Turkish Journal of Agriculture - Food Science and Technology, 12(10): 1713-1721, 2024
DOI: https://doi.org/10.24925/turjaf.v12i10.1713-1721.6947

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Intensity of Adoption of Improved Malt Barley Production Technologies in Ethiopia: A Case Study in Oromia Region

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ARTICLE INFO

Research Article

Received : 19.06.2024
Accepted : 14.08.2024

Keywords:
Adoption
Contract farming
Improved varieties
Chemical fertilizers
Tobit

ABSTRACT

Improved malt barley production technology packages are not yet widely adopted in Ethiopia. Stakeholders, including brewers, malt factories, research institutes, and farmer-based organizations, have been collaborating and promoting new malt barley production technologies in order to boost the intensity of acceptance. The aim of this study was to find out the intensity of improved malt barley production technologies adoption in Arsi zones, Oromia region, Ethiopia. A stratified random sampling approach with multiple stages was employed to collect primary data from 384 malt barley household heads. The data was analyzed using descriptive statistics, and the intensity of adoption of improved malt barley production technologies was determined using an econometric Tobit regression model. The findings specified that the most adopted improved malt barley variety was Traveler (47.92%), which was followed in descending order by Iboni (14.58%), Sabini (9.38%), Grace (5.47%), Holker (4.43%), and 18.23% unnamed varieties. The Tobit model result also depicted that the intensity to which improved malt barley varieties adopted were affected by, taking into account factors including contract farming involvement, cooperative membership, off-farm income, size of livestock holdings, access to training, and mobile ownership. Enhancing farmers' knowledge of the advantages of contract farming, income diversification, and mobile phone-based information delivery are among the many ways to support access to and accelerate the adoption of improved malt barley technology in the research area and beyond.

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Introduction

Cereals accounted for 95% (almost 10.5 million hectares) of the total area planted with major food crops in 2022 in Ethiopia. Where tef, maize, wheat, sorghum, and barley made up 29% (2.9 million hectares), 26% (2.5 million hectares), 19% (1.8 million hectares), 14% (1.3 million hectares), and 8% (800 thousand hectares) of the top five food security crop areas (Gizaw and Assegid, 2021). Malt barley for brewing and food barley for domestic use are the two types of barley production in 10-15% and 85–90% proportions in Ethiopia, respectively (Bishaw and Molla, 2020). In terms of productivity, barley ranks third among the primary crops, which are maize, wheat, barley, sorghum, and tef, in decreasing order: 4.2 ton ha^{-1}, 3.11 ton ha^{-1}, 2.6 ton ha^{-1}, 1.9 ton ha^{-1}, and 2.6 ton ha^{-1} (CSA, 2022). For a long period of time, barley has been one of the most prominent traditional food sources as it can be prepared into a variety of food items and is convenient to store and carry. Recently, the malt barley sub-sector now features active commercial supply chain coordination due to smallholder farmers and malt industry linkages. In 2021–2022, the country produced 20,718,071.07 quintals of barley, with an average productivity of 2.55 t/ha (Gizaw and Assegid, 2021).

Several production and marketing constraints, including high transaction costs for acquiring inputs, improved varieties, and markets, define the barley sub-sector, according to de Roo et al. (2019) and Effa et al. (2023). For high-quality malting, improved malt varieties such as Traveler, Grace, Sabini, Holker, and Iboni have been created as a result of the persistent increase in the domestic malting market (Bishaw and Molla, 2020). The current level of output is insufficient to meet the nation's projected consumption of nearly 700,000 metric tons by 2030 (de Roo et al., 2019). Barley yields have been unchanged over the previous few years, despite favorable growth circumstances when compared to other cereals. Studies suggest that average yields were to stagnate around 2.5 t/ha in many locations (CSA, 2021). A number of factors account for low barley productivity performance including low level of recommended fertilizer applications (Shewangizaw et al., 2022), old varieties use (Tekeste et al., 2023), and low level of improved field management practices (Dagnew et al., 2023) and poor quality and low quantity supply chain (Tigabie, 2024).

In response to the growing demand for beer, breweries have renovated and upgraded. Yet the malt factories need to get over obstacles in obtaining quality and sufficient supplies of raw materials if they are to produce enough malt. A variety of malt barley supply chains set up in the study area, which is one of the primary production locations. An improved bundle of innovations in crop production, including barley, must be promoted and adopted in order to take advantage of Ethiopian irrigated wheat commercialization clusters (Effa et al., 2023), contract farming proclamations (Bezabeh et al., 2022), and extensive farm clustering extension and advisory service provisions. Improved varieties, recommended fertilizer application, and improved field management practices were a few of the technologies that farmers employed. Applying sophisticated technologies at less than optimal rates is the main reason of low agricultural output. Farmers were using poor quality seed, which made the low production even worse. Soil types prone to waterlogging during periods of heavy rainfall also contributed to a slower response to adopt new technologies and slower crop growth, resulting in total crop failure or abnormally low yield.

To inform the development and transfer of new malt barley production technologies, the extent to which previously popularized improved malt barley production technologies were adopted had not been thoroughly studied. Therefore, the purpose of this research was to shed light on the factors that determine the extent of adoption of improved malt barley production technologies and generate decision support evidences for scaling malt barley innovations in the study area and beyond.

Methodology

Descriptions of the Research Site

The study was carried out in Ethiopia's significant barley production potential areas, including the Kofele and Shashemene districts in the west Arsi zone and the Tiyyo and Limu Bilbilo districts in the Arsi zone of the Oromia region. Astronomically, the zones are located at latitudes 7°08'58" N and 8°49'00" N and longitudes 38°41'55" E and 40°43'56" E (Figure 1). The districts are known to have significant clusters of malt barley production. Moreover, the districts situated in every zone encompassed the largest area dedicated to barley farming. The commercialization schemes for malt barley have facilitated it more to gather information about the availability and use of different services, which is thought to help improve agricultural technologies in general and malt barley production technologies in particular.

Publication Approval Committee

The Directorate of Knowledge Management and Scientific Communication (KMSC) approves research publications under the Ethiopian Institute of Agricultural Research (EIAR). The approval made by the head of the department in charge of a given research topic, the research center or research sector director, the deputy director general for research, and the KMSC director. Correspondingly, the publishing of this work has been allowed with decision number 219/0812/2024 on June 15, 2024.

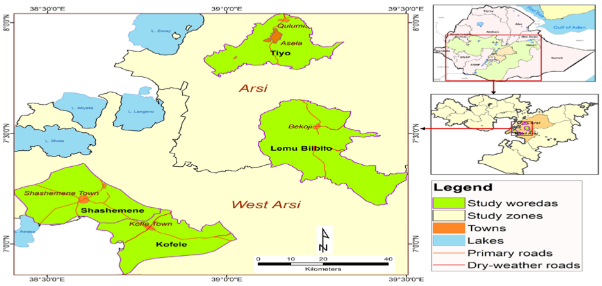

Figure 1. Map of the study area
(Arsi and West Arsi zones)

Sample Size Determination and Methods for Data Collection

The sample was chosen using two techniques: purposive sampling and probability sampling techniques. For the purpose of this study, household heads were surveyed using a multistage stratified random sample technique. Three factors were taken into account while choosing the sample districts: interventions of improved malt barley production technologies; the use of chemical fertilizers; and the cluster farming methods in connection to these enhancements. Hence, the districts of Kofele and Shashemene from the West Arsi zone and Limu Bilbilo and Tiyo from the Arsi zone were selected for the first stage. Two Kebeles were chosen at random in the succeeding stage from a list of the main malt barley growers in the allocated districts. In the third and final phase, the corresponding Kebeles provided a list of farm households that had grown malt barley in the preceding cropping season (Table 1). The next stage was to give every farm household name a unique serial number. After that, a conventional random sampling procedure was used to choose sample farm households. To determine the sample size, the formula given by Kothari (2004) was used as Eq. 1.

$$n = \frac{Z^2pqN}{e^2(N-1) + Z^2pq} \quad (1)$$

$$n = \frac{(1.96^2)(0.5)(0.5)(92{,}286)}{(0.05^2)(92{,}286) + (1.96^2)(0.5)(0.5)} \approx 384$$

Where n is the sample size needed, Z is the inverse of the standard cumulative distribution that corresponds to the level of confidence, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population and q = 1-p. The value of Z is found from the statistical Table, which contains the area under the normal curve of 95% confidence level and p = 0.5 is as suggested by Kothari (2004). Based on this, a total of 384 households were selected for the study from the four selected districts and assuming a 95% confidence level and ± 5% precision; q=1-p; and N is the size of the total population from which the sample was drawn. Finally, a sample of 384 farm household heads was selected from eight *Kebeles* by simple random sampling with probability proportional to size.

A pretested interview schedule was administered to collect primary data from in-person interviews of 384 randomly selected smallholder malt barley farmers. To collect information relevant to the study's objectives, both closed-ended and open-ended questions were included in the interview schedule to gather the primary data.

Table 1. Selected study districts, Kebele and household sizes

District	Sampled Kebele	Household size	Sample households	Cluster farming	
				CF*	NCF*
Limu Bilbilo	Chiba Micheal	1323	90	23	23
	Limu Dima	1261		21	21
Tiyyo	Haro Bilalo	1,233	84	19	19
	Dosha	1,358		23	23
Kofele	Gurmicho	1,203	92	22	22
	Alkaso	1,249		24	24
Shashemene	Hursa Simbo	1037	118	31	32
	Gonde Karso	946		28	29
Total		9,610	384	190	194

*CF= Cluster farming participants while NCF denotes non-participants of cluster farming; Source: Agriculture Office

Table 2. Summary of explanatory variables

Code	Descriptions	Measurement (unit)	AMBT
GEND	Gender of household head	1 if male 0 otherwise	+/−
AGE	Age of the household head	Year	+/−
EDUCS	Educational level of the household head	Number of school years completed	+
MASTS	Marital status	1 married 0 otherwise	+
HHSIZ	Number of family members	Number	+
FASIZ	Cultivated farm size	Hectare	+
LIVES	Livestock ownership	TLU	+
COPMEM	Cooperative membership	Yes=1, otherwise =0	+
CRACS	Credit access	Yes=1, otherwise =0	+
ADVIS	Access to advisory service	Yes=1, otherwise =0	+
OFINC	Off/non-farm income	Birr/year	+
MBFEX	Barley farming experience	Year	+
YIELD	Yield	Q/ha	+
DMKT	Distance to market	Number of minutes	−
PRICE	Price for 1 quintal barley	Birr/Qt	+
ACSIV	Access to imp. varieties	Yes=1, otherwise =0	+
ACSACH	Access to agrochemicals	Yes=1, otherwise =0	+
ACSTR	Access to training	Yes=1, otherwise =0	+
NUMCC	Number of crops cultivated	Number	−
CFP	Contract participation	Yes=1, otherwise =0	+

AMBT: Adoption of malt barley technology

Analytical Framework

Descriptive statistics were employed in the research to demonstrate the respondents' socioeconomic attributes. As an alternative, econometric models are used to investigate the variables affecting the rate of adoption of improved malt barley production technologies. For example, Shiferaw et al. (2014) show that in the zero (non-adoption) generating process, adoption decisions are described using Tobit type models for divisible technologies and Probit and Logit models for non-divisible technologies. The adoption status and extent of the improved malt barley production package were examined in this study using the Tobit econometric model. Tobit model was selected to identify factors affecting adoption of malt barley technologies and intensity of use of it. The model was chosen because of its advantage over other adoption models in dealing on a dependent variable with censored distribution and generating information for both probability of adoption and intensity of use of the technology. The improved malt barley variety's package consists of the improved malt barley varieties and the complementing inputs (De Roo, 2019). The adoption theories, which are used to examine the degree of adoption of technologies associated with malt barley production, presents potential adopters as agents who act in their own interests while being aware of the advantages and disadvantages of their decisions (Sahin, 2006).

It can also be examined the factors that influence the uptake and extent of enhanced malt production packages among malt barley growers using the so called model Tobit (Table 2). Subsequent to Maddala (1992), the model called Tobit that can be expressed as:

$$Y_i = \begin{cases} Y_i^* = \beta_i X_i + \mu_i \text{ if } Y_i^* > 0 \\ 0 \text{ if } Y_i^* \leq 0 \\ \mu \sim N(\mu, \sigma^2) \end{cases} \quad (2)$$

Where, Y_i is the observed dependent variable; in this instance, malt-barley adoption. Y_I^* is the unobservable latent variable. X_i is array of variables impacting the uptake of malt barley technology and its intensity. β is estimation of a vector with unknown parameters and μ_i is the residuals with a constant variance and a mean of zero that are independently and normally distributed. According to Maddala (1992), the Tobit likelihood function of the following form is maximized in order to estimate the model parameters:

$$L = \prod_{y_i^*} \frac{1}{\alpha} f\left(\frac{y_i - \beta_i X_i}{\alpha}\right) \prod_{y_i^*>0} F\left(\frac{-\beta_i X_i}{\alpha}\right) \quad (3)$$

The density and cumulative distribution functions of the variables f and F are Y_i^* and $\prod_{y_i^* \leq 0}$ denotes the product compared to those i of $Y_i^* \leq 0$ and $\prod_{y_i^* \geq 0}$ means the product over those i which Y_i^*.

Thus, a change in X_i (exogenous variables) has two effects. It affects the conditional mean of Y_i^* it influences the likelihood that the observation will fall in the positive portion of the distribution. The following techniques were used to separate adoption and intensity effects from the influence of explanatory variables. Thus, a change in X_i (explanatory variables) has two effects. An explanatory variable's marginal impact on the dependent variable's predicted value was as follows:

$$\frac{\partial E(Y_i)}{\partial X_i} = F(z)\beta_i \quad (4)$$

Where $\frac{\beta_i X_i}{\sigma}$ is denoted by z, Maddala (1992).

The malt-barley technology adoption likelihood, as an independent variable X_i changes is:

$$\frac{\partial F(z)}{\partial X_i} = f(z)\frac{\beta_i}{\sigma} \quad (5)$$

The change in adoption intensity in relation to a shift in an explanatory factor among adopters is:

$$\frac{\partial E(Y_i^*/Y_i^*>0)}{\partial X_i} = \beta_i\left[1 - z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^2\right] \quad (6)$$

Where, $F(z)$ is the cumulative normal distribution of Z, $f(Z)$ is the unit normal, or the value of the normal curve's derivative at a specific position 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.

The following equation was used to calculate the degree of acceptance of the malt barely technology package for those adopters: One way to calculate each farmer's adoption index is as follows:

$$AI_i = \sum\left[\left(\frac{AT_i}{RT_i}\right) IS_i\right] \quad (7)$$

Where AI_i is adoption index of i^th^ farmer, AT_i is the extent of let us say a recommended fertilizer amount that the farmer applied, RT_i is the recommended volume of fertilizer the farmer should apply, IS_i is the percentage of the score (provided by each invention) that can be attributed to a specific input. The package of recommendations' total contents are added up, and the highest possible adoption score 1 or 100% is established (Martey et al., 2014). For this investigation, the exact formula listed below was used in conjunction with the generic formula mentioned above:

$$AI_i = \sum_{j=i}^{m}\left(\frac{CL_{ji}}{TL_{ji}} + \frac{WA_{ji}}{WR_{ji}} + \frac{CF_{ji}}{CR_{ji}} + \frac{FA_{ji}}{FR_{ji}} + \frac{AS_{ji}}{SR_{ji}}\right) \quad (8)$$

Where: AI_i = adoption index of the ith farmer,

i = 1, 2, 3… n; n is total number of farmers

j = 1, 2, 3… m; m is total number of hectare of grown crops

CL = Cultivated land, and TL = total land

WA = weeding applied and WR weeding recommended

CF = cultivation frequency applied and CR cultivation frequency recommended

AF = Amount of fertilizer applied and FR = fertilizer recommended per hectare

AS = Amount of seed rate applied and SR = seed rate recommended per hectare

The adoption index result was changed into adoption index range of levels (Non-adopter = 0, Low adopter = 0.01- 0.33, Medium adopter = 0.34 - 0.66 and High adopter = 0.66 - 1.00). In this manner the model was used to test factors affecting package use intensity among farmers.

Results and Discussion

Descriptive Statistics for The Socioeconomic Status of Farm Households

A total sample of 384 heads of agricultural households made up the study's sample. Of the overall sample household heads, 94.79% were male, while 93.68% and 6.32% were male and female-headed farm households engaged in malt barley contract farming, respectively (Table 3). According to descriptive statistics, a male-headed household is more likely to participate in contract farming than a female-headed home. The average age of 45 for all selected household heads indicates that farm household heads were found to be in their active working age. Across the board, sample household heads had an average educational background of sixth grade. Out of the responders, just 20% had finished secondary school. Farmers that grow malt barley are generally thought to reach a low level of educational development. The sample household heads' average family size was 7 persons per household, which was higher than the national average of 4.6. Larger families thought to ensure that family labor is accessible for agricultural work in rural areas and reduce the cost of hiring labor, which could be one reason. Roughly half of the sample, or 49%, were malt barley farmers under contract, while 51% were not.

For sampled household heads, 1.84 hectares was the average landholding size. A livestock holding size of 7.26 was noticed in the sample families in the Tropical Livestock Unit. On average, 26.74 minutes was the journey time to elapse to reach the main road for all sampled household heads. Studies distance from main road determine information access and adoption rate improved technologies. The average farm area assigned to malt barley cultivation among the sample household heads was 0.74 hectares, implying that malt production accounted for roughly 40% from the average land holdings of 1.84 hectares.

As for technology, input and output markets, information access, and other areas, research shows that cooperative participation benefits farmers. There are only 53% cooperative members in the sampled houses (Table 4).

Table 3. Summary of demographic and socioeconomic variables

Item		Non-contract farmers		Contract farmers		T-Test
		Average	SD	Average	SD	
Respondent age		43.40	11.10	46.00	11.10	-2.02**
Family members		6.88	3.00	7.77	3.02	-2.90***
Educational level of the household head (grade completed)		6.07	3.37	6.13	3.59	-0.18
Landholding (ha)		1.70	1.66	1.98	1.46	-1.77*
Malt barley farm size (ha)		0.66	0.60	0.83	0.52	-2.88***
Household income (Birr/year)		48045	51292	86203	58317	-6.80***
Distance to main road (Min.)		30.03	18.17	23.53	18.76	3.44***
Livestock size (TLU)		6.84	4.28	7.69	4.31	-1.94*
Amount of credit used (Birr)		179.28	472.79	707.96	946.92	-6.90***
Variable	Item	NCF	Percent	CF	Percent	$\chi^2 - \text{test}$
Gender	Female	8	4.12	12	6.32	
	Male	186	95.88	178	93.68	0.93
	Total	194	100	190	100	
Marital status	Unmarried	9	4.64	12	6.32	
	Married	185	95.36	178	93.68	0.52
	Total	194	100	190	100	
Participation of training	Yes	140	72.16	181	95.26	
	No	54	27.84	9	4.74	37.34***
	Total	194	100	190	100	
Association in cooperative	Yes	57	29.38	146	76.84	
	No	137	70.62	44	23.16	86.77***
	Total	194	100	190	100	
Getting to credit	Yes	24	12.37	70	36.84	
	No	170	87.63	120	63.16	31.09***
	Total	194	100	190	100	
Having improved seeds	Yes	154	79.38	164	86.32	
	No	40	20.62	26	13.68	3.24*
	Total	194	100	190	100	

Note: NCF: Non-contract farming; CF: Contract farming; ***, **, and * represent significant t-test results at 1%, 5%, and 10% levels, respectively; Source: Estimated from survey data

Table 4. Demographic and social networks

Item	List	Number of respondents		Non-contract farmers		Contract farmers		$\chi^2 - \text{test}$
		No.	Percent	No.	Percent	No.	Percent	
Gender	Female	20	5.21	8	4.12	12	6.32	
	Male	360	94.79	186	95.88	178	93.68	0.93
	Total	384	100	194	100	190	100	
Marital status	Unmarried	21	5.47	9	4.64	12	6.32	
	Married	363	94.53	185	95.36	178	93.68	0.52
	Total	384	100	194	100	190	100	
Participation of training	Yes	321	83.59	140	72.16	181	95.26	
	No	63	16.41	54	27.84	9	4.74	37.34***
	Total	384	100	194	100	190	100	
Association in cooperative	Yes	203	53	57	29.38	146	76.84	
	No	181	47	137	70.62	44	23.16	86.77***
	Total	384	100	194	100	190	100	
Getting to credit	Yes	94	24.48	24	12.37	70	36.84	
	No	290	75.52	170	87.63	120	63.16	31.09***
	Total	384	100	194	100	190	100	
Having improved seeds	Yes	318	82.81	154	79.38	164	86.32	
	No	66	17.19	40	20.62	26	13.68	3.24*
	Total	384	100	194	100	190	100	

Note: *** and ** represent significant t-test results at 1%, 5%, & 10% levels respectively; Source: Estimated from survey data

It is anticipated that loans and other extension services will facilitate input supply and liquidity while drawing in farmers and connecting them to coordinated market chains. Only twenty-five percent of the sample homes were likely to use financial services. Regarding the availability and utilization of financial services, there were notable distinctions between malt barley farmers: those who sold their crop through formal agreements had more access and utilization of financial services. Farmers selling their malt barley crop through official agreements accounted for 37% of the total, while their counterparts accounted for only 12%.

Results of Econometric Analysis

Factors Influencing the Adoption of Malt Barley Technologies and Their Extent

The study identified the type of bundle of technologies pertaining to malt barley production that was essential to reaping higher yields and revenues. Malt barley farmers described varieties of malt barley grown in the research area as indicated in Table 5. Application of inputs, such as the recommended fertilizers, is necessary for the production of improved varieties of malt barley. Next, the adoption and the extent of adoption of improved malt barley varieties and chemical fertilizers were then treated as dependent variables. The extent to which contract farming participation is associated with the introduction of malt barley production technologies. Farmers reported using five varieties, listed in descending order in Table 5: Traveler, Iboni, Sabini, Grace, and Holker.

The adoption of improved malt barley varieties was found to be distributed as follows: 10.16% non-adopters, 11.72% low-adopters, 19.53% medium adopters, and 58.59% high adopters, Table 6 below depicts this information in ascending order, based on the varieties of malt barley used by farmers. Similarly, Table 7 classified the intensity or extent of chemical fertilizer use into four categories: 3.65% non-adopters, 40.10% low-adopters, 28.91% medium adopters, and 27.34% high adopters.

The Tobit model was used to evaluate adoption intensity, which indicated the proportion of chemical fertilizers applied as a function of fertilizer advised per unit of farm size. Probability ratio statistics are utilized to ascertain whether the adoption of updated technology is based on the selected independent factors in the model (Table 8). As a consequence of the independent variables such as improved varieties and fertilizers being concurrently associated with the adoption of technologies pertaining to malt barley at p<1%, the results indicate that both models have strong explanatory power.

The intensity to which improved malt barley production technology (the package that comprises varieties and chemical fertilizers) adopted was positively and significantly associated with variables including contract farming, cooperative membership, and off-farm income. However, only the extent to which improved varieties exhibited a substantial beneficial association with access to and training. Besides, intensity of chemical fertilizer adoption was positively and significantly correlated with the availability of advisory services; however, the intensity adoption of more advanced seed varieties and fertilizer was negatively correlated with sex, age, household size, landholding size, livestock holding, and number of crops grown. The following section discusses each significant variable.

Sex of the Household Head

Sex of the household head is included as a dummy variable with expected gender differential effect of malt barley technology adoption (improved varieties and chemical fertilizers). It was statistically significant but negatively influences chemical fertilizer adoption intensity. It implies that a household headed by a woman was 10.5% less probability of fertilizer adoption intensity as compared to male headed household heads. The result is supported by Kassie et al. (2018) who indicate presence of gender inequality in access and use of technology, inputs and services especially in developing countries including Ethiopia.

Age of the Household Head

Age-related coefficient for the head of the household was negative and significant ($p<0.01$) in adoption of improved variety. That means while age of the household head increases but the intensity of adoption of enhanced malt barley varieties decreases. That is more probable for younger farmers to use better malt barley technology as compared to their older counterparts. This is also because older farmers are still bound to the traditional ways they trust, and probably due to their lack of using media to see different methods of crop cultivation and communicate with technologically experienced farmers.

The outcome is consistent with studies by Beyene and Kassie (2015) and Abate et al. (2018) who also found a negative effect of age on technology adoption associating it with short-planning horizons and risk averse that come with aging.

Table 5. Summary of improved malt barley varieties adoption

Name of varieties	Frequency	Percent
Traveler	184	47.92
Grace	21	5.47
Sabini	36	9.38
Holker	17	4.43
Iboni	56	14.58
Unknown	70	18.23
Total	384	100

Source: Analysis of survey data

Table 6. Distribution of level of adoption of improved malt barley varieties

Adoption index range	Adoption category	Total		Contract		Non-contract		χ^2 value
		Freq.	%	Freq.	%	Freq.	%	
0.00	Non-adopter	39	10.16	2	1.05	37	19.07	52.75^{***}
0.01 – 0.33	Low adopter	45	11.72	12	6.32	33	17.01	
0.34 – 0.66	Medium adopter	75	19.53	38	20.00	37	19.07	
0.67 – 1.00	High adopter	225	58.59	138	72.63	87	44.85	

Note: *** represent significant chi-square test at <1% levels respectively; Source: Estimated from survey data

Table 7. Distribution of level of adoption of chemical fertilizers

Adoption index range	Adoption category	Total		Contract		Non-contract		χ^2 value
		Freq.	%	Freq.	%	Freq.	%	
0.00	Non-adopter	14	3.65	4	2.11	10	5.15	8.55**
0.01 – 0.33	Low adopter	154	40.10	66	34.74	88	45.36	
0.34 – 0.66	Medium adopter	111	28.91	60	31.58	51	26.29	
0.67 – 1.00	High adopter	105	27.34	60	31.58	45	23.20	

Note: ** represent significant chi-square test at <5% levels respectively; Source: Estimated from survey data

Table 8. Tobit estimates of adoption and intensity of adoption of malt barley technology

Variables	Improved varieties			Chemical fertilizer		
	Coef.	Robust Std. Err.	dy/dx.	Coef.	Robust Std. Err.	dy/dx.
Sex	-0.019	0.074	-0.003	-0.105*	0.060	-0.033
Age	-0.004*	0.002	-0.001	-0.001	0.002	0.000
Education	-0.009	0.005	-0.001	0.001	0.005	0.000
Household size	0.005	0.005	0.001	-0.013**	0.005	-0.004
Landholding size	0.019	0.013	0.003	-0.107***	0.018	-0.033
Number of crops grown	-0.034**	0.017	-0.006	-0.018	0.016	-0.006
Livestock holding size	-0.002	0.005	0.000	0.015***	0.005	0.005
Contract farming	0.196***	0.036	0.034	0.152***	0.039	0.047
Mobile ownership	0.114**	0.048	-0.020	-0.028	0.036	-0.009
Malt barley farming experience	0.005	0.004	0.001	0.001	0.004	0.000
Access to extension services	0.012	0.038	0.002	0.103***	0.037	0.032
Access to training	0.075*	0.045	-0.013	-0.001	0.043	0.000
Cooperative membership	0.088**	0.034	-0.015	0.071*	0.037	0.022
Off/non-farm income	0.000***	0.000	0.000	0.000*	0.000	0.000
Access to credit	0.023	0.033	0.004	-0.028	0.037	-0.009
Constant	0.900	0.187		0.482**	0.202	
Sigma	0.301	0.013		0.289	0.014	
Log pseudolikelihood	-129.53			-135.45		
LR Chi^2 (15)	6.25***			7.89***		
Number of obs	384			384		
Pseudo R^2	26.36%			34.60%		

Note: ***, ** and * implies statistical significance at 1, 5, and 10% levels, respectively; Source: Analysis of survey data

Household Size

The variable household size is statistically significant ($p<0.05$) but negatively determine the extent that farmers adopt chemical fertilizer. The negative sign of the variable household size indicates that smaller households are more likely to adopt more production recommendations (high adopters) compared with the larger size households. One of possible explanation to this finding may be the fact that households with larger household members may be burdened with additional cost in meeting other household needs and as such may decline to incur more cost for fertilizer purchases. Consistent with this finding, Simtowe et al. (2016) also observed negative relationship between household size and adoption of pigeon-pea in Malawi. On the other hand, to the contrary of this finding, Danso-Abbeam et al. (2017) found household size positively influencing maize technology adoption in Ghana.

Farm Size

Research shows that the size of land holding directly correlates with the intensity to which crop production technologies are adopted. Yet, the result shows that malt barley farm size was statistically significant with negative influence only adoption of recommended fertilizers at ($p<0.00$). The notion is small land holders have a higher propensity to adopt recommended chemical fertilizers than large farm size holders. The finding agrees with Mengistu and Degefu (2017) who observed negative relationship between inorganic fertilizer adoption in wheat production and farm size in Ethiopia. However, other studies on impact of landholding size on improved technology also document significant positive correlation between land and the decision to adopt including fertilizer (Adedeji et al., 2013).

Livestock Holding (TLU)

Livestock holding in TLU found to positively and significantly determine chemical fertilizer adoption intensity. The idea is that households with larger livestock holdings were better equipped to manage any risks associated with the use of production methods, such as chemical fertilizers, and faced less difficulty affording agricultural inputs. The result was as expected and agrees with finding of Kassie et al. (2018) who indicate that livestock holding positively and significantly determined intensity of adoption of improved maize varieties in Ethiopia.

Number of Crops Cultivated

It is a proxy for plot fragmentation, and it was found to be statistically significant with negative coefficient, which implies that an increase in a number of crops cultivated by one crop, the likelihood of adoption of improved varieties was reduced by 3.4%. The implication was that farmers producing a wider variety of crops are less inclined to invest in capital-intensive technology for crops like malt barley. The result is in line with the finding by Sibhatu et al. (2015) who observed that number of plots owned by a farm household was inversely associated with adoption of wheat technology package in eastern Ethiopia.

Contract Farming Participation

A positive strong relationships was observed between improved varieties and chemical fertilizers adoption intensity and contract farming participation at ($p<0.00$). As the marginal effects showed that malt barley contracted farmers' intensity of adoption of more advanced cultivars as well as chemical fertilizers were 19.62% and 15.23% more than their non-contract malt barley farmers' counterparts respectively. The result meets the expectations and the findings of Maertens and Vande Velde (2017) and Ragasa et al. (2018) also found that contract farming significantly increased yield gains in staple crops like maize and rice in Ghana and led to a greater adoption of technology.

Mobile Ownership

The coefficient of mobile phone ownership was significant and positively determined the adoption intensity of improved varieties. Having access to mobile phone, the probability of adoption intensity for improved varieties increased by 11.22%. The finding is consistent both with the hypothesized sign and several studies that report similar findings that access to mobile phones enhance transferring knowledge and information to a household living in remote rural areas access and use of alternative source of information that positively affect adoption as well as the extent of adoption technologies in Ethiopia and elsewhere (Kaske et al., 2018; Van Campenhout et al., 2018).

Access to Extension Services

The results show that access to extension services of the household head possesses a noteworthy and favorable influence on chemical fertilizers. This is consistent with the expectation and prior studies of Mengistu et al. (2017) who observed positive and significant effect of access and use of advisory services in intensity of fertilizers adoption in eastern Ethiopia. But to the contrary, Degefu et al. (2017) reveal a negative influence of every day contact of farmers with extension officer in wheat technology adoption. Most likely, the farmer is being contacted repeatedly for similar extension and advisory service deliveries with minimal or no marginal benefits, or the extension officer is not providing desirable information and imparting knowledge along with access to inputs.

Training in Malt Barley Cultivation

Adoption intensity of malt barley varieties alone had been found to be impacted by access to training in malt barley cultivation. That is the involvement of farmers in relevant training programs give them access to knowledge regarding improved farm management methods and practices, as result training participants farmers were 7.54% more likely to allocate a greater proportion of their farms to improved technologies including new varieties than non-participants of training given on improved malt barley production methods. The result is consistent with the anticipated effect and prior studies such as Shiferaw et al. (2014) and Shiferaw et al. (2015) who show positive role of training to uptake of technologies in staple crops such as wheat varieties in Ethiopia.

Cooperative Membership

Both improved variety and chemical fertilizer adoption intensity were significantly and positively influenced by farmer cooperatives membership. Improved varieties use intensity among household heads that are cooperative members was 8.81% more per hectare than household heads that do not belong to farmer organization. Similarly, chemical fertilizer adoption intensity among farmers that belong to farm cooperative was 7.06% more than their non-member counterparts. The findings corroborated previous research showing farmer cooperatives, among other things, act as platforms for the dissemination of information, technology, and the facilitation of input and output markets (Mengistu and Degefu, 2017; Degefu et al., 2017).

Off-farm Income

The extent and extent of adoption of high yielding varieties and chemical fertilizers is positively and significantly determined by off-farm income earned by the household head. The idea is that a farmer may afford to buy chemical fertilizers and new varieties to increase productivity and output as their off-farm income increases. The result is consistent with research by Diiro (2013) and Gideon et al. (2017), which mention off-farm income as a way for farmers to overcome the financial barriers that rural households experience when adopting new agricultural technologies.

Conclusions and Policy Implications

This study deals with determinants of adoption of improved malt barley varieties and recommended chemical fertilizer on a sample of 384 farm household heads in Oromia region, Ethiopia. The Tobit regression model revealed that the intensity of adoption of both improved malt barley varieties and chemical fertilizers was positively and significantly determined by contract farming participation, cooperative membership, and off-farm income. Additionally, the intensity of adoption of chemical fertilizers is positively and significantly influenced by livestock holding size and access to extension services, whereas the intensity of adoption of improved malt barley varieties is positively and significantly determined by mobile ownership and training access. Once more, the intensity of improved varieties adoption decline with age and the number of crops produced; among female household heads, the intensity of chemical fertilizer adoption decreases with growing family and landholding sizes.

The findings of the study implies that a concerted effort ought to be made to enhance farmers based institutions that facilitate service deliveries for malt barley farmers that include contract farming participation, cooperative membership, and off-farm income so as to increase the adoption of improved varieties. Opening access to knowledge and information through better access to extension, training and mobile phones also lead to improved intensity of malt barley technology adoptions.

Declarations

Acknowledgment

The heads of farm households, agricultural experts, and extension agents are highly appreciated for their assistance in data collection and sharing their knowledge on farming practices. We also thank EIAR for funding this research.

Conflicts of Interest

There are no conflicts of interest related to the authorship and publication of this research manuscript

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