyzed by descriptive statistics and double hurdle econometric model. The probit model statistics shows that from the total 13 variables, 7 of them show statistically significant difference with the adoption decision at 1%, 5% and 10% level of significance depicted that sex headed household, TLU, family size; cooperative membership, extension service, total land size and education affected the likelihood of adoption of improved lentil varieties positively and significantly. The truncated model results were positively and significantly influenced the intensity of use of improved lentil varieties production in the study show that the level of adoption has significantly active labor force, TLU, family size and access to credit. Finally, the study recommends that, adoption and intensity of use of improved lentil varieties should be given due attention for enhanced by rising farm household asset formation, and providing extension and credit services.

***Keywords*:** Adoption, double hurdle, Ethiopia, Gimbichu district, household, improved lentil variety

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1. INTRODUCTION

Agriculture is the back bone of Ethiopian economy and can diversify and intensify agricultural system because of the varied agro-ecologies that promote agricultural productivity and conserve the rich biodiversity of the region (World Bank, 2016). It contributes 42 % of the GDP of the country and about 85 % of the population gains their livelihood directly or indirectly from agricultural production (CSA, 2015). On the other hand, Ethiopian farming is dominated by a rain fed scheme, which accounts for approximately 97% of the current cropland area and is widely regarded as a low-yield system (Korbu *et al.*, 2020). The Ethiopian agricultural system generally subsistence primarily for the majority of essential food crops, including lentils (Negussie, 2004).

Lentil *(Lens Culinaris Medikus)* is among the oldest domesticated crop in the world. Its provides nutritional security to low income consumers a sits seed contains high amounts of digestible protein, macro-and micro nutrients, vitamins, fiber and carbohydrates for balanced nutrition. Lentil straw is a valued animal feed throughout West Asia, North and East Africa regions, and sometimes financial returns to farmers equal that from seed (Sarker, 2018). Thus, farmers grow a variety of legume crops for food and feed, as well as to earn money and, more importantly, to restore crop land fertility. Farmers' involvement in legume growing has risen almost twice over the last 20 years, increasing from 4.5 to 8.5 million farmers (Atnaf *et al.*, 2015). As well as its high protein content, it is economically and environmentally beneficial to use atmospheric nitrogen through biological nitrogen fixation (Kebede, 2020).

Improving productivity of agriculture is one of the economic growth and development strategies of Ethiopian government. Improved agricultural technologies are important to boost production to meet the national demand for food security and income generation. Successive Ethiopian governments have focused on promoting technology-led initiatives to enhance productivity, particularly in smallholder agriculture (FDRE, 2010). In Ethiopia Adoption of agricultural technology is not as such a long history in which traditional farming practices are still dominant in the farming system. The country has more than 51.3 million hectares of land generally suitable for cropping activity while about 11.8 million hectares of land being cultivated traditionally (MoA, 2010). Hence Ethiopian smallholders typically produce with their indigenous seed are characterized by low adoption of improved agricultural technologies. Because of the low productivity of the agricultural sector, Ethiopia has become highly dependent on food import in that domestic food production and supply have consistently been below the national demand (Negasa *et al*., 2002)

According to the 2007 CSA report lentil mainly depends on soil type, altitude and agro-ecologic conditions, in Ethiopia, lentil grows between 1700-2400 m.a.s.l. with annual rainfall ranging from 700-2000 mm. and grown on black vertisols.

The average annual total harvests of lentil for the last ten years in Ethiopia were about 90,159.63 tons of grains from about 92,998.61 hectares of land (CSA, 2004-2013). Ethiopian Central Statistical Agency (CSA, 2017) indicates, Pulses grown in 2016/17 covered 12.33% (1,549,911.86 hectares) of the grain crop area and 9.69% (about 2,814,633.20tone) of the grain. Lentil to put fifth stage under pulse crop planted to area coverage 0.90% (about 113, 684.63 hectares) production in quintals 0.57% (166,274.220 productions in tone) compared to other major pulse crop lentil is low production (CSA, 2017).

In addition to the low rate of adoption of modern agricultural inputs, the decreasing size of farms, which resulted in shorter fallow periods and even continuous cropping, contributed to the low productivity of the agricultural sector. Technology adoption is among the most revolutionary and impactful areas in agriculture sector. Agricultural innovations also play a significant role in fighting poverty, lowering costs of production (Kassie *et al*., 2011). Improving the livelihood of rural households in the course of agricultural productivity would remain a mere wish unless the level of technology adoption is improved (Ajayi *et al*., 2003). In such regards, adopting agricultural technology become a concern of agricultural experts, policy makers, agricultural researcher, and other stakeholder.

Breeding program is based at the Debreziet Agricultural Research Center (DZARC) of the Ethiopian Institute of Agricultural Research (EIAR) has generated (released) a number of improved varieties to get high yield and resistant to pests and diseases, drought tolerant and early maturing. In Gimbichu district improved lentil technologies are being promoted by research center. The technologies promoted include improved lentil varieties, recommended fertilizer rates and types, improved agronomic and weed control practices. From Oromia Region East Shewa zone in Gimbichu district are potential producers of lentil and no study was conducted on adoption and intensity of adoption of improved lentil variety previously in this area of Gimbichu district.

2. MATERIALS AND METHODS

2. 1. Description of the Study Area

The study was conducted in Gimbichu district located in East Shewa zone, Oromia Regional State in the central highlands of the country. It is located north east of DebreZeit which is 50 kms south east of Addis Ababa. Most parts of the district are situated in high altitude of more than 2300 meters above sea level. Lentils, chickpeas and fenugreek are important cash crops in the district. The district is geographically located 8.9542^0 N latitude and 39.1014^0 E longitudes.

2. 2. Method of Data Collection

Study area was purposively selected based on production status and past lentil technology promotion. First stage was randomly selection of lentil growing Kebeles of the districts, followed by selection of sample households. Four lentil growing kebeles were randomly selected as a sample from 26 kebeles of the district. Second stage: 166 sample respondents were selected using systematic random sampling technique from each kebeles based on probability proportional to size for the interview purpose.

2. 3. Sampling size

The sample size for the study was determined by the formula of Yamane (1967) to minimize availability of error and bias during sample determination selection for the study. The formula for sample determination at 8% confidence interval is described as follows

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

$$n = \frac{N}{1+N(e)^2} = \frac{2,660}{1+2,660(0.08)(0.08)} = 166$$

where:

n = is the sample size for the study,
N = is the total households of the study area which is 2660,
e = is the maximum variability or margin of error or which is 0.08 in this study. The sample size from each *kebeles* was determined based on their proportion to total share of households residing in each *kebeles*.

Table 1. Number of respondents in each of the selected rural kebeles

No	Kebeles	Number of lentil grower household heads	Selected number of respondents (HHH)
1	Adadi Gole	737	46
2	Areda	689	43
3	Dobi	641	40
4	Tulu Fera	593	37
	Total	2,660	166

Source: Computed from own survey data, 2019

2. 4. Method of Data Analysis

Both descriptive statistics and econometric model were used for analysis of the data. The data was analyzed using software SPSS version 21.0 and STATA 14 software. Descriptive statistics like mean, standard deviation, percentage and frequency were used in analyses.

Econometric model for determinants of adoption of improved lentil varieties and intensity of adoption. Factors' affecting the adoption of a farm technology has been widely analyzed using the Heckman (1979) and Tobin (1958) models. Heckman (1979) model is used with the assumption of selection bias in the process of adoption. Tobin (1958) model is the most widely used. The prime assumption for a Tobin (1958) specification is that farmers demanding modern technologies have unconstrained access to the technology. The double hurdle model originally proposed by Cragg (1971) in addition to its assumption that the two decision tiers are not necessarily affected by the same set of factors, is a remedy to the problem of corner solution arising in the Tobit model, and has been extensively in use in several studies (Yu and Ninpratt, 2014). The first hurdle is to decide to be a potential adopter, while the second hurdle is how much (intensity) to adopt. The advantage with this approach is that it allows us to understand the characteristics of a class of households that adopted the technology, households wanting to adopt but reporting no positive use (due to access constraint) and households that have never adopted the technology (Yu and Nin-Pratt, 2014).

This study used a double hurdle model assuming that factors that affect farmer's choice of adoption are not necessarily the same to the factors that affect the intensity of adoption. A double hurdle model consists of two separate stochastic processes that determine the decision to adopt, and the intensity (degree) of use of a technology. The first hurdle is an adoption decision equation with a probit model. The model has an adoption (Y) decision with an equation

$$\left.\begin{array}{l} Y_i = 1 \text{ if } Y_i^* > 0 \text{ and } 0 \text{ if } Y_i^* \leq 0 \\ Y_i^* = \alpha' Zi + Ui \end{array}\right\} \quad \text{Adoption equation}$$

where:

Y^* = latent variable that takes the value 1 if the farmer adopts improved lentil varieties and 0 if otherwise
Z = vector of household characteristics
α = vector of parameters.

The level of adoption (T) has an equation of the following:

$$\left\{\begin{array}{l} T_i = T_i^* \text{ if } T^* > 0 \text{ and } Y^* > 0 \\ T_i = 0 \text{ otherwise} \\ Ti^* = \beta' X_i + Vi \end{array}\right\} \quad \text{Intensity equation}$$

where:

Ti is the observed answer to the proportion of improved lentil varieties
X is a vector of the household characteristics
β is a vector of parameters.

The error terms, Ui and Vi are distributed as follows:

$$U \sim N(0, 1)$$
$$V \sim N(0, \delta^2)$$

The log-likelihood function for the double-hurdle model is:

$$\text{Log L} = \sum_0 \ln[1 - \emptyset(\alpha Z'i)(\frac{\beta X'i}{\sigma})] + \sum_+ \text{In}[\emptyset(\alpha Z'i)\frac{1}{\sigma}(\frac{Yi - \beta Xi}{\sigma})]$$

Under the assumption of independency between the error terms Vi and Ui, the model, as originally proposed by Cragg (1971), is equivalent to a combination of a truncated regression model and Probit model. The Tobit model, as presented above, arises if λ = β/δ and X = Z

The estimation of the model Tobit log-likelihood is the sum of the log-likelihoods of the truncated and the probit models. Therefore, one simply has to estimate the truncated regression model, the Tobit model, and the Probit model separately and use a likelihood ratio (LR) test. The LR-statistic can be computed using Green (2000):

$$\Pi = -2[\ell n\, LT - (\ell n\, LP + \ell n\, LTR)] \sim \chi^2 k. \ldots.$$

$$Xt\beta = \beta 0 + \beta 1X1 + \ldots. + \beta 12X12 + \varepsilon_i$$

where: β0 = constant;

3. RESULTS AND DISCUSSION

3. 1. Descriptive Statistics

3. 1. 1. Demographic and Socio-economic characteristics of the respondents in Dummy variables

For this study, the data was collected from both adopters and non-adopters of improved lentil varieties. Tables, below depicts the statistical t- test an X^2-test comparison of variables expected to determine adoption of improved lentil varieties produce by sample households.

The descriptive results show that adopters of improved lentil varieties were significantly different from non-adopters in many cases such as sex of household head, active labor force, livestock ownership, farm land holding size, family size, cooperative membership, access to credit services, frequency of extension contact, educational level, off/non-farm income, and farming experience toward improved lentil varieties on certain attributes. On the other hand, adopters did not make significant difference in terms of Age of household head, market distance with compared to non-adopters.

From total of 166 sample households, only 8 were female-headed and the majority of sample respondents, about 158 samples were male- headed households. As shown in Table 2, from the entire household heads interviewed, about 95% were male headed while about 5% were female headed, who are divorced or widowed at the time of survey. The survey data show that statistically significant difference is observable in the sex of household head since almost all of the respondents were male headed households. Accordingly to X^2-test result (X^2 = 6.7775, P = 0.009) show that is statically significant difference between adopters and non-adopters at 1%.

Literate households are expected to have better skills, better access to information and ability to process information. Adopter categories were seem to significantly vary in terms of formal education level that is years of schooling (Table 2). The distribution of total sample respondents in terms of literacy level has shown that 23.49% were illiterate and 76.51 % were literate. The literacy level was argued to have positive impact on the adoption of new technologies. The result of this study shows that the proportion of literate farmers in the non-adopters category was 60%. The result Chi-square statistics was statistically significant between the adopters and non-adopters (X^2 = 7.9879, P = 0.005) of household heads indicates statistically significant in the educational status among adoption categories. This shows that the education level of adopters of improved lentil is higher than non-adopters of the technology, implying the influence of the variable in making adoption decisions similar result with (Tesefay *et al.,* 2016). Frequency of extension contacts by extension workers varies among the sample households. From the total sample households, 22.29% were reported not frequently having contact with extension agent, while 77.71% of sample households were reported having frequently contact with the extension agent at different level of frequency. From the non-adopter groups 55% of respondent did not have any contact with extension agents frequently. This clearly shows that the major proportion of adopters get extension service on improved lentil production than non-adopters.

The chi-square analysis result (X^2 = 32.55, p = 0.000) shows significant relationship of contact of extension agent with the adoption and intensity of use of improved lentil varieties. The earlier researchers, Girmachew (2005), Abrhaley (2007) and Dawit (2017)) also reported similar result. From sampled respondents 68.67 % reported having access to credit while the remaining 31.33% reported lack of access to credit in the study area. With respect to credit accessibility response of farmers in the adoption categories 22.50% of non-adopters and 83.33% of adopters used credit for purchasing agricultural technologies (improved seed, fertilizers, chemicals, etc). The hypothesized proposition was supported by the significant relationship (X^2 = 52.22, p = 0.000) found at < 1 % significant level.

The respondent member of the cooperative farmer in the study area were 84.34% reported having member of cooperative, while the remaining 15.66% reported has no member. Table 2, indicates that, 87% of the adopter and 75% of the non-adopter sample respondents member in cooperatives to share their own common values and experience. The respondents' member of the cooperative had significant relationship with the adoption and intensity of use of improved lentil variety with (X^2 = 3.47; P = 0.062) the result revealed that there is significant relationship between member of the cooperative organization and the adoption and intensity of use of improved lentil varieties production at 10% significant level

Table 2. Results of Dummy explanatory variable.

Variables	Adopters (N = 126)		Non adopters (N = 40)		X^2- value	Total sample (N = 166)	
	Freq.	Percent	Freq.	percent		Freq.	percent
Sex of HHH							
1 for Male	123	97.62	35	87.50	6.777***	158	98.18
0 for Female	3	2.23	5	12.50		8	4.82
HHH affiliation to an cooperative							
Yes	110	87.30	30	75	3.478*	140	84.34
No	16	12.70	10	25		26	15.66
Whether HHH Access to Credit							
Yes	105	83.33	9	22.50	52.229***	114	68.67
No	21	16.67	31	77.50		52	31.33
Whether HHH Access to Extension							
Yes	111	88.10	18	45.00	32.554***	129	77.71
No	15	11.90	22	55.00		37	22.27
HHH education							
Literate	103	87.75	24	60	7.9879***	127	76.51
Illiterate	23	18.25	16	40		39	23.49

, ** - shows significant at <1% and 10% level of significance.
Source: survey data, 2019

3. 1. 2. Demographic and Socio-economic characteristics of the respondents in Continuous variable

The average size of cultivable land owned by the sample respondents was about 1.04 ha for non-adopter households and 1.85 ha for the adopters. The mean differences of total land holdings for the two groups have strong significance. The average farming experience of sample respondents was 14.34 years with standard deviation of 6.5. The average farming experience of the adopters and non-adopters were 15and 12, respectively. The mean difference in farming experience among adopters and non-adopters is statically significant at 1%. Accordingly tot-test result the adopters and non-adopters households statistically similar result with Tesefay *et al*., 2016).

In this study the household farm cash income was estimated based on the sales of crops, livestock and livestock products. (Table 3), indicates that, the average annual farm income of the sample households was 37,774.36 ET birr. The maximum annual farm income was 112,576 ET birr while the minimum was 4,140 ET birr. The average annual farm income for adopters and non-adopters sample households was birr 40,807.73 Birr and 28,219.22 Birr respectively. The minimum and maximum farm income of adopter and non-adopter sample households ranges from 6375 Birr to 112576 Birr and 4140 Birr to 94110 birr respectively. The major cash income for sample households in the study area is from sale of crop. The mean comparison (t = -3.3380, P = 0.0005) test result showed that significant mean difference among adoption categories.

The maximum and minimum tropical livestock unit of the sample households was 13 TLU and 2.56 TLU for adopters. For non-adopters the maximum and minimum tropical livestock unit of the sample households was 4.93 TLU and 1TLU. On average the total sample households have about 5.37 tropical livestock unit. The tropical livestock unit was strongly and statistically significant at 1% difference between adopters and non-adopters of the sample households.

The average labor available for sample households in man-equivalent was 3.34 with standard deviation of 1.58. In adopter and non-adopter the maximum and minimum labor available for sample household is 8 and 1 person above 15 ages (Table 3). This is evident from the result (t = -3.9091 and P = 0.0001) which shows as significant mean difference between adoption categories.

In this study, it is hypothesized that the farming experience (measured in years) is positively correlated with the decision to adopt newly introduced crop varieties. The average farming experience of sampled households was 14.34 years with standard deviation of 6.5. More experienced farmers may have better skills and access to new information about improved technologies. It could also imply that knowledge gained over time from working in uncertain production environment may help in evaluating information thereby influencing their adoption decision (Idrisa *et al*., 2012). The respondents' farming experience had significant relationship with the adoption and intensity of use of improved lentil variety with (t=-2.6160; *P*=0.0049) at 1% significant level.

Large family size may be an indicator for availability of labor provided that there are more people within the age range of active labor force. Based on this assumption, the variable was hypothesized to have positive and significant relationship with adoption and intensity of adoption of improved lentil varieties. In this study, the average family size of the sample households was 5.53 persons with standard deviation of 1.98.

The average family size of households were 5.8 and 4.65 persons for adopters and non-adopters, respectively. The maximum family size was 11 while the minimum was 1 person. Accordingly to t-test result (t = -3.3358, P = 0.0005) the adopters and non-adopters households statistically significant 1%.

Table 3. Results of Continuous explanatory variable.

Variables	Adopters (N = 126)		Non adopters (N = 40)		t- value	Total sample (N = 166)	
	Min	Max	Min	Max		Mean	SD
Age of HH	25	67	25	60	0.44	40.30	8.71
HH size	1	11	1	9	3.33***	5.5	1.9
Farming experience	3	33	4	30	2.61***	14.34	6.5
Farm size (ha)	1.125	3	0.25	1.75	11.87***	1.65	0.51
Farm income'000	6.375	112.576	4.14	94.11	3.33***	37.77	21.40
Livestock unit TLU	2.56	13	1	4.93	7.68***	5.36	2.45
Active labor force	1	8	1	8	1.7032**	3.34	1.58
Distance to nearest market	2	180	2	60	0.6229	24.04	22.8

****, *** -** shows significant at <1% and 5% level of significance.
Source: Own survey, 2019

Under normal conditions, improved lentil varieties are preferred by smallholder farmers in the study area which have better yield potential, resisting crop diseases, ecological characteristics and market price. According to the survey, the improved varieties Alemaya and Derash, were known by 89.68% and 53.97% have been widely demonstrated to farmers and adopted with associated cultural practices in the study areas.

Table 4. Types of improved lentil varieties adopted and Not-adopted by smallholder farmers.

Name of improved lentil Varieties	Frequency		Percent	
	Adopter	Non-adopter	Adopter	Non-adopter
Alemaya	113	13	89.68	10.32
Derash	68	58	53.97	46.03
Teshale	27	99	21.43	78.57
Adaa	6	120	4.76	95.24

Source: Own survey (2019)

3. 2. Econometric Model Results

The probit model was employed to identify factors influencing adoption of improved lentil varieties by smallholder farmers in the study area. The chi-square (X^2) distribution was used as the measure of overall significance of a model in probit model estimation. The model had a log pseudo likelihood of (-11.60) after seven iteration. The Wald chi2 test statistics with 13 degree of freedom is equal to 40.37, and prob> chi2 = 0.0001 is used to test the dependence of the adoption of improved lentil on the selected independent variables in the model (the hypothesis that all coefficients are equal to zero is rejected at 1% significance level). The pseudo R^2 (0.8735) which indicates 87.35 % of the variation between adopters and non-adopters of improved lentil varieties which explained by the variables.

3. 2. 1. Determinants of adoption of improved lentil varieties by smallholder

The results of the model show that out of the thirteen variables included in the model, five are correlated with improved lentil varieties adoption and found to have statistically significant effects on the adoption of improved lentil varieties on the sample respondents.

The model outputs showed that sex of household, member of cooperatives, tropical livestock unit and land holding size have significantly correlated influence on the households' adoption decision of lentil varieties at 1% significance level. Whereas having difference in education level and extension service are significant factors affected adoption of improved lentil varieties at 5% of significance level. Having household size significantly correlated with decision of household lentil varieties adoption at 10% significance level (Table 5).

The probit model shows that household head sex is positively and significantly associated with adoption of improved lentil varieties. The result confirms that as compared to male-headed households, female-headed households are less likely to adopt improved lentil varieties than male-headed farmers. Implication female-headed households on likelihood of adoption of improved lentil varieties might be that female-headed households have a lower labor endowment, lower farm land holding and livestock unit ownership, and less access to information on improved lentil varieties compared to their counterpart. From marginal effects, being male-headed households, *citrus paribus*, increase by 18.48% the adoption of improved lentil varieties as compared to female-headed households. In the study area, letting females to be a household head is not yet well developed and recognized in such instances, due to the cultural and socio-economic factors, their likelihood of adopting improved lentil varieties becomes negligible. The overall finding is consistent with the results reported by (Solomon *et. al*, 2014 and Menale *et. al*, 2012) pointed out a positive association between a female-headed household and improved wheat variety adoption.

Livestock are considered as an asset that could be used either in the production process or be exchanged for cash (particularly small ruminants) for the purchase of inputs (seed, fertilizer, herbicide, etc.) whenever the need arises. Tropical livestock unit, which is a proxy for measuring wealth status of household head (in terms of tropical livestock unit), is found to have a positive and significant influence on adoption of improved lentil varieties, indicating that farmers with large number of livestock are more likely to adopt improved lentil varieties than others. Results of analysis of marginal effect show that a unit increase in tropical livestock unit increases the decision of improved lentil varieties adoption by 6.37% of adopters of sample households.

This is because farmers with relatively more livestock unit make use of their income obtained from sale of livestock for the purchase improved seed for grown improved lentil varieties. Also livestock, particularly oxen, are used for draft for different farm operations. This implies that being owner of more livestock unit increase the probability of adoption of improved lentil varieties (Tesfaye *et al.*, 2016; Leake and Adam, 2015).

Farm land size is a limiting factor of production in the improved lentil varieties adoption decision that significantly affects improved lentil varieties adoption. It is worth to note that, having more farm land size is one best option whereby smallholders could be prompted in diversifying their crop production. Farm size has a positive and significant effect on adoption of improved lentil varieties. The positive effects of farm land size indicate that farmers with relatively large farm land size decide to adopt improved lentil varieties than owners of small farms land size. This is in agreement with the hypothesis formulated regarding the relationship between improved lentil varieties adoption and land holding size of the households. As a basic production factor, the more farmers have cultivable land, the more likely to adopt agricultural technologies particularly improved lentil varieties that could possibly increase crop yield. Probably, owning more arable land could be taken as a prerequisite to adopt and employ agricultural technologies since farmers incur a cost. Being rational decision makers, while incurring a cost for improved varieties, totally, farmers want to employ improved varieties within their own land where the final crop yield could not be shared and sub-divided.

The marginal effects indicated that as land holding of the households' increases by a unit (1 hectare), the farmers' probability to use improved lentil varieties increases by 43.34% as compared to non-adopters. During focus group discussion farmers told that shortage of farm land due to cultivated on small pies of land. The result is supported by findings of earlier studies on technology adoption of (Masresha *et al.,* 2017 and Geremew, 2012).

Memberships to cooperative have positively and significant influence on adoption of improved varieties at1% significance level. This implies that farmers who are members of cooperative are more likely to adopt improved lentil varieties. The primary cooperatives available also facilitate mostly to purchase improved seed, fertilizers production supporting agricultural inputs such as plant protection chemicals for farmers'. As a result, memberships in the cooperative have favorably influence the households' likelihood decision to adopt improved lentil varieties. The marginal effects result shows that being member of cooperative, *citrus paribus*, increase by 11.5% the likelihood of adoption of improved lentil varieties. Generally, it is known that being a member of cooperative is advantageous to farmers since they can get information easily and can access different services Contrary to this, Tewodaj *et al*. (2009), Degnet and Mekibib (2013) and Degefu *et al.* (2017) found a positive result of relationship of cooperative membership with technology adoption.

Having extension contact has positively and significantly related to adoption of improved lentil varieties, implying that's farmers with having extension service are more likely to adopt improved lentil varieties than those not having extension service. Extension service is powerful and crucial to achieve better adoption of improved agricultural innovations. Henceforth, extension service by development agents with farmers is assumed potential force which accelerates the effective dissemination of adequate agricultural information to the farmer, thereby enhancing farmer's decision to adopt improved lentil varieties.

For the analysis marginal effect, having extension service from development agents during the production season, increase the likelihood of adopting improved lentil varieties by 6.7% adopters of smallholder farmer. The farmer how have more frequency of extension contact with development agent update themselves on the availability and arrival of improved lentil and aware of application technology than those less visited by the development worker. The studies conducted by Isaiah *et al*. (2007), Solomon *et al*. (2011) and Leaked and Adam, (2015) found frequency of contact with extension agent affect positively and significantly adoption decision of smallholder farmers.

Education of the household head positively influences participation in improved technology. Education was significant at 1% level of significance. The positive marginal effect indicates increasing participation with every additional year of education. For instance, a marginal effect of 0.085 implies that if an individual adds one grade in school the probability of being an adopter increase by 8.5%. This implies that education of the household head increases the probability of using improved varieties. This finding corresponds with Afework, and Lemma, (2015) and Leaked and Adam, (2015) who found similar results.

Family size to be positive and significant at 10% significance Level, indicate that each family adding in one person the probability of adoption of improved lentil varieties increased by 1.05%. Similar results were reported by Alene *et al.* (2000): Milkias and Abdulahi (2018) but Contradicting with the research.

Table 5. Estimation of the probit model for adoption of improved lentil varieties.

Robust Marginal effect						
Variables	**Coef.**	**Std.Err.**	**dy/dx**	**Std. Err.**	**Z**	**P**
Age	0.0410145	0.035416	.0016334	.001331	1.23	0.224
sex	4.64251***	1.200535	.1848875	.0553157	3.34	0.001
active labor force	0.2169037	0.2062334	.0086382	.0075806	1.14	0.246
TLU	1.600112***	0.3927941	.0637243	.0181292	3.52	0.001
Family size.	0.2652833*	0.1562797	.0105649	.0054351	1.94	0.078
Cooperative membership	2.907142***	0.9032011	.1157766	.0307274	3.77	0.001
Credit use	1.00938	0.7982818	.0401984	.0270398	1.49	0.153
Extension service	1.689698**	0.8074209	.067292	.0289228	2.33	0.041
Nearest market distance	-0.0204368	0.018149	-.0008139	.0006998	-1.16	0.251
Total land size	10.88288***	2.900026	.4334093	.0852986	5.08	0.000
Education	2.138104**	0.8721654	.0851498	.0447751	1.96	0.045
Income	-.0295814	0.0218661	-.0011781	.0008471	-1.39	0.129
Experience	-.027243	0.0578571	-.0010849	.0024528	-0.44	0.817
Cons	-28.37354	7.698518				
Number of obs = 166 Wald chi2(13) = 40.37 Prob> chi2 = 0.0001 Log pseudo ikelihood = -11.599741	Pseudo R2 = 0.8735					

*, ** and *** - shows significant of coefficient at 1%, 5%and 10% respectively probability level.
Source: survey data, 2019.

3. 2. 2. Determinants of intensity of use of improved lentil varieties

According to the result of the Table 6 in the truncated model, active labor force had a positive influence on the intensity of use of improved lentil varieties at 1% significance level. This explains that new improved lentil varieties appear to be labor intensive. Suggesting that farmers who have more active family labor force allocate more area to improve lentil varieties since they can supply the required labor for different production activities of improved lentil varieties. This means active labor force increase by one person the adopter the allocated to cultivate improve lentil varieties increased by 0.38ha. This result is in conformity with other finding of Alene *et al*. (2000).

Table 6. Estimation of the truncated model for level of adoption of improved lentil varieties.

Variables	Coef.	Std. Err.	Z	P>|z|
Age	.0015961	.0018313	0.87	0.383
sex	.0396127	.1186156	0.33	0.738
active labor force	.038362***	.010279	3.73	0.000
TLU	.0469766***	.0067465	6.96	0.000
Family size	.0197955**	.0082903	2.39	0.017
Cooperative membership	.0415918	.0458987	0.91	0.365
Access credit	.1660125***	.0529007	3.14	0.002
Extension service	.0419415	.0489463	0.86	0.392
Nearest market	-.0001491	.0006535	-0.23	0.820
Education	-.0120245	.0426221	-0.28	0.778
Experience	-.0010789	.0025334	-0.43	0.670
Cons	-.297939	.1797211	-1.61	0.108
Number of obs = 126 Wald chi2(11) = 83.31 Prob > chi2 = 0.0000				

** and *** - shows significant of coefficient at 1% and 5% probability level.
Source: survey data, 2019

The result of the truncated model revealed that the intensity of use of improved lentil varieties is positively and statistically significantly affected by access to credit at 1% significance level. This means that households to have access to credit the allocated to cultivate improve lentil varieties increased by 0.166ha than households without access. The expected access to credit provides an importance in intensification of improved lentil varieties by financing agricultural inputs, that is, improved seeds and fertilizers. The financial strength for households to engage in intensive farming leading to more marketable surplus. Another plausible reasoning could be that households with access to credit need to raise enough money to pay back their debts/loans. Hence, if farmers can get credit access, they can buy more improved lentil varieties. The finding is consistent with other study (Hassen *et al*., 2012)

The econometric result showed that household size affects households' level of adoption in improved lentil positively and significantly at 5% significance level. The household member's increases by one the allocated area to cultivate improve lentil varieties increase by 0.19 hectare. This confirms the finding of Benjamin *et al*. (2014), Siziba *et al*. (2011) and Makhura *et al*. (2001) that households with large family sizes need to use improved lentil.

Livestock ownership had positively and significantly influence of the intensity of improved lentil at 1% significance level. As the livestock ownership increases by one the household will the area to cultivated improved lentil increases in 0.047ha. As livestock provides the required draft power for different farm operation and cash for purchased of improved input like seed.

4. CONCLUSIONS

The level of adoption observed in the study area is an indication of the existence of substantial potential to improve smallholder productivity with minimum cost compared to development and introduction new technologies. As repeatedly stated improved lentil varieties production is important in solving food security and poverty problem in agriculture based economies demand for substantial efforts in improving agricultural production and productivity. As result of this, institutional support provided to this sector, such as credit service, extension service was not to the expected level. These factors together with several household personal, demographic and socio-economic factors greatly affected the adoption and intensity of improved lentil varieties production and consequently production and productivity of the sector.

Recommendation

Based on the research finding and conclusions of this study, the following points are recommended to improve farmer's adoption of improved lentil varieties as to enhance its production and productivity.

Sex of the household was one of the significant variables determining the adoption of improve lentil varieties. It should focus on different strategies that should give attention on empowering women in using improved lentil technology, particularly, in improved varieties. Livestock ownership was one of the significant variables determining the adoption and level of adoption improve lentil varieties. Therefore, making effort to improve the existing livestock ownership in the study area through improved livestock management approach has to be considered as a central and core component of any development intervention to improve the adoption improve lentil varieties. Institutions like cooperatives play an enormous role in disseminating technologies such as improved seeds and fertilizers, and in providing information for farmers in order to disseminate technologies. Further attempts to address farmers through cooperatives, therefore, play great roles in enhancing adoptions of technologies. Education of the household head positively influences participation in improved technology. This indicates that increasing adoption of improved lentil varieties would increase as the educational level of the households. This implies that interventions to speed up lentil technology adoption and dissemination must be targeted at improving farmers' knowledge and skills by capacitating and supporting FTCs focused especially on aspects of lentil production, marketing and consumption. Policies and strategies should therefore place more emphasis on expanding primary education and increasing school enrolment rates of children in rural areas to achieve increased agricultural productivity in the future.

Active labor force was powerful in explaining adoption and intensity of lentil technologies suggesting that these technologies required additional labor for different operations and hence may not achieve high adoption in areas where there are labor shortages. Therefore, policies and strategies should consider availability of labor before introducing such labor intensive technologies. Land is a limiting factor of production in agriculture. Farmers with more land are more likely to adopt among households was found to be influenced a relatively higher share of their land for lentil varieties. Thus, adoption becomes more difficult in the farms with relatively small land size. However, increasing the size of landholding cannot be an option to increase lentil varieties adoption since land is a finite resource.

Therefore, intervention aimed to improve land fertility status and increasing productivity of land through proper utilization of available land resource is required. Furthermore, the finding of this study suggests that institutional service like credits are the key factors in influencing the level of adoption. Thus availability of credit service can help to facilitate farmers to adopt improved lentil varieties. Expanding sources of such institutional service is another possible recommendation from the present study, if actively to adopt of improved varieties the smallholder farmers is required in lentil production in the study area. In order to improve farmers level of adoption of improved lentil varieties as well as land allocated for improved lentil, extension workers should provide farmers with more practical trainings under farmers' direct participation in the demonstration centers. In addition to this as discussed in the descriptive part of the study larger numbers of farmers have reported the existence of disease problem in the study area, hence farmers should get training on how to avoid disease problem and avail materials required for crop protection based on their needs and other research should be done on it, especially on their prevention and control methods. Hence, Agricultural research center and agricultural offices should provide technical assistance of this crop about it; production, management pest and disease control.

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