Determinants of households’ willingness to pay for improved teff seed in Yilmana-Dinsa Woreda, Northern Ethiopia

Yaregai Tilahun1* and Benyam Tadesse

Abstract: The willingness of farmers to pay for improved teff seed has positive effects on utilization of improved teff which increases agricultural production, productivity rural household income. However, the extent to which the willingness of teff producers to pay for improved teff seed was not studied in the study area. Hence, the primary goal of the study was to examine the willingness to pay for improved teff seed in Yilmana-Dinsa woreda, West Gojjam Zone. To collect quantitative and qualitative data, both primary and secondary sources were employed from 121 sampled respondents. The data were examined using expressive and inferential (t-test and chi-square test) statistics and econometric model (bivariate probit). The result showed that 79.3% of sampled farmers were willing to pay the seed and the value of mean willingness to pay from both double bounded dichotomous choice and open-ended questions was 26.89 and 32.67 birr per kilogram, respectively. The results of the bivariate probit model showed that sex, education level, extension contact, on-farm income, and credit have taken have a positive and significant effect, while off-farm income and initial starting bed have a negative and significant effect on the willingness of farmers to pay improved teff seed. Based on the findings government and other stakeholders need to focus on strengthening...
Improved seed access through organized seed systems that comprehend all actors and promising cultivars through a well-established national extension and credit system to fill the current seed system gaps.

Subjects: Agriculture & Environmental Sciences; Environmental Management; Environment & Economics; Biodiversity & Conservation; Economics; Macroeconomics; Microeconomics; Economic Forecasting; Environmental Economics

Keywords: Bivariate probit model; WTP; teff; improved seed; determinants

1. INTRODUCTION

The Ethiopian economy heavily depends on agriculture as the foremost basis of employment, income, and food security for the enormous popularity of the population. The agriculture sector contributed 20.6% for poverty reduction (Agricultural Transformation Agency (Agricultural Transformation Agency (ATA), 2017), 37.2% to the GDP and 78% to export income, and employment opportunity for 75% to male and 59% to the female population in the country (World Bank Group, 2016). Besides this, it plays a vigorous role in reducing food insecurity and in raising the income of 12 million farmers in the country (Semreab, 2018). Diversifying and increasing agricultural production through increase improved seeds can aid to overwhelmed hunger and deficiency by enhancing household production and productivity (Abebe & Bekele, 2015; Asfaw et al., 2011; Taffesse et al., 2013) and create new market opportunities for smallholders (A. Teshome & Jochen, 2016).

Despite its contribution to the national income and poverty reduction, the farming system of smallholder farmers in Ethiopia is subsistence. Smallholder farmers are cultivating 95% of their farmland (Gebre-Selassie & Bekele, 2012) using mostly traditional farming practices (Bayissa, 2014; S. Teshome & Tegegne, 2017) and inadequate improved technology (Semreab, 2018) be found in the low productivity Ethiopian agriculture (Zerihun et al., 2014). Furthermore, the majority of the agriculture sector is made up of smallholder farmers who cultivate a maximum of 1.17 hectares of land (WB (World Bank), 2013). This is mainly true for the major food crops grown up in the country (S. Teshome & Tegegne, 2017).

Major crop categories include cereals, pulses, and oilseeds, which are not only constituted the major food crops for the majority of the country’s population but also served as a source of income at the household level and a contributor to the country’s foreign currency earnings. Teff (Eragrostis teff (Zucc.) Trotter) is the utmost significant native cereal crop in Ethiopia which is a very labor-intensive crop (Ferede, 2013) grown by 48% of Ethiopian farmers next to maize in terms of production (CSA (Central Statistical Authority), 2016). It has accounted for one-third of the cultivated area and one-fifth of the total production of all cereals grown in Ethiopia (Vandercasteelen et al., 2013). It is mainly grown in West and East Gajjam zones of the Amhara region and East, West and North West Shewa zones of Oromia regions (CSA (Central Statistical Authority), 2019).

Agricultural production in general and teff production, in particular, could be boosted either through increasing the farm size or through improving adopted improved agricultural inputs (Beshir & Wegary, 2014; Mignouna et al., 2011). However, due to limited agricultural inputs and land scarcity in Ethiopia, the feasible way to achieve this goal is through delivering improved seeds and technical efficiency (Ferede, 2013; Feyisa, 2020; Hailu et al., 2014; Mekonnen et al., 2017; Semreab, 2018; S. Teshome & Tegegne, 2017). However, due to the low willingness of farmers to adopt available improved varieties by smallholder farmers Ferede (2013), there is a significant gap occurrence between potential teff yield and actual farmer’s yield (S. Teshome & Tegegne, 2017). So, the appropriate and recommended amount of improved seed through improving households’ willingness for paying improved seed can able to achieve greater productivity and sustainability at the household level (Addis et al., 2019; Tilahun, 2018).
The adoption of improved agricultural inputs by crop producers in Ethiopia has a long-term concern by extension agents, researchers, and other stakeholders for raising agricultural production and yield (S. Teshome & Tegegne, 2017). However, several area-specific pieces of evidence indicate that the adoption rate and willingness of farmers to pay for modern agricultural inputs in the country is very low (Abewab & Belay, 2001; Taffesse et al., 2013; Hailu et al., 2014) due to limiting factor of slow dissemination and low rate adoption of improved teff varieties (Ferede, 2013; S. Teshome & Tegegne, 2017). As a result, the actual productivity of teff is lower than the potential productivity due to the limited adoption of improved technologies (Gebru et al., 2020; Mulugeta, 2011; Tesfaye et al., 2016).

To enhance the productivity of teff production; improvement of improved seed is essential through raising farmers’ willingness for improved technologies using both conventional and modern breeding techniques (Ayana, 2017). However, the willingness of farmers to pay for improved technologies is a function of farmers’ knowledge, attitude, and intention (Aryal et al., 2009; Gonfa, 2015). The decision of farmers to pay for improved seed is affected by various factors which may be specific to socio-cultural, geographical, and agro-ecological zones (Gonfa, 2015; Lunduka et al., 2019; Minten et al., 2013). In addition, the accessibility of the market with the price of input influences the behavior and willingness of farmers to pay for improved seeds (Emuru, 2015; Munthali, 2013).

There have been extensive research studies have been performed on teff management strategy in different agro-ecology zones (Mihretie et al., 2021), utilization of teff for human food (Barretto et al., 2021; Cheng et al., 2017), and livestock feed (Assefa & Nurseta, 2013), economic feasibility (Ferede, 2013), the impact of teff on household income (Tamirat, 2020; Vandercaesteelen et al., 2016; Yonas, 2006), anticipatory demonstration of improved teff variety (Gemechu & Alemu, 2016), the role of teff to Ethiopian economy (Hassen et al., 2018), the efficiency of teff production (Endalew et al., 2021; Wake, Yami, Bekele et al., 2019b), analysis of teff value chain (Nitsuh, 2019), adoption of teff seed (Debelo, 2015; Semreab, 2018; S. Teshome & Tegegne, 2017). So far, there have not been any empirical studies on determinants of farmers’ WTP for improved teff seeds in Ethiopia in general and in the study area in particular. Therefore, this study aims to contribute to addressing this research gap. With this background, this study was intended to investigate the determinants of farmers’ WTP for improved teff seed in Yilmana-Dinsa Woreda, Northern Ethiopia.

2. Research methods

2.1. Description of the area
Yilmana-Dinsa Woreda is one of the fifteen Woredas in the West Gojjam Zone of the Amhara region on which the economic base of the population is dependent on crop production. Regarding population, almost 96.8% of them are employed in agricultural production activities and the remaining 3.2% of the population are participating out of agricultural production activities like trading, animal fattening and distilling of local alcohol. Attitudinally, the district ranges from 1500 to 2999 masl. Except for few hills (which is a major problem in the area), the woreda has agriculturally suitable land in terms of topography. The agro-ecological conditions of Yilmana-Dinsa districts are suitable for the production of cereals and grain legumes. About 87% of land area in districts lies in mid-highland (woinadega) whereas the remaining 12% is highland (dega) and less than 1% lowland (Kolla). The districts have monomodal rainfall distribution with average annual rainfall reaching 1006 mm.

2.2. Sources and data collection methods
The study was conduct based on both primary and secondary data. The primary data were composed by using a formal survey from a sample of farmers in the study area through both open and closed-ended questionnaires using face-to-face interviews. Before the data collection, the questionnaires were pre-tested on eight households to assess the correctness of the proposal,
simplicity, clarification, and significance of the question. Subsequently, appropriate modifications and corrections were prepared for the questionnaire depending on their answer. Enumerators who have a college diploma and working in the district were hired and trained about the intention of the study and on the techniques of data collection. In addition to sampled household questionnaires, group discussions and key informants discussions were assessed to acquire further assistance information for the study.

In addition to primary data, secondary data were collected from different sources by reviewing documents such as reports and databases of government institutions, the district agricultural office, district agricultural trade and industry office, and websites. Published and unpublished documents were reviewed to secure relevant secondary information. Besides district offices information, websites were visited to generate relevant secondary information focusing on WTP for teff seeds.

2.3. Method of sample size determination

Two-stage sampling procedures were used for selecting sampled household heads. At the first stage, three teff-producing kebeles were selected randomly. In the second stage, from the selected kebeles, about 121 sample households were nominated randomly from each kebele through probability proportionate to size sampling techniques. Yamane (1967) was used to determine the selected sampled households. Accordingly, the required sample size at 95% confidence level with the level of precision equal to 9% was used to determine the sample size required to represent the population.

\[
\begin{align*}
 n &= \frac{N}{1 + N(e)^2} \\
 &= \frac{5893}{1 + 5893(0.09)^2} = 121
\end{align*}
\]

Where: \( n \) = sample size \( N \) = population size \( e \) = level of precision (9%)

2.4. Methods of data analysis

The data which was collected from primary and secondary sources were analyzed using descriptive statistics, inferential statistics, and econometric models. Descriptive statistics like average, frequency, standard deviation, and percentage were used to describe demographic, and socio-economic characteristics of the sampled respondents. Inferential statistics such as chi-square and t-test were used to see the existence of significant mean or percentage difference between willing and non-willing households in terms of the hypothesized independent variables on the initially offered bid.

While in an econometric model, the bivariate probit model was used to identify both factors affecting the WTP of households for improved teff seed and to estimate the parametric MWTP of farmers for improved teff seed. The model is used to explain the willingness to pay, with the hypothesis of two decisions in the double bounded reply and their error terms are interconnected and this increases estimation efficiency. The sampled farmers are issued a two-level bid in the double bounded dichotomy modeling approach, where the subsequent bid is dependent upon the reply to the first bid. The respondent farmer either to receive or discard the initial bid depends on his or her utility derived from the different scenarios. The general expression for the model is formulated following Greene (2003) two related equations:

\[
\begin{align*}
 Y_1 &= \alpha_1 + \beta_1 X_1 + \sum_{j=1}^n \beta_j X_j + \epsilon_1 \\
 Y_2 &= \alpha_2 + \beta_2 X_2 + \sum_{j=1}^n \beta_j X_j + \epsilon_2 \\
 \text{Corr}(\epsilon_1, \epsilon_2) &= \rho
\end{align*}
\]

Where: \( Y_1 \) and \( Y_2 \) are the binary responses to the WTP questions; \( B_1 \) and \( B_2 \) are the bids in the first and second bid questions; \( X \) represents explanatory variables and \( \alpha's \) and \( \beta's \) are the coefficients to
be estimated. The explanatory variables of model 1 can be different from the explanatory variables of model 2. But in this study, the explanatory variables of both models are the same \(X_i = X_j\).

In general, there are four possible outcomes: both answers “yes”; both answers “no”; “yes” followed by a “no”; and “no” followed by a “yes”. The probability that the respondent \(j\) answers to the first bid and the second bid given by (Haab and McConnell, 2002):

1. \(t^1 \leq \text{WTP} < t^2_{(\text{min})}\) for the yes-no responses;
2. \(t^1 > \text{WTP} \geq t^2_{(\text{min})}\) for the no-yes responses;
3. \(\text{WTP} \geq t^2_{(\text{max})}\) for the yes-yes responses;
4. \(\text{WTP} < t^2_{(\text{max})}\) for the no-no responses;

Following Haab and McConnell (2002), the econometric modeling for the formulation of double-bonded data is given as:

\[
\text{WTP}_{ij} = \mu_i + \epsilon_{ij}
\]

Where \(\text{WTP}_{ij}\) is the \(j^{th}\) respondents WTP and \(i = 1, 2\) represents first and second answers;

\(\mu_i = \text{mean value for the first and second answer; } \epsilon_{ij} = \text{unobservable random factor.}\)

The likelihood of correctly interpreting each of the two-bid answer sequences (yes–yes, yes–no, no–yes, no–no) can be represented as follows.

\[
\begin{align*}
\Pr\text{ (yes, no) } &= \Pr(\text{WTP}_{ij}\geq t^1, \text{WTP}_{ij}<t^2) \\
\Pr\text{ (yes, yes) } &= \Pr(\text{WTP}_{ij}>t^1, \text{WTP}_{ij}\geq t^2) \\
\Pr\text{ (no, no) } &= \Pr(\text{WTP}_{ij}<t^1, \text{WTP}_{ij}<t^2) \\
\Pr\text{ (no, yes) } &= \Pr(\text{WTP}_{ij}<t^1, \text{WTP}_{ij}\geq t^2)
\end{align*}
\]

The \(j^{th}\) contribution to likelihood function becomes:

\[
\begin{align*}
L_j(\mu/t) &= \Pr(\mu_1 + \epsilon_{1j} \geq t^1, \mu_2 + \epsilon_{2j} \geq t^2)^{YN} \\
Xpr(\mu_1 + \epsilon_{1j}>t^1, \mu_2 + \epsilon_{2j} \geq t^2)^{YY} \\
Xpr(\mu_1 + \epsilon_{1j}<t^1, \mu_2 + \epsilon_{2j}<t^2)^{NN} \\
Xpr(\mu_1 + \epsilon_{1j}<t^1, \mu_2 + \epsilon_{2j} \geq t^2)^{NY}
\end{align*}
\]

Where \(t^1 = \text{first bid price, } t^2 = \text{second bid price}\)

\(YN = 1\) for yes–no answer, 0 otherwise;

\(YY = 1\) for yes–yes answer, 0 otherwise

\(NN = 1\) for no–no answer, 0 otherwise;

\(NY = 1\) for no–yes answer, 0 otherwise.
The formula set above (bivariate discrete choice model) assumes a normally distributed error terms with a mean of zero and respective variances $\sigma_1^2$ and $\sigma_2^2$, then WTP$_{y1}$ and WTP$_{y2}$ have a bivariate normal distribution with means $\mu_1$ and $\mu_2$, variances $\sigma_1^2$ and $\sigma_2^2$, and correlation coefficient $\rho$. The $j^{th}$ contribution to the bivariate probit likelihood function is given as:

$$L_j(\mu/t) = \theta_1e_2(y_1, y_2)$$

Where: $\theta_1e_2 = \text{the bivariate normal cumulative distribution function with zero means}$

$$d_{y1j} = 2y_{1j} - 1, \text{ and } d_{y2j} = 2y_{2j} - 1$$

$y_{1j} = 1$ if the response to the first question is yes, and 0 otherwise

$y_{2j} = 1$ if the response to the first question is yes, and 0 otherwise

$\rho = \text{correlation coefficient}$

$\delta = \text{standard deviation of the error.}$

After running a regression of dependent variable (yes/no indicator), depending on the normality assumption of WTP distributions, the mean WTP value is determined as follows:

$$\text{MWTP} = \mu = -\frac{\alpha}{\beta}$$

Where MWTP = the mean willingness to pay for improved teff seed; $\alpha$ = coefficient for constant (intercept) term, $\beta$ = is the coefficient of the “bid” value posed to the respondent in the bivariate probit regression model. The explanatory variables used in the model were described in (Table 1).

3. Results and discussion

3.1. Socioeconomic characteristics of sampled respondents

Data from 121 respondents were utilized for the analysis purpose. Out of the total sampled respondents, 79.3% were willing to contribute to the pre-specified initial bid offered and 20.7% of the households were not willing to contribute to the initial pre-specified bid offered. Overall, the socioeconomic characteristics of sample households are described as follows.

3.1.1. Sex of the household head

The result in (Table 2) showed that out of 121 total sampled respondents in the target area 96 (78.1%) respondents were a willingness to pay improved teff seed whereas the remaining 25 (20.6%) respondents were not willing to pay in the study area. From the total of willing respondents, 81 were males and 11 were females. While out of non-willing respondents 18 were males and 9 were females. The result of the chi-square test showed that there was a significant variation between willing and non-willing respondents at a 5% level of significance.

3.1.2. Access to training

From the total respondents surveyed, about 82.6% of the households can get access to training and information from those who are willing to pay improved seed and 23.3% did not get access to training from those who are not willing to pay. The value of chi-square ($\chi^2$) in (Table 2) indicated that there was a substantial difference among household heads who had access to training and those who did not have a concerning willingness to pay for improved seed.
### Table 1. Summary of independent variables and their effect of maximum willingness to pay

| Variables                        | Data type    | Measurement | Hypothesis |
|----------------------------------|--------------|-------------|------------|
| Sex of the household heads       | Dummy        | 1 if male, 0 if female | ±ve        |
| Family size of household heads   | Continuous   | Number      | +ve        |
| Education level of household heads | Continuous  | Years       | +ve        |
| Farming experience               | Continuous   | Years       | +ve        |
| Amount of credit token           | Continuous   | Birr        | +ve        |
| Frequency of extension contact   | Continuous   | Number      | +ve        |
| Distance to the nearest market   | Continuous   | Kilometers  | -ve        |
| Off/non-farm income              | Continuous   | Birr        | ±ve        |
| Land allocated for teff production | Continuous  | Hectares    | +ve        |
| Access to training               | Dummy        | 1 if Yes, 0 if No | +ve       |
| Ownership to transport facility  | Dummy        | 1 if Yes, 0 if No | +ve       |

#### 3.1.3. Age of the household head

The result in (Table 2) revealed that the mean age of sample respondents was 41.1 years. The mean age of households who can will to pay and non-willing to pay was found to be 42.6 and 40.1 years respectively. The outcome of the t-test revealed that there was a statistically significant variation in the mean average age of willing and non-willing households at a 1% significance level. This underlines that age difference is an important component in willingness to contribute decisions.

#### 3.1.4. Level of education

The result shows that the mean of years that the household head spent in school from the total sampled respondent was 2.37 and from those of the willing respondents was computed to be 3.72 years and from those of non-willing respondents was 1.02 years. The outcome of the t-test showed that there was a significant variation between willing and non-willing households at a 1% significance level in terms of the educational status of the respondents. This implies that the educational level of the respondents was among the most factors for household heads on the informed decision capacity for the usage of improved teff seed.

#### 3.1.5. On-farm income

The mean annual income of the total sample households that were collected from farm activities was found to be 30.89 thousand with a minimum of 4.5 thousand and a maximum of 78 thousand. The total mean annual cash income obtained from households who are willing to pay for improved teff seed was greater than the average annual income of those households who were not willing to contribute to pay. The t-value in (Table 2) showed that there was a significant variation in the mean total income between the willing and the non-willing households. This implies that households’ income has a significant impact on their willingness to pay for the presumably better teff seed.


### Table 2. Summary statistics of independent variables by willingness status for the initial Bid

| Variables              | Willing (N = 96) | Non-willing (N = 25) | Total (N = 121) | Min. | Max. | Test statistic (t, chi²) |
|------------------------|------------------|----------------------|-----------------|------|------|-------------------------|
| Sex                    | 87.5             | 66.7                 | 78.04           | 0    | 1    | 18.37**                 |
| Access to training     | 82.6             | 23.3                 | 53.71           | 0    | 1    | 27.65***                |
| Age                    | 42.67            | 40.13                | 41.1            | 23   | 65   | 6.26**                  |
| Level of education     | 3.72             | 1.02                 | 2.37            | 0    | 10   | -10.72***               |
| Farming experience     | 22.46            | 26.04                | 24.25           | 3    | 29   | 5.94                    |
| Family size            | 6.75             | 5.89                 | 6.32            | 2    | 11   | 0.97                    |
| Farm size              | 2.89             | 3.45                 | 3.17            | 0.75 | 5.37 | -1.68                   |
| On-farm income         | 43,267           | 18,523               | 30,895          | 4,500| 78,000| -12.74***              |
| Off-farm income        | 2,382            | 4,576                | 3,479           | 800  | 11,500| -2.08                   |
| Extension contact      | 2.56             | 1.02                 | 1.23            | 0    | 14   | 4.1                      |
| Initial bid            | 17.86            | 26.58                | 22.23           | 14   | 29   | -8.86***                |
| Credit use/ taken      | 5,685.4          | 456.8                | 30,711.1        | 0    | 11,500| -13.08**                |
| Distance to market     | 3.78             | 4.84                 | 4.31            | 0.32 | 6.5  | 0.96                    |

***, ** implies statistically significant at 1% and 5% significance level. NB: t-test is for continuous variables and chi²-test is for categorical variables in the test statistics.

Source: Own survey result, 2021

3.1.6. Frequency of extension contact

The result indicated that the total mean contact of sampled teff seed users with extension agents was 1.79 days with a minimum and maximum of 0 and 4 days per month, respectively (Table 2). The mean number of extension contact per month for willing households was 2.56 days and that of the non-willing households was 1.02 days. The mean extension contact difference among willing and non-willing sampled respondents were statistically significant at a 1% probability. This implies that access to extension contact had an important role in households' decision to invest more in improved seed that is designed hypothetically to increase productivity and income.

3.1.7. Amount of credit taken

It is one of the building blocks of developmental institutions mainly for alleviating financial constraints thereby increasing the need for household improved seed. The average credit taken by willing households was 5,685.4 birr while the average credit taken by non-willing households was service 456.8 birrs. At a 5% level of significance, the t-test revealed that there was a significant difference in credit service between willing and non-willing households. This suggests that the willing households had easier access to finance and were able to purchase better seeds than their counterparts.

3.1.8. Initial Bid value

Before implementing the final survey, the pilot survey was conducted using an open-ended elicitation format to set up starting bids and decide on their payment. The statistical results of the bid distribution reveal that the mean value of the initial bid for the willing respondents was 17.86 whereas the mean value of the initial bid for the non-willing respondents were 26.58. The
chi-square ($\chi^2$) results in (Table 2) above showed that there was a significant variation between the willingness status of households and the value of the initial bid offered at a 1% probability level. This underlines that the opening bid price difference is an important component in the desire to pay to a decision.

3.2. Determinants of farmers willing to pay
In addition to the descriptive statistics, we have estimated an econometric model to determine the relationship between various socioeconomic variables and farmer's desire to pay for improved teff seed. However, to run the model, the proposed explanatory variables were checked whether multicollinearity is present or not. The result showed that there were no multicollinearity problems between the explanatory variables because the mean-variance inflation factor (VIF) is 1.97.

Before coefficient and marginal effect results of the bivariate probit model were interpreted, a decision was made whether the data is appropriate for independent probit/logit, bivariate probit interval data model, random effect model, and recursive probit. However, the result in (Table 3) indicated that the correlation coefficient result is 0.436 which is different from zero and significant at a 5% level of significance. It implies that there is a positive connection between the two WTP responses. Therefore, the two dummy-dependent variables could be assessed simultaneously. Hence, the bivariate probit model was found to be the most appropriate model for this double bounded contingent valuation data.

As indicated in (Table 3) the predicted probability of the joint marginal effect for the two simultaneously modeled probit regression indicates the probability of success and failure for both responses (initial and follow-up responses) is 16.78 and zero percent respectively. This implies that the likelihood of accepting both bid values (the initial and follow-up bid) is 16.78% and the likelihood of rejecting those two bid values is 0 percent. The result of the bivariate probit model shows that the probability of the chi$^2$ distributions (145.64) at 28 degrees of freedom is 0.0000, which is significant at less than 1% probability level. Hence, this displays that the explanatory variables included in the model in explaining the willingness to pay both for the first and the second bid equation fit the model at a 1% probability level.

3.2.1. Sex of household head
The results from the bivariate probit model showed that the sex of the respondent is statistically significant and had a positive effect at less than 5% probability level for the specified initial and follow-up bids, respectively. This implies that a male-headed household was more willing to pay improved teff seed than female-headed households. The marginal effect result of the model in (Table 3) revealed that keeping other factors constant, being a male household can increase the probability of saying yes to the specified initial and follow-up bid by 8.3%. This is mainly because of some cultural constraints and disposed to fewer resources ownership legacy female-headed households less willing to pay improved seed than male-headed households. The findings of this study are similar to those of some other researchers who attempted to investigate the impact of gender on willingness to pay (Almansa et al., 2012; Belay, 2018).

3.2.2. Education level
Education level was a positive effect on farmers on the maximum willingness to pay for improved teff seed positively and significantly for both the initial and follow-up decisions at 5% and 1% level of significance, respectively. The model result shows that as we precede follow-up questions to the respondents they reconsider their responses and their likelihood of accepting the follow-up bid increases so that the level of significance increased. As other variables kept constant, the marginal effect estimation of the model indicated that a one-year increase in education level increases the probability of accepting the initial and the follow-up specified cash contribution by 10.6%. This result was also stayed by Munthali (2013), Ahmed et al. (2015), Emuru (2015), and Mbugua (2016) researched assessing farmers’ willingness to pay for improved common bean seed, soil conservation practice, improved forage seed, and community-based potato cold storage facilities; respectively.
3.2.3. Frequency of extension contact

The result of extension contact had positive and a significant effect on the household’s willingness to pay for improved teff seed for both the initial and follow-up decisions at a 1% level of the significance level. The marginal effect result showed that, for each one-day additional contact days taking other factors constant, the household would be 5.1% more likely willing to pay for improved teff seed for both the first and second bid values. As a result, teff producers who can more frequent contact with extension agents can get advice, training on seed usage and harvesting at a right time with the right amount that would improve their yield (Abineh, 2021). This implied that the use of improved seeds through their interest can produce more amount of output than their relatives (Tilahun, 2018). However, the provision of improved teff seeds at a right time with the right quantity is quieting a major challenge to many smallholder producers in the study area. The result has stayed with the result of Dagninet et al. (2016) and Belay (2018).
3.2.4. Off/non-farm income
Off-farm income was also an important factor that affects significantly and negatively on a household’s willingness to pay for improved teff seed for both the initial and follow-up decisions at a 5% level of significance. The marginal effect result indicates that in increase the income of households who generate from off-farm would lead to a decrease in the willingness of farmers to pay for improved teff seed by 6.4% keeping other factors constant at their mean value. This is due to households who had received more income from off/non-farm activity; farmers mostly shift towards the off/non-farm income activities rather than engaging in the on-farming activity. Similar effects of this variable had been found by Biratu and Asmamaw (2016) and Belay (2018).

3.2.5. On-farm income
Income from the farming activity was a positive and significant effect on farmers on the willingness to pay for improved teff seed for both the initial and follow-up decisions at 5% and 10% level of significance, respectively. As other factors were constant, the marginal effect result of the model showed that once the annual income of a household was increased by 1 unit (100 Ethiopian birrs), the probability of the households’ willingness to pay for improved teff seed was increased by 1.6% for both the preliminary and follow-up bid responses. This is due to households who had received more income from on-farm activity can employ and waste their time and resource for agricultural production activity to raise their yield through paying improved and new technology agricultural seed and inputs. Similar effects of this variable had been found by the finding of Muhammad et al. (2015), Kasaye (2015) and Workie (2017).

3.2.6. Credit taken
As hypothesized before, the amount of credit taken was found to be a positive and significant effect on the follow-up bid equation at a 1% significance level. As other factors are constant, the marginal effect result indicated that as farmers can get more access to credit, the probability of the household’s willingness to pay for improved teff seed also increased by 1.2%. This finding was in line with the result of Emuru (2015) on the willingness of smallholder farmers to pay for enhanced forage seed in the case of Tigray, Ethiopia. This is because households who have to get more amount of credit can minimize their financial constraints and buy more improved seeds than their counterparts.

3.2.7. Initial Bid value
The results found in the model indicated that the initial bid has a negative and significant effect on both the respondents’ initial and second follow-up bid equation at 1% and 5% significance levels respectively. This implies the possibility of a yes response to the initial and follow-up bid increases with a decrease in the offered initial bid which indicates that the likelihood of accepting an offered bid amount increases as the bid amount goes down and vice versa which is consistent with the economic theory. The marginal effect results of the bivariate probit model showed that as the discrete values of initial bid increases by one unit, the probability of saying ‘yes’ to the initial bid decreases by 8.3% for both response decision. The result was in line with the findings of Kasaye (2015), Workie (2017), and Belay (2018).

3.3. Mean WTP from double bounded dichotomous choice
The result in (Table 4) found that the mean values of the cash that the surveyed households paid for improved seed were found to be 26.89 per kilogram. This was the average price of parameter estimates of both the initial and the follow-up responses of the bivariate regression models.

\[ MWTP = \text{Ave} \left( \frac{\hat{\beta}_1 + \hat{\beta}_2}{2} \right) = \frac{-2.97 + 1.11}{2} = 26.89 \]

The Wald Chi-square (χ²) distribution was used as the measure of the overall significance of a model in the bivariate probit model estimation. The result of the bivariate probit model showed that the probability of the chi² distributions (145.64) at 28° of freedom is 0.0000, which is significant at less
than 1% probability level. Therefore, the parameters included in the model taken together are significantly different from zero at a 1% probability level. So, the assumption of the null hypothesis which says “the coefficients of all explanatory variables included in the model were zero” should be rejected (Table 4).

In the Bivariate Probit Estimates Rho (ρ), coefficients of correlation of error terms of the double-bounded model are positive and statistically significant at a 1% significance level. This implied that there is a linear association between the random component of the responses to the initial bid and the second bid. The association between the random effect on the response of the initial bid and the second bid is not perfect due to the result of Rho (ρ) which is less than unity. This implies that there is a positive correlation between the two responses. Besides, the correlation coefficient of the error term is less than one implies that the random component of WTP for the first question is not perfectly correlated with the random component from the follow-up question.

### 3.4. Mean WTP estimation from the open-ended format

In the open-ended question, respondents were asked to state the maximum amount in cash they would like to pay for improved teff seed. The amounts of cash that the households would contribute to the improved teff seed vary from 0 to 75 Ethiopian birr per kilogram (Table 5).

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**Table 4. Parameter estimates of the double bounded bivariate probit model**

| Variables   | Coefficients | Standard Error |
|-------------|--------------|----------------|
| Initial bid | -0.247***    | 0.035          |
| Constant    | 2.973        | 2.543          |
| Second bid  | -0.195**     | 0.027          |
| Constant    | 2.095        | 1.854          |
| /athrho     | -12.548**    | 241.572        |
| Rho         | -1.0000      | 0.0000         |

Bivariate probit regression Number of observation = 121
Wald chi² (28) = 145.64 Prob> chi² = 0.0000
Log likelihood = -191.489
LR test of rho = 0: chi² (1) = 6.47 Prob> chi² = 0.031

***and ** shows statistically significant at 1% and 5%.

Source: Own survey result, 2021

**Table 5. Sampled households’ pay demand**

| Amount of cash | Number of respondents | Percent |
|----------------|-----------------------|---------|
| 0              | 25                    | 20.66   |
| 1–15           | 8                     | 6.5     |
| 16–30          | 22                    | 17.9    |
| 31–45          | 31                    | 25.2    |
| 46–60          | 23                    | 18.7    |
| 61–75          | 9                     | 7.3     |
| 76–100         | 3                     | 2.4     |
| Total No of Obs. | 121                   | 100.0   |

Mean = 32.674
Std. err = 18.597

Source: Own survey results, 2021
From the total of 121 sample respondents, 25 sampled households were not willing to contribute cash for improved teff seed. On the other hand, the remaining 96 sampled respondents were willing to contribute some amount of money that they already stated during the survey despite the amount of money they willingly contribute differs from one respondent to the other. The average maximum amount of money that farmers were willing to contribute for improved teff seed practices was 32.89 ETH Birr per year (Table 5).

4. Conclusion
Improving the use of improved seed can trigger yield increase and lead to improvement in agricultural production and food security. However, most smallholder farmers cannot pay the required amount of money to the recommended amount of improved agricultural inputs. Due to this fact, this study was aimed at determining the willingness of household respondents in Yilmana-Dinsa District to pay for improved teff seed. So, to address these objectives, both quantitative and qualitative data types from primary and secondary sources were used using semi-structured questionnaires. The data were analyzed using descriptive statistics (average, frequency, standard deviation and percentage), inferential statistics (chi-square and t-test) and econometric model (Bivariate probit model).

The result of the descriptive statistics showed that out of 121 sample respondents, 79.3% were willing to pay improved teff while the remaining 20.7% were non-willing respondents for improved teff seed. The results from the descriptive statistics revealed that sex, access to training, level of education, age, on-farm income, extension contact, and credit use were statistically significant by chi-square and t-tests between willing and non-willing respondents at their mean values. Therefore, these variables are the most important attribute to a household’s willingness to pay for improved seed.

A bivariate probit model was employed to analyze the influence of the hypothesized explanatory variables on farmers’ willingness to pay for improved teff seed. Among a given 13 given explanatory variables; sex of the household head, education level, frequency of extension contact, on-farm income, and amount of credit taken were a positive and significant effect on both the first bid response (WTP1) and second follow-up bid response (WTP2). While off-farm income and initial bid revealed a positive and significant effect on respondents of both first bid response and second follow-up bid response. In addition, the bivariate probit model was also used to compute the mean willingness to pay from the double bounded dichotomous choice. For the time being, mean willingness to pay from the open-ended format were also intended for comparison purpose. Consequently, the mean willingness to pay from the double bounded dichotomous choice format and open-ended format was estimated to be 26.89 and 32.67 birrs per kilogram, respectively.

Based on the findings of the study, the following points need to be considered as possible policy implications to reinforce farmers to increase their willingness to pay for improved teff seed. Since female-headed households were less willing to pay improved teff seed than male-headed households; there is a need to reinforce resource ownership and empower women through self-help groups and support them by creating awareness on cultural constraints. Regarding credit utilization, policymakers have to intensify the attention of capital markets in the study area with the flexible collateral prerequisite that will improve their willingness of farmers to pay for improved technologies.

Moreover, policies and strategies should strengthen the existing educational system and area-specific extension education through training, and awareness to enhance farmer’s willingness to pay improved seeds to raise their farm product and income. As the educational level and interactions of farmers with extension agents would be vital to read and accept a new idea, innovation, market information, the interaction between extension agents with farmers should be strengthened. Frequent training on best seed purchasing practices should be introduced through organizing promotional and certified seeds for rural areas. It can also be seen from the result that the annual non-farm income of households has a statistically significant and negative impact on
households’ willingness to pay for improved teff seed. So, the concerned bodies would be raising their farm production and decrease their off-farm income activities by delivering the required amount of agricultural inputs and other consultation activities.

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Author details
Yaregal Tilahun
E-mail: yaregtil@gmail.com

Benyam Tadesse
E-mail: tadessebenyam7@gmail.com

1 Department of Agricultural Economics, College of Agriculture and Natural Resource, Mizan-Tepi University, Tepi, Ethiopia.

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