Determinants of intensity of bread wheat packages adoption in Tigary, Northern Ethiopia

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A R T I C L E I N F O	A B S T R A C T
	The aim of this study was to identify factors influencing the intensity of use of improved bread wheat package adoption in the study area. Two kebeles was selected randomly among the potentially wheat producing kebeles in each selected districts and a total of 120 randomly selected households were interviewed for this study. Tobit model was used to elucidate factors affecting adoption of technology packages. Result of the econometric model indicated, male headship (sex), TLU and multiple production objective orientation were important variables which had positively and significantly influenced adoption and intensity of adoption of improved bread wheat production package. Whereas, age of the household, increased annual off-non farm income, increased areas of own farm land, being far apart from the farmer training center and residences had shown negative relationship with adoption and intensity of adoption. The overall finding of the study underlined the high importance of institutional support such as extension; credit and market to enhance adoption of improved wheat production package. Therefore, policy and development interventions should give emphasis to improvement of such institutional support system so as to achieve wider adoption, increased productivity and income to small scale farmers.

Introduction

The economic development of Ethiopia is highly dependent on the performance of its agricultural sector since it is the main economic pillar of economic growth of the country. Agriculture 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). The sector is dominated by smallholder farmers (96%), where about 56% of the smallholder farmers possess less than one hectare of land (Taffesse et al., 2012; CSA, 2016). Despite its contribution to the GDP and export earnings, the sector's productivity is very low. In this regard, the research system, along with the other stakeholders, has to play a major role in improving technologies required to enhance agricultural productivity in the country (Biftu et al., 2016; Biftu and Diriba, 2016).

Efforts have been underway by the national agricultural research system since its establishment in 1956 and a number of technologies have been released for the farming community. In spite of these efforts, productivity gains are not as such adequate in the country. Low level of adoption of technologies is among the major reasons (Spielman et al., 2010; Hailu et al., 2014; Ahmed et al., 2014). Many technology adoption studies emerging in crop sub-sector revealed that the gain from adoption is not satisfactory compared to the expectations, and hence further interventions on factors impeding these are

suggested (Kotu et al., 2000; Dixon et al., 2006; Dercon and Christiaensen, 2011; Asfaw et al., 2012; Shiferaw et al., 2014; Ahmed, 2015; Jaleta et al., 2016; Yigezu et al., 2015; Beshir, 2016; Biftu and Diriba, 2016; Hagos, 2016; Seymour et al., 2016).

So far, the Tigray Agricultural Research Institute (TARI) has released a number of wheat varieties by its own and in collaboration with the national research institutes, but the productivity of wheat for the region is below the national average (CSA, 2013). This is mainly due to, among others, lack of farmers participation in variety selection processes (have low contact with researchers), lack of system to follow on demand driven and problem-oriented issues. Low level of adoption of crop technologies is also among the major factors contributing to low productivity (Mulatu et al., 2005; Cavatassi et al., 2011). This low level of adoption holds true for wheat technologies as well.

A lot of efforts have been done in the generation of improved varieties through the formation of Farmers Research Groups (FRGs), but generation of technology is not an end by itself, unless it reaches to the end users. Even though the district has high potential (agro-ecologically) for wheat production, a number of farmers are still using the old varieties that have been released before. These varieties are becoming highly susceptible to disease and their yield is also deteriorating from time to

time (because of the rust problems). On one hand, there are many high yielding and disease resistant improved bread wheat varieties released by Tigray Agricultural Research Institute (TARI) and Ethiopian Institute of Agricultural Research (EIAR). On the other hand, farmers of the district are still growing old varieties, and some reduce their plots allotted to wheat.

Moreover, Ethiopian government has been promoting a package-driven extension that combines credit, fertilizers, improved seeds, and better management practices (Bingxin et al., 2011). Given this scenario, technology adoption studies should take in to account package-based adoptions of technologies. For instance, wheat technology packages in East and Southeastern zones of Tigray include improved planting methods (row planting), improved varieties, appropriate use of inorganic fertilizers, and weeding practice. However, many of the adoption studies focused on a single component of the technology package (Croppenstedt et al., 2003; Asfaw et al., 2011; Beshir et al., 2012; Ahmed, 2015; Biftu et al., 2016). In such cases, it is difficult to have a clear understanding of the adoption of technology packages. Other existing studies on wheat technology adoption are broad and at national level (Shiferaw et al., 2014; Jaleta et al., 2015). These, in turn, have a limitation in terms of targeting solutions towards addressing policy interventions in specific contexts. Hence, the study is designed to identify factors influencing the adoption of wheat production technologies package by wheat producers in study area.

Material Methods

Description of the Study Area

Tigray National Regional State is one of the nine regional states forming the northernmost part of Ethiopia and bordered by Eritrea in the north, Sudan to the west, Amhara National Regional State to the southwest and Afar National Regional State in the east. It is located 12.5°15ʼ – 14° 50' N and 36° 27' – 39° 59ʼ E (Emiru Birhane et al., 2011**;** Gebre Hadgu et al., 2014). The study was done on two zones of Tigray region by selecting two districts in regard to their wheat potentiality. The districts are named Hawzen (Eastern zone) and Degua temben (South-eastern zone) See figure 1.

Hawzen: is found in the eastern zone of Tigray Regional State. Its located at 78 km away from Mekelle, the capital of the region to east direction and 861 km from Addis Ababa to south direction (Anonymous, 2014). It's found between 13°53'N and 13°50'N longitude and 39°26'E and 39°29'E latitude. The annual rainfall ranges between 500-700 mm with altitude ranging from 1500-2450 masl, and more than 60% is categorized as woina dega (i.e., midland areas). The main rain lasts from mid-June to mid-September, with temperature ranging from 12°C to 28°C (Fredu et al., 2008). It is the second most densely populated district from Eastern zone next to Atsbi Wonberta district. The population size of the district according TBPF (2010) is about 129,681 (62,787 males and 66,894 females) whom lived at 24 rural "kebeles" and one town, Hawzien. The district has a population density of about 67.8 persons per square kilometer–above the 61.6 persons per square kilometer average for the zone.

Degua Tembien: is one of the four rural woredas in South Eastern Zone of Tigray region that has 23 tabias: 22 rural tabias & 1 urban tabia. Its geographical location is in between 39°10' E longitudes & 13°38' N latitudes. Its area is approximately 1.125 sqkm. The land use pattern of the woreda shows that 19.472ha is cultivated land, 24.523ha is covered with forest and 68.508 ha is covered with bush & shrubs. According to 2007 census (CSAE. 2007), the woreda has 124.590 (115.815 in rural & 8.775 in urban) population and can be disaggregated by gender in Rural: Male 58.404, Female 57.411; in Urban: Male 4.025, Female 4.750. The total number of rural HHs in the woreda is 27.696. The woreda's climatic zones are lowland/kola/, temperate/weina dega/ & highland/dega/ with proportion of 26%, 30.5% & 43.5% of the woreda's area, respectively. The altitude of the woreda capital is 2618 meter above sea level. The daily weather condition ranges from 18°C to 25°C. The annual amount of rainfall ranges from 600–800 mm (Ayenew et al., 2011).

Sample size and Sampling method

A multi-stage sampling procedure was followed in selection of sample respondents. The wheat production potential of the regions is accounted for determining number of districts and kebeles to be used among the selected regions. In the first stage, list of major wheat producing districts were prepared in the region and sample districts were selected randomly. Second, two kebeles was selected randomly among the potentially wheat producing kebeles in each selected district. Thirdly, 30 HHs was selected in simple random sampling technique from each sample kebeles, finally a total sample comprising 120 wheat producer HHs was interviewed to undertake the survey.
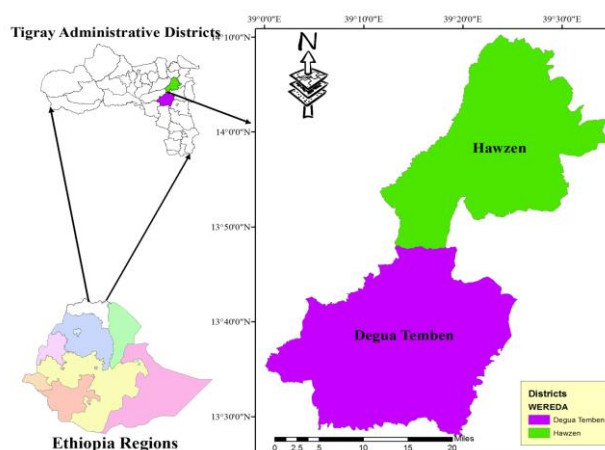

Figure 1 Map of the study area

Methods of Data Collection

Primary data were collected from the sample respondents on different issues such as farm household farm resources, farming practices and adoption of wheat production packages using structured interview schedule. Interview schedule was pre tested before the execution of the field survey on randomly selected farm households and the necessary amendments as ordering, wording of questions, and inclusion were made. Then, training was organized to enumerators on the content and interviewing technique. Additional information like recommended fertilizer rates were collected from secondary sources.

Analytical Technique

The quantitative data analysis and presentation involves the use of both descriptive statistics and econometric model. Descriptive statistics such as frequency distribution, measures of central tendency, was used to describe and present the characteristics of farming households.

Moreover, Selection of econometric model requires taking in to account the nature of the dependent variable, among others. The dependent variable, the adoption index, is a continuous value between zero and one in this study. A dependent variable which bears a zero value for a significant portion of the observations requires a censored regression model. Tobit model was employed to see the intensity of adoption of the package. According to Gujarati (1995) this model helps to examine the factors affecting adoption and intensity of use after the practice is adopted simultaneously. The Tobit model, therefore measures not only the probability that a farmer will adopt the new practice but also the intensity of use once it is adopted or of the introduced technology. Therefore, a direct application of the Tobit estimation sufficiently provides the needed information on the probability and intensity of adoption of wheat production package.

Following Maddalla (1997), the Tobit model can be defined as

$$AI_i = \begin{cases} AI_i^*, \text{if.} AI_i^* > 0 \\ 0, \text{if.} AI_i^* \leq 0, \ AI_i^* = \beta\chi_i + \mu_i \\ i = (1, 2, \ldots) \end{cases} \qquad (1)$$

Where: AI_i is the adoption index for i^{th} farmer, AI_i^* is the latent variable which is not observable, χ_i is a vector of factors affecting adoption and intensity of adoption, β_i a vector of unknown parameters need to be examined and μ_i is the error term which is normally distributed with mean 0 and variance σ^2.

The model parameters are estimated by maximizing the Tobit likelihood function of the following form (Maddala, 1997; Amemiya, 1985).

$$L = \prod_{AI_i^* > 0} \frac{1}{\sigma} f\left(\frac{AI_i - \beta_i\chi_i}{\sigma}\right) \prod_{AI_i^* \leq 0} F\left(\frac{-\beta_i\chi_i}{\sigma}\right) \qquad (2)$$

Where:
f : is the density function,
F   : is cumulative distribution function of AI_i^*,
$\prod_{AI_i \leq 0}$: is the product over those i for which $AI_i^* \leq 0$
$\prod_{AI_i > 0}$: is the product over those i for which $AI_i^* > 0$

Stata 12 software was employed to run the Tobit model.

Results and Discussion

Demographic Characteristics of The Sample Respondent

Descriptive results for continuous variables show that the average age of the respondents is 45.89 years with a standard deviation of 10.27. Moreover, the minimum and maximum ages of the respondents are 22 and 73 years

respectively. This shows that most of the sampled household heads were within their productive age bracket and actively involved in farm activities in the study area. It was hypothesized that farmers with younger age have more probability of adopting improved wheat technologies. About 23% of the respondents are female headed households. More than half percent about 67.49% of the sampled household heads were literate. With respect to the family size, the average family size of a household was 6.1. The maximum family size is 10 for the sample while the minimum is two persons. Which is larger than the national average of 4.6 persons per household (CSA, 2014).

Factors Influencing the Adoption and Intensity of Use of Improved Bread Wheat Production Packages

In order to get essential information and insight to what extent household, institutional and socio-economic factors are affecting intensity of wheat packages adoption conducting systematic study is quite pertinent. Hence, analysis of intensity of wheat packages adoption in the study area is an appropriate issue to be answered. For this purpose, intensity of wheat package adoption was organized by developing index of adoption (variety, fertilizer, weeding and row planting) based on the package adopted by each household. The table below reports determinants of intensity of wheat packages adoption using Tobit model. The likelihood ratio chi-square of 250.35 with a p-value of 0.00 tells us that our model is the best fit. As can be seen from table result there are 8 (eight) important variables that are statistically significant and explain the intensity of wheat packages during 2015/2016 production season.

Among the 16 independent variables seven of them being (male headship (sex), livestock size (as measured by TLU) and multiple production objective orientation were found to influence intensity of wheat package adoption positively. While increased in age of the household, increased annual off-non farm income, increased areas of farm land, being far apart from the farmer training center and being residences of *D/Tembeine* were found to influence adoption of wheat packages negatively implying farmers who are in favor of these variables were less likely in adopting the aforementioned wheat packages. Since the dependent variable (intensity of adoption) used in the *Tobit* model in level, the marginal effects are marginal adoption index as well.

Gender of the household head: Gender of the household head influenced positively and significantly intensity of wheat package adoption. At margin being male headed household the probability of wheat adoption intensity increases by 15 percent and vice-versa for female headed households. This implies that male-headed households have a higher probability of wheat packages adoption intensity than their counterparts perhaps this could be because of the pre-existing economic difference. In most cases it is believed that men and women have differential roles in small-scale farming. Accordingly, they face different problems and farming constraints and aspired technologies that can address these problems. Given these state of affairs, being male or female in heading the household, in the subsistence agriculture,

matters a lot in terms of adoption decision. This finding is similar with the finding of Pender et al., (2004), on land management practices in Tigray Region. The implication of this finding reflects the presence of gender differentials with respect to wheat packages adoption intensity within the farming community of the study area and calling for gender sensitive strategies in promoting yield enhancing agricultural technologies. Besides this also confirms the finding of Tadesse (2008), Ahmed (2010) and Yemane (2010) and consistent with the prior expectation that male headed households are performing more production activities than the female headed households. Also the studies by Doss et al. (2001), and Bingxin and Alejandro (2014) found that male-headed households were found to be more likely to use improved wheat varieties than female headed households.

Age of the household head: The result of the *Tobit* model showed that age was negatively related with wheat package adoption intensity. The coefficients this variable was significant at less than 1% probability levels implying that as farmer gets older the probability of adopting wheat packages becomes decreased by 0.95 %. The model result showed that younger households are more likely to adopt wheat packages than old aged ones. This could be due to labor constraint old aged encounter might enforce them to adopt relatively less labor intensive single technologies than packages that are more suit to younger aged household heads. The possible explanation behind this finding might be, having more adult labor force within a given household enables land user to adopt wheat packages that needs relatively more labor force. The negative sign shows that as the age of the household increase, the probability of the household to adopt improved wheat varieties will decrease. This result is congruent with the study by Bingxin et al. (2011), Asfaw et al. (2011), Hailu et al. (2014) and Jaleta et al. (2015) found a negative influence of age on adoption of technology confirming the younger age groups are adopters compared to their counterpart, the elders.

Livestock size: Number of livestock owned as measured by TLU (All livestock are converted to Tropical Livestock Units=TLU, 1 TLU is equals to 250 kilo gram Strock et al., 1999) has a significant and positive influence on the intensity of wheat package adoption. Around the mean value of the variables, increases in the quantity of TLU by one unity increase level of adoption by 2.9 percent. The implication for this result is indicates that, greater ownership of livestock promotes intensive farming practices as this smooth financial constraints to purchase the component packages and hire additional labor during peak agricultural seasons. Those farmers who owned big number of tropical livestock unit had positive influence on the intensity of wheat package adoption and significantly at (P<1%). The finding of this result is in conformity with the result of Ahmed (2010) on determinants of adoption of improved durum wheat (*Triticum durum*) varieties in the highlands of bale. Tesfaye et al. (2010) revealed the positive relationship of livestock holding and technology adoption in Yelma Dansa and Farta Districts of Northern Ethiopia. In addition, Birhanu (2002) indicated as livestock ownership increases adoption/intensity of adoption and correlate positively.

Crop production objectives: At the same time controlling for other factors, at the margin, the probability of wheat package adoption intensity increases by more than 6.7 percentages point (P<1%) as the household head becomes both consumption and market oriented rather than those with single objective either consumption or market.

Distance from farmer training centre: It influence adoption intensity negatively and significantly. Based on the model result the coefficient of this variable is negative and also statistically significant at less than 5 percent probability in influencing the intensity of adoption. At margin as farmers being far apart by hours the probability of wheat package adoption intensity decreased by 0.24 percent. Perhaps as a farm households are far and far from FTC it is expected to be less likely to get information and to participate in intensive farming activities that demands better social networking. The result is in agreement with findings by Alemitu (2012), Minyahil (2008) and Bayissa (2010). Moreover, this result is also in line with results of a prior study conducted by Asfaw et al., (2012) which had revealed a negative influence of distance from office of agriculture on technology adoption.

Location: Being living in D/Temben the probability of adoption intensity decreased by 18 percent (P<1%) and vise- versal for *Hawzen* district. This might be due to differences in the quality and quantity of agricultural extension services delivered in the areas resulting differences in knowledge, skill and attitudes of improved wheat packages. The result depicts that location matters in adoption of wheat technology package. Other studies on crop technology adoption at various levels also depict the effect of variations in districts on adoption (Asfaw et al., 2011; Asfaw et al., 2012; Croppenstedt et al., 2003; Jaleta et al., 2015; Kaleb and Negatu 2016).

Farm size (Land size): Farm size has a significant and negative influence on the intensity of wheat packages adoption at less than 5 percent significant level. At margin, around the mean value of the variables, increases in farm size by one hectare results decrease level of adoption by 15 percent. The negative relationship between size of holdings and the probability of adopting wheat packages might be due to the labor-intensive and capital intensive nature of package approaches and resulting difficulty for poor households despite their holding sizes. This could be due to the fact that as the area of available farmland increases, there is a tendency for the farmers to go into multiple cropping, thereby reducing the land for wheat production. This is in agreement with the findings of Roos et al., (2000), Breen et al., (2009) and Rämö et al., (2009) on perennial energy crop adoption, but contrary to the findings of Doss and Morris (2001) for the adoption of inorganic fertilizer. A similar finding was also reported by Alen et al., (2000) and Asfaw et al., (2011) on adoption of crop technology components.

Annual off-non-farm income: Around the mean values of the variables, an increase in annual income by 1 Ethiopian Birr (1 Ethiopian Birr is equivalent of 0.0365 US Dollar, National Bank of Ethiopia accessed on March 25, 2018.) reduced intensity of wheat packages adoption by around 4.7 factors; probably this might be due the shift in non-agricultural tasks (See Table 1).

Conclusion and Recommendations

Conclusion

This study was conducted in order to assess adoption and intensity of use of bread wheat technology package. Bread wheat technology package consider in this study consisted of improved bread wheat varieties, fertilizer, row planting and weed management. The results of the econometric model indicated the relative influence of different variables on intensity of use of bread wheat technology package.

A total of sixteen explanatory variables were included into the model of which eight of them had shown statistically significant influence on the intensity of use of bread wheat technology package. Accordingly, sex, TLU and crop production objective were found to have positive significant effect on the adoption and intensity of use of bread wheat technology package. On the other hand, age, farm size, annual off & non-farm income, location and FTC distance had shown negatively and significant influence on the intensity of use of bread wheat technology package.

Table 1 Tobit model results on intensity of use of improved bread wheat production packages

Variable	Coef.	Std. Err.	t-value	P-value
Sex	0.1512***	0.0505	0. 2.99	0.003
Age	-0.0065***	0.0021	-3.03	0.003
Male_family	0.0051	0.0144	0.35	0.725
Female_family	0.0020	0.0154	0.13	0.896
Educgrade	-0.0042	0.0069	-0.61	0.546
TLU	0.0293***	0.0056	5.25	0.000
oxen	0.0467	0.0287	1.63	0.107
Total land size	-0.1448**	0.0714	-2.03	0.045
Own land	0.0002	0.0002	1.22	0.226
Off_non_farm_income	-4.70e-06*	2.79e-06	-1.68	0.095
Crcredit	0 .0302	0.0365	0.83	0.410
totconext14_onwheat	-0.0001	0.0015	-0.04	0.972
FTC_distance	-0.0025**	0.0011	-2.21	0.029
Market_Distance	-0.0003	0.0005	-0.59	0.555
Distact_name	-0.1822 ***	0.0389	-4.68	0.000
crop_sowing_objective	0.0651***	0.0201	3.24	0.002
Constant	1.6714***	0.2225	7.51	0.000
Sigma	0.18208	0.0120477		
Tobit regression	Number of obs = 116, LR chi2(16) = 250.35, Prob > chi2 = 0.0000			
Log likelihood = 30.906227	Pseudo R2 = 1.3279			

Source: Model output, *, ** and *** represents significance at 10%, 5% and 1% level respectively.

Recommendation

The results of the study indicate that age of household head influences the intensity of adoption of bread wheat packages negatively and significantly. Younger farmers are more likely to adopt adopters of bread wheat packages. Hence, introduction of new agricultural technology in the area may be successful if it focuses on younger farmers.

As it is confirmed in this study distance of DA office from the farmers' home has an influential effect on adoption and intensity of adoption. Therefore, attention should be given to the close assignment and placement of DAs to the rural villages where the farmers can get them easily for extension advises and supports for better adoption. Farmers' perception of the bread wheat technology package is another very important characteristic that fosters the adoption process. Research and development activities should be geared towards generating bread wheat technology package that can easily be established using low soil moisture/ drought tolerant varieties.

In general, the result of this study indicated that adoption and intensity of use of bread wheat technology package was the result of many interplay of several factors, which needs much due attention by the stockholders in the provision of different packages like improved varieties, fertilizing, row planting and weed management need to be integrated to achieve a sustainable production system.

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