DETERMINANTS OF ROW PLANTING OF TEFF CROP PRODUCTION IN HULET EJU ENESEEAST GOJJAM ZONE, AMHAR REGIONAL STATE, ETHIOPIA

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ABBREVIATIONS and ACRONYMS

ADLI	Agricultural Development Led Industrialization
ATA	Agricultural Transformation Agency
BoARD	Bureau of Agriculture and Rural Development
CSA	Central Statistical Agency
FGD	Focused Group Discussions
FTC	Farm Training Centers
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
KII	Key Informant interview
LDCs	Less Developed Countries
MoA	Ministry of Agriculture
PADETES	Participatory Demonstration and Training Extension System
SNNP	Southern Nations, Nationalities, and Peoples
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
STATA	Statistics and Data
TLU	Tropical Livestock Unit

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ABSTRACT

The factors that affect Teff row planting practice in the area is not studied and documented. Therefore, the main aim of this study was to investigate the determinants of Teff row planting practice, to examine the yield difference between row planting and broadcasting practice on Teff grain production and to assess challenges and opportunities of Teff row planting practice. Descriptive cross-sectional study design was used and data were collected from 96 households. Three kebeles in the woreda namely: Debera Selam, Fiker Lehager, and Abiyotu Selam were selected purposively. Structured interview schedule, key informant interview, and focus group discussion were used to collect the data. The data were checked for completeness, coded, entered, and analyzed using SPSS version 16. Descriptive and inferential statistical technique such as chis-quare test and t-test were also used. Moreover, binary logistic regression analysis was used to identify determinants of Teff row planting practice. The result reveals that 36.46 percent of the respondents implemented the Teff row planting practice in study area, household labor, land size, participation in training, sex of household head and accesses to credit service were found to have positive and significant effect on the Teff row planting practice at 5% significance level in addition to these educational status of the household head have positive significant effects on the practice of Teff row planting method at 10% significance level but age of the respondents had negative and significant effect on the Teff row planting practice at 5% significance level. The study also revealed that there was a significant yield difference between row planter and broadcasting planter. Therefore, the Woreda office of agriculture in collaboration with other stakeholders should work intensively to improve Teff row planting practice by the farmers in the study area.

***Keywords**; Agriculture Row Planting, Hulet Eju Enese Teff*

1. INTRODUCTION

Agriculture has been and continues to assume center stage in economic policy of many Less Developed Countries (LDCs) in general and Sub-Saharan Africa (SSA) in particular. Consequently, growth in the agricultural sector has been critical to achieving poverty reduction and income growth creating spillover effects to the remaining sectors (World Bank, 2014). However, production and productivity of the agricultural sector in SSA and much of the developing world is generally low due to poor technological acceptance (Abraham *et al*., 2014 and Lulit *et al*., 2012).

Agriculture plays the most important role in Ethiopia economy and it accounts for 32.7 of GDP in 2019/2020(NBE, 2019/2020). But, owing to natural and artificial causes the nation has not appropriately benefited from its abundant natural resources and good agricultural development policy. The area has failed to record the wanted economic development to allow its people draw out of poverty (Spielman, D.J. 2008). Recently agricultural production and productivity increase on a sustainable basis required large scale adoption and diffusion of new technologies (Mehumud. *et al*., 2009).

Crops are the major agricultural commodities on which Ethiopians depend for their daily food requirement. Teff is the most ancient indigenous staple food and important crops for farm income, food and nutrition security in Ethiopia. Furthermore, it is highly nutritious and important part of Ethiopia's cultural heritage and national identity, plus to that its international popularity is rapidly growing because of its health advantage for the people having celiac disease. (Mekidelawit, *et al.*, 2018)

Teff is believed to be originated, domesticated and diversified in the country. In a country of over 80 million people, it accounts for about 15% of all calories consumed in Ethiopia. Furthermore, approximately 6 million house- holds grow Teff and it is the dominant cereal crop in over 30 of the 83 high-potential agricultural woredas. Furthermore, it has the largest value in terms of both production and consumption in Ethiopia and the value of the commercial surplus of Teff is second only to coffee (Minten, *et al*., 20012).

The low national or regional Teff productivity is mainly attributed by lack of improved agronomic practices. Broadcast method of sowing has been predominantly used in the past years;

however, new agronomic practices could increase the productivity of the crop. Row planting and transplanting method of a month age Teff seedlings are one of the promising planting techniques to boost the yield of Teff (Seyfu, 1997; Kebebew *et al*., 2011).

Broadcast planting method is the most widely employed practice among smallholder farmers in Ethiopia. These methods of seed by hand at high speed a practice with potentially low productivity. In particular, broadcasting seeds is likely to lead to a fall in yield due mainly to the difficulty in hoeing and hand weeding; and the competition with weed resulting from the uneven distribution of the seeds. Teff is among the crops commonly cultivated using the broadcast planting possibly explaining the considerably low levels of yield associated with Teff production. Consequently, implementation of row planting practice could be quite beneficial in terms of enhancing the productivity and yield levels.

Such row planting practice allow for reduced seed rate along with increased space between seedlings, which in turn have been shown to achieve important production increments over broadcasting sowing. More importantly, the technologies allow for better weeding, decreased competition between seedlings, and better branching out and nutrient uptake of the plants (Chauhan, *et al*., 2014).

Therefore, the low national or regional Teff productivity is due to a lack of improved agronomic practices. Row planting and transplanting of month-old Teff seedlings are two of the promising planting techniques to boost the yield of Teff. The broadcast planting method is the most widely employed practice among smallholder farmers in Ethiopia, but row planting practice could be beneficial in terms of enhancing productivity and yield levels. However, the lack of improved agronomic practices is to blame for the low national or regional Teff productivity. Two of the potential planting methods to increase Teff output are row planting and transplanting month-old Teff seedlings. Although Ethiopia's smallholder farmers primarily use the broadcast planting technique, row planting technology may be advantageous for raising productivity and yield levels.

1.1. Statement of the Problem

Teff is the major staple food crop to most of the Ethiopian people living in the highlands which comprise more than 65% of the population. However, the national average yield of Teff is very low, 1.4 ton per hectare and the development of high yielding cultivars would be very beneficial (CSA, 2013). Teff is a highly valuable grain for Ethiopian people both in production and in consumption. It is a staple food and a source for more than 15% of calories intake by the total population of the country. More than 6 million households "livelihood depends on the production of Teff covering the largest agricultural area of the country than any other types of grain, however, the amount of production is not as much as its area coverage and value (Berhe *et al*. 2011; Bekabil *et al*., 2011; ATA, 2013).

Teff production system used by the majority of farmers is very traditional, most of the farmers in the country in general and in particularly in the study area use broadcast Teff seeds, i.e. scattering seed by hand that consumes high seed rates. This reduces Teff yields because of the high amount and uneven distribution of the seeds makes weeding difficult and increased competition with weeds and other Teff plants lowers nutrient uptake by the individual Teff plant (Berhe *et al*. 2011; Fufa *et al*. 2011).

According to Mekdim *et al*. (2016) study stronger influences found for labor use to sow the Teff seed and apply fertilizer on the experimental plot. As expected, the labor input for row planting Teff seeds increases significantly because of the additional effort wanted to carefully construct the rows. Broadcast planting one hectare of Teff land on average takes 42 person-hours, but row planting increases the labor input for sowing by 138 person-hours, i.e., 20 person-days extra per hectare. Similarly, the labor input for applying fertilizer increases by 41 person-hours because the fertilizer has to be carefully applied to the constructed rows, rather than by scattering the fertilizer by hand. Unexpectedly, the labor use for weeding also increases, but this effect is only weakly significant.

A number of empirical studies (Chilot, 1996, Wodaly, 1999; Birhanu and Zerihun, 2017 and Gezahegn, 2004) studied on the improved seeds but this is not the only constraint to maximize Teff production. That means there is no research that has been conducted so far in the study area in relation to factors affecting Teff row planting practice. Therefore, the goal of this study was to

fill this gap and provide evidence. The study also examined yield difference between row planting and broadcasting practice on Teff grain production.

1.2. Objectives of the Study

1.2.1. General Objective

To investigate the determinants of Teff row planting practice in Hulet Eju Enesedistrict

1.2.2. Specific Objectives

1. To identify factors affecting the application of Teff row planting practice in the study area.
2. To examine yield difference between row planting and broadcasting practice on Teff grain production.
3. To assess challenges and opportunities of Teff row planting practice.

1.3. Research Question

In order to evaluate the determinants of Teff row planting practice in study area, this paper was expected to answer the following research questions.

1. What are the problems faced by the local people in the application of row planting on Teff?
2. Is there any difference between row planting and broadcasting practice on Teff grain production?
3. What are the basic challenges and opportunities that face farmers during row planting ?

1.4. Significance of the Study

Implementation of Teff row planting practice was a significant for agricultural policy maker. Therefore, this research is essential to understand the factors determinants of Teff row planting practice for increasing production and productivity in the study area. It may also be important for policy makers and other stakeholders to achieve maximum production effort in the selected commodity.

The results of this research could be useful for the agricultural government or policy makers, farmers and agricultural expert for their respective decision. Specially, it was useful for office of agriculture in Hulet Eju EneseWoreda to the particular and Amhara regional state to the general. In this research we would identified some important and policy relevant variables in related to Teff row planting application and its impact on rural household Teff income.

1.5. Scope and limitation of the study

Since it was not possible to cover the whole Amhara Regional state with the available time and resources, the research was limited the study size and the scope of the problem to a manageable size. Hence, the study focused on the representative sites in wereda Hulet Ej Enese. The study considers farmers who are practicing row planting of Teff and who doesn‘t practice. Substantial qualitative and quantitative information was gathered on agricultural production, the different aspects of the Teff row planting practice.

We encountered with a number of difficulties while conducting the research. During our field work gathering data from the respondents was a difficult task, this was mainly because of the reason that farmers hesitate and afraid of giving information that may affect their wellbeing. Household survey by itself is complex and to get reliable data especially on household landholding, volume of production, income, number of livestock as well as other variables which have close economic and social implications are not always free from error. Assessing other related problems to row planting practice was impossible due to time and financial constraints. Another limitation of this study is it did not apply multivariate regression

2. LITERATURE REVIEW

2.1. Theoretical Review

2.1.1. Basic Concepts and Definitions

Teff (Eragrostis Teff): also known as Teff, Williams's lovegrass or annual bunch grass, is an annual grass, a species of lovegrass native to the Horn of Africa, notably to modern day Ethiopia .It is cultivated for its edible seeds, also known as Teff. Teff was one of the earliest plants domesticated. It is one of the most important staple crops in Ethiopia and Eritrea. (Stallknecht, and Gilbert F, 1998; Aptekar, and Lewis, 2013; Bell and Randy A, 2015)

Eragrostis Teff is a self-pollinated tetraploid Annual cereal grass it's a C4 plant, which allows it to more efficiently fix carbon in drought and high temperatures, and is an intermediate between a tropical and temperate grass. (Stallknecht *et al*., 1993; Ketema, and Seyfu, 1997; Bultosa, G., 2016).The name Teff is came from the Amharic word "ጠፋ" Teffa, which means "lost this probably refers to its tiny seeds, which have a diameter smaller than 1 mm. Teff is a finestemmed, tufted grass with large crowns and many tillers. Its roots are shallow, but develop a massive fibrous rooting system. (Stallknecht *et al*., 1993; Encyclopedia Britannica, 2016)

Productivity: Productivity is commonly defined as a ratio between the output volume and the volume of inputs. In other words, it measures how efficiently production inputs, such as labour and capital, are being used in an economy to produce a given level of output. Low Teff productivity is partly caused by the way farmers sow Teff seed apply broadcast the seed using a rate of 25-50 kg per hectare (ATA, 2013). This practice reduces yields because of the uneven distribution of the seeds, higher competition between plants for inputs (water, light and nutrients) and difficult weeding once the plants have matured (Fufa *et al*. 2011). Reducing the seed rate to between 2.5 and 3 kg per hectare allows for reduced competition between seedlings and optimal growth of the Teff plants. By row planting land management and especially weeding can also be done more readily and the incidence of lodging is reduced (Tareke Berhe *et al*., 2011, Chanyalew Sebsebe and Kebede Assefa., 2013).

Row planting: Is defined as planting with space and involves the growing of plants on a plot of land with sufficient space between each of the plants so that they can develop their roots and shoots more fully. The Ethiopian agricultural transformation agency (ATA, 2012) investigated that crop planting with space starts with growing seedlings in garden center and planting these in

the field with sufficient and equal spacing between each seedling. On the other hand, seed grain can be sown in rows with enough spacing between the seeds and rows simultaneously and started since 2011 /2012 production year. Mostly, it practices in Ethiopia with crops such as sorghum, maize and Teff.

According to ATA, in recent years much of Ethiopian farmers have begin planting many of their grains in rows, which includes wheat, maize, barley and sorghum and they also started to realize this technique yields better results, reducing the competition among individual plant. However, on Teff which is a national grain of the country, most of the farmers are still following the traditional way of planting Teff seed. Therefore, it resulted in Teff grain yield reduction (Mekidelawit A., 2018).

The results of Ethiopian Institute of Agricultural Research (EIAR) trials showed that yield increases from implementing row planting were small and that changing the seed rate, planting depth and planting space did not affect Teff yield significantly (Chanyalew and Assefa 2013).

Broadcast planting/sowing

Broadcast seeding is of particular use in establishing dense plant spacing, as for cover crops and lawns. In comparison to traditional drill planting, broadcast seeding will require 10–20% more seed. It is simpler, faster, and easier than traditional row sowing. Broadcast seeding works best for plants that do not require singular spacing or that are more easily thinned later. (Toumey, James W. 1916). After broadcasting, seed is often lightly buried with some type of raking action, often done using vertical tillage tools. Utilizing these tools increases the success rate of germination by increasing seed-to-soil contact (Toumey, James W. 1916).

Seeds sown in this manner are distributed unevenly, which may result in overcrowding. This method may not ensure that all seeds are sown at the correct depth. Incorrect depth, if too deep, would result in germination that would not allow the young plant to break the surface of the soil and prevent germination. If they are not sown evenly then there would be a lack of various nutrients from sunlight, oxygen etc in many crops or plants (Toumey, James W. 1916).

2.2. Empirical Review

Production of Teff: Teff (Eragrostis Teff (Zucc.) is one of the most important native cereal grain species in Ethiopia both in terms of production and consumption. 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). In Ethiopia, Teff is mainly produced in vast areas of Amhara and Oromia and the total area covered by Teff was 1,014,268 ha and 1,289,405 ha respectively and also with smaller quantities in SNNP and Tigray (CSA, 2011). There are 19 major Teff producing zones in the country. The major Teff producing zones in Amhara region are; East Gojam, West Gojjam, North Gonder, South Gonder, North Wollo, South Wollo, North Shewa and Awi zone. In Oromia region the major Teff producing zones include the East Shewa, West Shewa, South West Shewa, North Shewa, East Wallaga, Horo Guduru Wallaga, Jimma, Illubabor and Arsi Zone (CSA. 2011).

The length of growing period (LGP) ranges from 60 to 180 days (depending on the variety and altitude) with an optimum of 90 to 130 days. Teff is cultivated widely covers around 31 percent of the total annual average and 21 percent of the total grain production. A total production of 4.42 million tons is harvested from over a 3.02 million hectare of land. During the last 19 years the area coverage of Teff showed a 59 percent increment (from 1.9 million ha in 1994 to 3.02 million ha in 2013) more than any other cereal crops. During the same period, production of Teff increased from 1.86 in 1994 to 4.43 million metric ton, which is about 138 percent, while its productivity rose from 0.98 ton/ha to 1.46 ton/ha, which is almost a 50 percent increment (National Teff Research Commodity Strategy., 2016).

2.2.1. Yield Improvement under Teff row planting practice

According to ATA report (2013) most of the farmers who employed Teff row planting practice experienced yield increases across all regions. Row planting and transplanting practice produced high yields, it increased yield by almost 70% from the national average of 12.6 quintals/ha to 20.9 quintals/ha. In Amhara and Oromia transplanting produced the highest yields followed by row planting and broadcasting. Transplanting in these two regions produced the highest regionally average yields of 23 quintals/ha. In SNNP and Tigray row planting produced the highest average yields of 22 and 21 quintals/ha respectively.

Transplanting in SNNP and Tigray produced the second highest average yield with broadcasting producing the lowest in comparison to this practice. The ATA report revealed that across all regions broadcasting showed the lowest yields, though with the exception of SNNP broadcasting still achieved significantly improved yields over the national average. Despite the importance of Teff in Ethiopia, yields are remarkably low. While in 2012 - 2013, Teff land productivity reached 1.4 ton per hectare, this is rather low when compared to other cereals such as maize (3.1 ton per hectare), rice (2.8 ton per hectare) and wheat (2.1 ton per hectare) (CSA 2013).

Traditionally, farmers broadcast the seed using a rate of 25–50 kg per hectare (ATA 2013) this practice reduces yields because of the uneven distribution of the seeds, higher competition between plants for inputs (water, light, and nutrients), and difficult weeding once the plants have matured (Fufa *et al*. 2011). As a solution, it has been proposed to reduce seeding rates and to plant a seed in rows or to transplant seedlings. Reducing the seeding rate to between 2.5 and 3 kg per hectare allows for reduced competition between seedlings and optimal tillering of the Teff plants. By row planting or transplanting, land management and especially weeding can also be done more readily and the incidence of lodging is reduced (Berhe *et al*. 2011, Chanyalew and Assefa, 2013).

2.2.2. Factors affecting application of row planting practice in Teff production

According to (Behailu, 2014) the household size of the respondents significantly affects the respondents‟ ability to accept row planting practice. Similarly, (Geremew *et al*., 2016) noted that man equivalent is one of the significant variable that influence the decision of smallholder farmers to apply or not to apply row planting of Teff production.(Yonas, 2014) noted that having more working family member increases the probability of participating in row planting of Teff. It is positive and significant at 5 percent probability. Existence of higher number of working family labor encourages farmers to participate in the program.

A study conducted in Wolaita Zone shows that the land size owned by the household, farming experience and number of livestock owned measured in TLU have positively and significantly influenced the decision to implement and apply row seeding of Teff (Geremew *et al*., 2016). Similarly, (Yonas, 2014) noted that cultivated land size and number of livestock owned in TLU positively influenced participation in row planting. A study conducted in Tigray region

showed that level of education of the household head and the number of training provided to farmer had significantly affected the application of row planting practice (Yonas, 2014).

2.2.3. Conceptual Framework

From the earlier studies, it is established that the acceptance of Teff row planting practice is expected to improve Teff grain yield with reduced seeding rate. At household level the implementation of Teff row planting practice is determined by different factors. Those factors included in this research are shown in the conceptual framework in Figure 1 below.

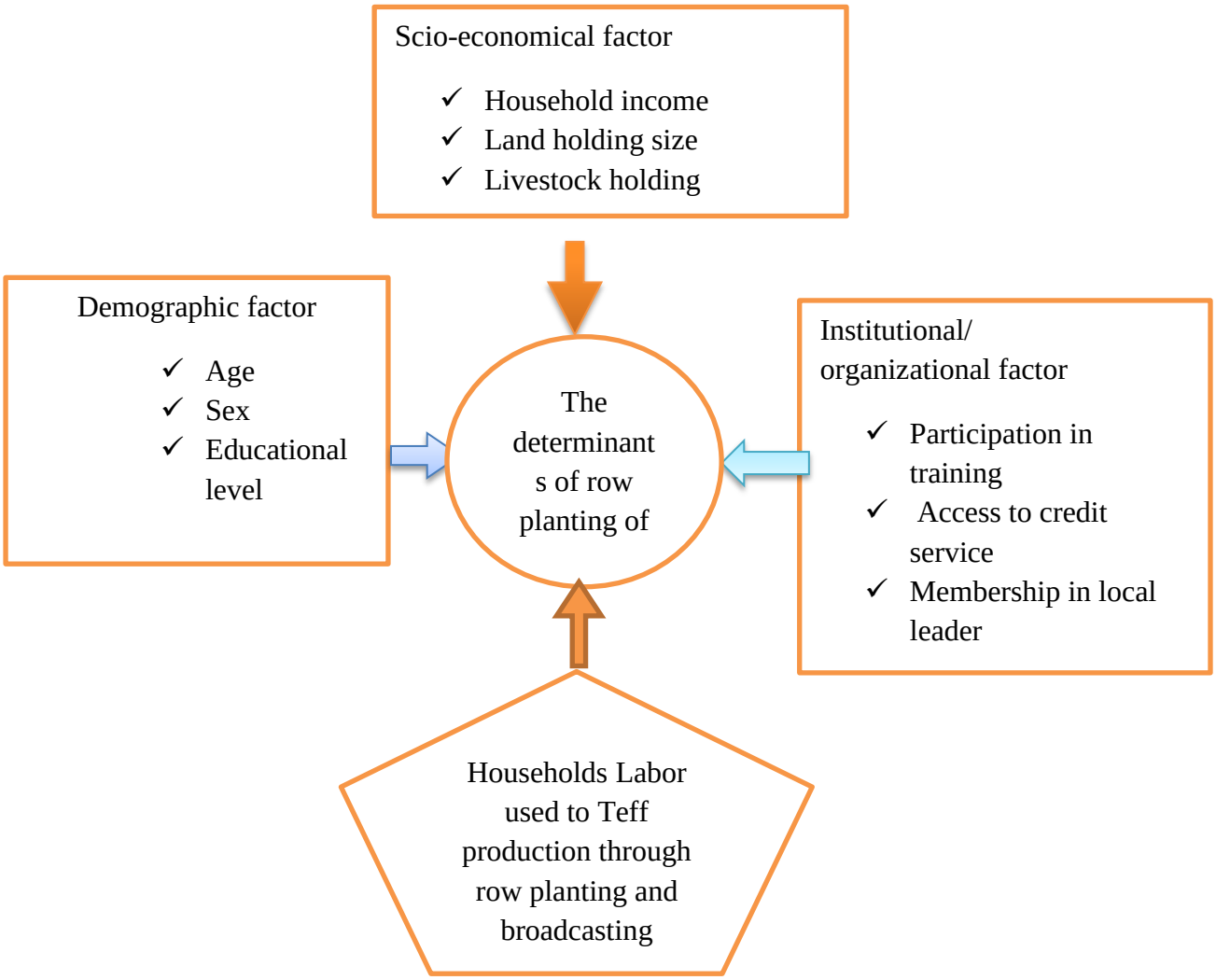

Figure 1 a conceptual framework

Adopted from literatures

3. METHODOLOGY

3.1. Description of the Study Area

Hulet Eju Enese is one of the woredas in the Amhara Region of Ethiopia. It is part of the Misraq Gojjam Zone and is bordered on the south by Debay Telatgen, on the west by Bibugn and Goncha, on the northwest by the Mirab Gojjam Zone, on the north by the Abay River, on the east by Goncha Siso Enese, and on the southeast by Enarj Enawga. According to the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), the woreda has a total population of 275,638, an increase of 38.27% over the 1994 census, of whom 137,382 are men and 138,256 women; 30,594 or 11.10% are urban inhabitants. The population density of 184.17 is greater than the Zone average of 153.8 persons per square kilometer. The majority of the inhabitants practice Ethiopian Orthodox Christianity, with 93.37% reporting that as their religion, while 6.55% were Muslim.

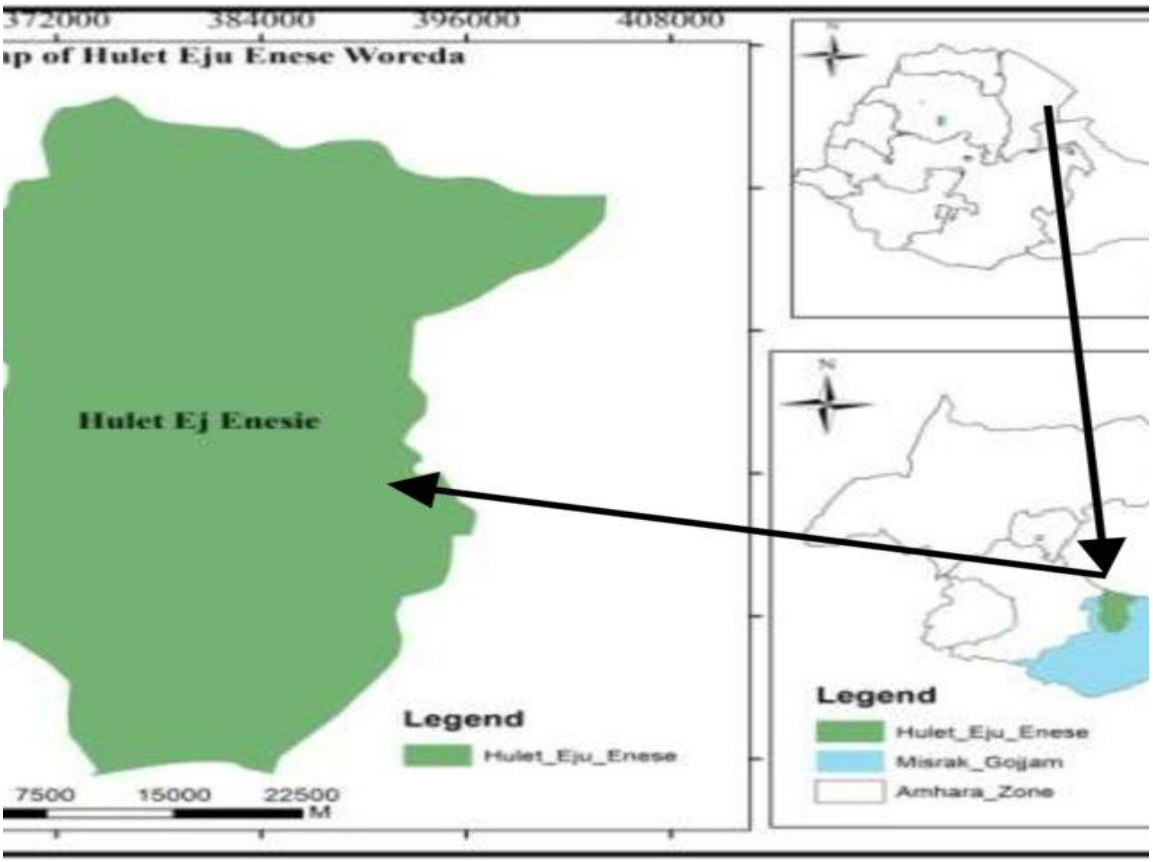

Figure 2 Map of the study area

3.2. Method of Data Collection and Sources of Data

This research used both primary and secondary data sources to collect qualitative and quantitative data from sampled households. Primary data was collected through interview schedule; Focused Group Discussions (FGD), and Key Informant interview (KII). The questionnaires were pre-tested to redesign the mode of data collection and find out the simplest way to collect data. Secondary data was collected from Hulet Eju EneseWoreda offices of agriculture and official documents. Scheduled interviews were designed in line with stated objectives and research questions and included diverse issues that could provide an understanding of the socioeconomic attributes of the sample households

Key informants' interviews were conducted with Hulet Eju Enese Woreda agricultural officer and each sampled kebele development agent. Focus group discussions were conducted from the natural resource fieldwork (from harvesting of Teff in cooperation or locally debo) and from the spiritual church. Each focus group discussion consisted of 6-10 individuals for better representation of information and reliability of data.

3.3. Sampling techniques

Two-stage sampling technique was employed to select the sample household. First, Hulet Eju EneseWoreda was selected purposively based on Teff production coverage from the total cultivated land in the woreda was better than others. Secondly, the kebeles of the woreda stratified into their potentials of Teff producing. From a total (25) of potential Teff producing kebeles of the Woreda, the sample was selected randomly, three kebele namely Debera Selam, Fiker Lehager, and Abiyotu Selam. The sample size was determined by using a formula provided by Yamane (1967). The sample size for each kebele was determined by using proportionate sampling techniques. The formula is described as follows:

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

Where

n=sample size

N= number of households heads who grow Teff in the selected kebeles

e= refers to error tolerated for the study

Total number of households in the three kebeles =1132+986+681

N=2799

e=error tolerated for the study (10%)

$$n= \frac{2799}{1+2799(0.1)^2}=96$$

The required sample size was 96 and it selected from each stratum groups, we were use proportionate selecting producers; Out of total selected 96 sample size, 61 non row planters of Teff crop and 35 row planters of Teff crop sample from small farm household was selected. We were show how it was selected in proportionally farm household sample size from each stratum group stated in the (table 1).

Table 1 Distribution of Sample size by Probability Proportional Sample (pps)

Kebele	Number of households (Ni)	Probability Proportional Sample (PPS) Size				
		row planter		Non row planter		Total Sample(n_i)
		N_a	n_a	N_{na}	n_{na}	
Debera Selam	1132	425	14	707	24	38
Abiyotu Selam	986	370	12	616	22	34
Fiker Lehager	681	255	9	426	15	24
Total	2799	1050	35	1749	61	96

Source: own computation; n_i= total number of households selected from kebele $_i$ ($_i$ = 1, 2, 3, 4, 5, 6); N_i= total number of households in kebele i; Na = Total number of row planter; Nna=Total number of Non row planter; n_a = row planter households selected; nn_a = Non row planter households.

3.4. Methods of Data Analysis

The quantitative data was coded and entered into SPSS and STATA then analyzed by using descriptive statistics such as frequency, mean and percentage, minimum and maximum value. The statistical significance of the variables in the descriptive part was tested for both dummy and continuous variables using chi-square and t-test, respectively.

3.4.1. Econometric model specification

According to Behailu G. (2014) Binary logistic regression analysis is the best regression technique for analyzing data with categorical dependent variables. It is used when there are only two categories of the dependent variable and when there is a combination of numerical and categorical independent variables. Logistic regression provides a coefficient 'b' which measures each independent variable's partial contribution to variations in the dependent variables. The goal is to correctly predict the category of outcome for individual cases using the most parsimonious model. The logit model is a mathematical transformation used to normalize a distribution of predictor variables.

It is defined as

$$\text{logit}\,(p) = \log\,[p\,/\,(1\ p)] = \ln\,[p\,/\,(1\ p)].$$

The logit model was applied in this study to investigate the determinants of row planting of Teff crop production in Hulet Eju Enese district of a household that can take one of the two values, implementation of Teff row planting and broadcaster.

According to Gujarati (1995), the functional form of the logit model is presented as follows.

$$\text{logit}\,(p) = \log\,[p\,/\,(1-\ p)] = \ln\,[p\,/\,(1-\ p)]$$

Whereas p ranges from 0 to 1, logit (p) scale ranges from negative infinity to positive infinity and is symmetrical around the logit of 0.5 (which is zero). The logit model was applied in this study to investigate the determinants of row planting of Teff crop production in Hulet Eju Enese district of a household that can take one of the two values, implementation of Teff row planting and broadcast planting.

$$P_i = E\left(Yi/xi\right) = \frac{1}{1+e^{-(\beta 0+\beta 1 xi)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$P_i = E\left(Yi/xi\right) = \frac{1}{1+e^{-zi}}$$

Where Pi is a probability of ith household being the practice of Teff row planting and ranges from 0 to 1; Zi is a functional form of m explanatory variables (X) which is expressed as:

$$Z_i = \beta_0 + \sum_{i=1}^{m} \beta i X_i \quad i = 1,2,3\ldots..m \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where: β_0 is the intercept and β_i are the slope parameters in the model.

3.5. Working definitions of the variables and hypothesis

Dependent variable

Participation of Teff row planting practice is the dependent variable. It is a dummy variable, 0 for non-row planter and 1 for the row planter. Therefore, it was hypothesized that row planters are more likely to practice row planting.

Independent variable: the independent variables are identified from previous studies and the nature of the study area. These variables are expected to result in variation in implementation of Teff row planting practice by farmers in the study area. The independent variables are as follows:

Age: this variable is continuous and it is measured in number of years from birth. The role of age of farmers in explaining technology implementation is some-what doubtful in the literature. Whatever the condition, it is important to include age as a factor that would help to explain implementation decisions. It is assumed that as farmer age increases the probability of practicing is expected to decrease because as the farmer's age increases, it is expected that the farmer becomes conservative (Sulo, 2012). It was hypothesized that it affects Teff row planting practice negatively.

Sex of household head: gender of household head; a dummy variable for gender relationships (male=1, female=0). The sex difference is one of the factors influencing acceptance of new technologies. Due to many socio-cultural values and norms, males have freedom of mobility and participation in different extension programs and consequently have greater access to information. Therefore, it was hypothesized that male farmers are more likely to Teff row planting practice. **(**Mulatua A.2019)

Education level: it is often assumed that educated farmers are better able to process information and search for appropriate technologies to alleviate their production constraints. Nevertheless, it is significant to examine the role of education in the practice of row planting decisions. It was treated as a categorical variable to see the influence on the acceptance of Teff row planting method at farmer's level. It is measured as 0, if the farmer is did not attend formal education, 1, if the farmer attended primary education, 2, if the farmer attended secondary education. Row planting was expected to correlate positively with education. (Tesfaye *et al.,* 2001)

Household income: the household income refers to the total annual earnings of the family from sale of agricultural and non-agricultural produce such as sale of crop, livestock and livestock products, and trade activities after meeting family requirements. It is measured in Birr and treated as a continuous variable. This is believed to be the main source of capital for purchasing agricultural inputs. According to Chiputwa *et al*. (2011) households with relatively higher income are expected to better accept technology. It was hypothesized to affect row planting of Teff positively with the increase in income level of farmers.

Use of credit: Farmers can invest in new technologies either from past accumulated capital or through borrowing from capital sources. It is measured as a binary variable: 1, if the farmer gets credit and 0, otherwise. It was hypothesized to affect Teff row planting practice positively.

Participation in training: training is one of the means by which farmers acquire new knowledge and skills and it is measured in terms of participation in training program and treated as 1, for farmers participated on the training of Teff row planting method 0, otherwise. Hence, participation in training influences farmer's adoption behavior (Mustapha *et al*., 2012). It was hypothesized to affect row planting practice positively. .

Household labor size: It is measured in man Equivalent. Availability of labor force is likely to influence the acceptance of innovation. A farm with a larger number of workers per unit of land area is more likely to be in a position to try and continue use a potentially profitable innovation. Large household size may mean having sufficient labor required to manage and operate Teff row planting practice. Or it may mean greater pressure on the household resources. In this study, it is hypothesized to affect row planting practice positively. (Yonas Berha., 2014).

Livestock holding: livestock is an important source of food, income and draft power for crop cultivation for the farm community. Hence, the household with large livestock holding can have more access for draft power for crop cultivation. It is measured in terms Tropical Livestock Unit (TLU) which is hypothesized to influence row planting practice positively because it is a proxy variable for wealth status (Habtemariam, 2004).
Membership in local leader: It is measured as a binary variable: 1, if the farmer membership in local leader and 0, otherwise. It was hypothesized to affect row planting practice positively

Landholding: this refers to the area of land that the farm household owned and measured in a hectare. It is large economic resources and one of the important resources, which enable farmers to invest in the implementation of new agricultural technology. It is also an important factor to practicing Teff row planting method to increase its production and productivity. In line with this, a farmer with large farm size can accept more agricultural innovation and the opposite is true for small farm size farmers. Therefore, it is treated as a continuous variable which is hypothesized to influence row planting method positively. (Mulatua A.2019)

4. RESULTS AND DISCUSSION

4.1 Results of Descriptive and Inferential Statistics

Table 2 Descriptive statistics result

Variable Continuous		Row planter		Broadcasting planter		Total		t- value/X2
		Mean	SD	Mean	SD	Mean	SD	
Age of household		33.8285	12.9102	46.6229	10.6178	41.958	13.0068	5.2467***
Household labor size		4.98	.797537	3.76	1.1027	4.21	1.15895	-5.2467***
Land size of household		1.67	0.115669	1.62	0.09420	1.64	0.072898	-0.3531
Dummy		**N**	**%**	**N**	**%**	**N**	**%**	
Educational status of the respondent	0	8	22.85	39	63.93	47	48.96	38.8624***
	1	5	14.7	19	31.15	24	25	
	2	22	62.85	3	4.92	25	26.04	
Access to credit service	0	2	5.71	56	91.80	58	60.41	68.9212***
	1	33	94.29	5	8.20	38	39.59	
Participate in training	0	19	54.29	42	68.85	61	63.54	21.2397***
	1	28	45.71	7	31.15	35	36.46	
Sex of household head	0	5	25	15	75	20	20.83	1.4318
	1	30	39.47	46	60.52	76	79.17	

Source: Own computation (2015)

Educational status of the respondent

The result in Table 2 reveals that out of the total respondents (48.96%) of the household heads were did not attend formal education from those, 8 (17.02%) of them practice row planting method . Of the study participants, 24(25%) household heads were only attended primary education, of these, 5 (20.83%) of them implement row planting practice. None participant of the respondent is about 26.04 percent of the respondents attended secondary education and among the participants who attend secondary education 22 (88%) of them practice row planting

method. The Chi-square result indicates that there is positive relationship between row planting practice and educational status of the household heads.

Age of the household head

The result in Table 2 reveals that the average age of the sample household head is 42 years where the average household age of participants in row planting is 34 and the corresponding figure for non-participants is 47. The t-test result in table reveals existence of statistically significant that shows the Row planters are younger than Broadcasting planters of them from respondent.

Access to credit service

The survey results on Table 2 show that, out of the total, 40% of the respondents used credit. The Chi-square value shows that there was significant relationship between the use of credit and Teff row planting practice at 1% significance level.

This significance relationship shows that the variation in the credit use between two groups has its own implications on the Teff row planting method. Therefore, improving the access and utilization of credit improves the probability of accepting Teff row planting practice.

Participate in training

The survey results on Table 2 show that from the total respondents, 36.45% of them attended training program on Teff row planting package. 80 percent of participants of the training program accept Teff row planting method whereas only 31.15 percent of non-participants of the training program sown with row planting methods. The Chi-square value shows that there was significant relationship between attending the training program and row planting practice. This significance relationship shows that the variation in the participation of training between two groups has its own implications on the implementation of row planting method. Therefore, participants of the training program have better chance to implement row planting practice.

Household labor size

The survey results on Table 2 show that the average number of the labor force in terms of adult equivalent for row planter was 4.98 adults equivalent and that of broadcasting planter of the practice was 3.76 adults equivalent. The t- value shows that there was significant mean

difference in labor force availability between Row planter and Broadcasting planter households at 1% significance level, this significance mean variation shows that the variation in household labor between two groups has its own implications on the Teff row planting method. Therefore, labor availability among the row planter was significantly higher than broadcasting planter.

4.2. Descriptive analysis about yield difference between row planting and broadcasting

Teff grain productivity partly and mainly depended on the type of production system applied. In broadcasting method of planting the average Teff grain yield obtained per hectare of land was 8.6 quintals. The average total amount of Teff grain yield harvested from broadcasting method of production in birr was 47,300. According to the data achieved at the time of focused group discussion the yield of Teff straw produced through broadcasting in quantity was much less than that of produced through row planting method. See table 3

Through row planting production system in average 16.16 quintals of Teff grain yield produced per hectare of land and its average returns 88,880 birr per hectare. This was much better than the amount of yield achieved through broadcasting method.

Table 3 Descriptive statistics for yield difference

Variable	Row planter		Broadcast planter		Total		X^2
Household annually	Mean	SD	Mean	SD	Mean	SD	-23.75***
Teff grain Yield	16.16	19.86	8.6	16.6	13.12	18.76	
Teff grain in ETB	88,880		47,300				

Source: Own computation (2015).

4.3. Econometric analysis

The model results in Table 4 shows that, among the 10 independent variables included in the model, seven variables were found to significantly affect the Teff row planting practice.

The variables are briefly discussed below:

Age of the respondents; had negative and significant effect on the technique of Teff row planting practice at 5% significance level. The coefficient of the variable implies as age of the

respondents increase by one year, the likelihood to Teff row planting practice decreases by 0.0054 units.

Therefore, a farmer with higher age has less chance to accept Teff row planting method. The elders have less interest to accept improved Teff row planting practices because it needs high physical labor. Therefore these finding is in agreement with previous report by (Chiputwa. *et al*., 2018) they noted that, having more working family member increases the probability of participating in row planting of Teff.

Sex of household head: this variable is significant at 5% significance level and in terms of sex there is significant difference male and female in participating row planting of Teff. The possible explanation is that female household head take many times to be awarded in new agricultural technology, because in the rural area in most of the time women are expected to do homework rather others. Due to that they could not attend any administrative meeting in given kebele to get new information in aspect of any useful things.

Education level: it had positive and significant effects on the practice of Teff row planting method at 10% significance level. A study conducted in different parts of Ethiopia showed that the level of education of the household head significantly affected the implementation of row planting practice. An increase in the level of education by one year for the mean educational level increases the likelihood for Teff row planting practice by magnitude of 1.32 keeping other things at their respective mean.

Therefor Education helps household to increase productivity through promoting awareness on possible advantage of modernizing agriculture and on working efficiency, diversify income, accepting new technology which are used to improve Teff crop productivity and information from development agents. Therefore, educated is better to participate in row planting of Teff than illiterate one.

Household labor: it had positive and significant effect on the practice of Teff row planting method at 5% significance level. The information gathered from FGD participants reveals that "in the study area, row planting is labor intensive practice and it needs high labor for seeding of Teff on the farm". Therefore, the household who has large labor size has better chance to implement Teff row planting method.

The information gathered from FGD and KI participants reveals that "in the study area, row planting is labor intensive practice and it needs high labor for seeding of Teff on the farm". Therefore, the household who has large labor size has better chance to practices Teff row planting method. The finding is in agreement with previous report by (Mekidelawit. *et al*. 2018) they noted that, having more working family member increases the probability of participating in row planting of Teff.

Land holding size: it had positive and significant effect on the implementation of Teff row planting method at 5% significance level. A similar finding has been reported by a study conducted in Wolaita zone, the land size owned by the household measured in hectare positively influenced the decision to accept and apply row seeding of Teff. For instance, one hectare increases in the farm size from its mean increase the likelihood for Teff row planting practice by magnitude of 0.071 holding other things at their respective mean. Also this finding is in agreement with previous report by (Yonas, 2014) who noted that cultivated land size is positively influences on the participation in row planting. It is significant at 5 percent probability level.

Accesses to credit service: this variable is positively related with row planting practice and significant at 5% probability level. As compared to the farmer who has no access to credit, the likelihood for Teff row planting practice increases by 0.18 for the farmer who has credit access holding other things at their respective mean.

Small farm household heads who have the opportunity of getting credit for agricultural inputs, more participate than those who have no access. The possible explanation is that household heads who got credit; they would use row planting equipment more easily to enhance households' Teff crop yields.

Participation in training: it had positive and significant effect on the practice of Teff row planting method at 5% significance level. Farmers who got training on Teff row planting had higher probability of practicing row planting method compared to those who did not get training.

The coefficient of the variable shows that as the household participation in training increase by one more training implementation of row planting practice increase by 0.8 units. This result is consistent with the finding of (Berhane *et al,* .2011) who reported that the number of trainings

provided to farmer had significantly affected the implementation of row planting practice at the 5%. Significantly level.

Therefore, among seven factors discussed above, Sex of household head, education level of respondents‟, household labor, land holding size, credit access, and participation in training, had positive and significant effect on the implementation of Teff row planting method. However, age of respondents had negative and significant effect on the acceptance of Teff row planting practice at 5% significance level.

Table 4 Econometric analysis of Average marginal effects

Variable	**Delta-method**		**estimates table, star(.1 .05 .001)**
	Coef.	**P>|z|**	
AHH	-.0054203	0.036	-.14648723**
SHH	3.422867	0.040	3.4228674**
ELHH	1.316356	0.068	1.3163559*
HLS	.0689051	0.005	1.8622081**
LHHH	.0710332	0.032	1.9197207**
RCHH	.1774753	0.000	4.7963915**
HPinT	.0783188	0.033	2.11662**

Source: Own computation (2015). *****P<0.01, **P<0.05 and *P<0.1**

It was important to running the logistic regression model; both the continuous and dummy explanatory variables were checked for the existence of multi-co linearity problem. The problem arises when at least one of the independent variables is a linear combination of the others. The existence of multi-co linearity might cause the estimated regression coefficients to have the wrong signs and smaller T-ratios that might lead to wrong conclusion. According to Gujarati (2004) has suggested that the two techniques are conducted to test the existence of multi-co-linearity problem. Variance inflation factor (VIF) was employed to detect the problem of multi-co-linearity among the continuous variables. VIF can be defined as:

$$\text{VIF } (Xi) = \frac{1}{1-Ri^2}$$

Where: Ri2 is the square of multiple correlation coefficients that results when one explanatory variable (Xi) is regressed against all other explanatory variables. The larger the value of VIF (Xi) the more "troublesome" or collinear the variable Xi is. As a rule of thumb, if the VIF of a variable exceeds 10, there is a multi-co-linearity problem. Based on the above explanation there is no multi-co linearity in continues variables because the vif value of variables are less than ten. Likewise to test multi-co linearity problem of dummy variables, correlation command was applied and the correlation coefficients were used to test the correlation between the variables. When the value of the correlation coefficient >0.75, there is a multi-co-linearity problem. But in this research paper there is no problem of multi co linearity between dummy variables. Since the value of correlation command for all dummy variables are less than 75%.

In the binary logit model heteroskedasticity problem is expected. Due to this we used the remedial called robust standard error which makes the data more strong.

4.4. Challenges and opportunities of Teff row planting practice from gathered information

Information gathered from key informant (KI) and Focus discussion group (FDG) interview revealed that all of the participants agreed that Teff productivity using row planting method is highly effective but in the context of Hulet Eju Enese there are many barriers which were raised by them. Among these, its labor intensiveness and lack of continuous support were the top most barriers. Furthermore, some of the household heads perceived that it is time-consuming, especially for those who do not have children.

Due to the above mentioned reasons the row planting practice does not expand as the government desired. In addition, the major issue in this Woreda is absence of row seeder machine which is not available in local market. To solve this problem, they are currently using plastic bottle, which is designed for the purpose of containing mineral water, as row seeder machine. Furthermore, development agents provide both theoretical and practical training about the importance of row planting.

They also observe them while practicing and help them take corrective measures. Regarding the row seeder machine they communicate many times with different stakeholders to create access

for the farmers but still now they could not get it. They are striving to introduce the row seeder machine to the Woreda.

Land based on the data from FGD and key informant interview one of the major factors contributed to farmers' vacillation on Teff row planting practice was their fear of crop failure. As a result of this the district and kebele's administrative officers and DAs forced farmers to apply the row planting method during Teff production. Based on the data gathered through FGD and key informant interview, unwilling nature of farmers and force applied by district officers and DAs created a game of 'hide and sick' among them due to this reason many farmers sow Teff using traditional broadcasting method on their field in the night time when no DAs can appear on the field, which created another problem of un proportion able seed distribution over the field resulted from lack of visibility.

During FGD most youth respondents found it very difficult to Teff row planting practice which is mainly resulted from the fact that their land holdings were very small in size so they did not want to take risk of applying Teff row planting practice.

Most of the respondents applying row planting practice on Teff production did not left the recommended space (20 cm) among rows, as the result of lack of access to row seeder machine rather they left 35 cm of distance between each rows by using the width of traditional plow instrument. Due to large opening spaces left among rows the amount of weeds increases and at the same time agricultural lands were wasted. Some of the respondents planted Teff seed much deeper than it was recommended (2-3 cm) using the length of traditional plowing tool which ranges up to 25 cm, this resulted in delayed germination of Teff 85 seeds or sometimes due to the smaller size of Teff seed at this depth it never germinate, therefore many respondents did not accept row planting practice. Those who had planted Teff in rows due to the length of time it took for germination fearing they may ended up empty handed, they plowed their land once covered with Teff seed and sow crops that can be harvested in short period of time.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Implementation of Teff row planting method in the study area is low, almost (36.46%) of the study participants accepted the method. There were many reasons for the underutilization. It includes time consumption, labor intensiveness of the method, and unavailability of the row seeder machine. High education level, large household labor size, large land holding size, sex household (male ness), credit access, and participation in training had positive and significant relationship with Teff row planting practices at 5% significance level. High education level is also positively significance at 10%. However, as the age of the respondents increase the acceptance of Teff row planting method decreased and this was statistically significant at a 5% significance level. This study concludes that row planting method is a vital means for Teff productivity improvement.

5.2. Recommendations

Based on the results of this research, the following core points which are presented as recommendations in order to improve the Teff row planting practices in the process of Teff grain production, It is better to encourage row planting practice implementation because the results of this study confirmed that application of row planting method increases substantially the yield of Teff grain production.

As age increase the farmer Teff row planting practices decrease so forcing farmers to Teff row planting practices not bring the expected outcome rather it may aggravated their rigidity not to accept any new farming technologies. Therefore in order to improve farmers level of implementation of Teff row planting practices DAs should provide farmers with more practical trainings under farmers' direct participation in the demonstration centers.

According to The result of this research women's negatively affected so we recommended to give training of women by female DAs as Mache as possible.

Education level had significant positive effect on the implementation of row planting method. Education enhances farmers' ability to perceive, interpret, and respond to new events in the

context of risk. Therefore, governmental and non-governmental organizations should give emphasis on the adult education for farmers to improve farmers' awareness about the acceptance of practicing and increases their access to accept row planting in the study area.

Household labor had a significant positive effect on the implementation of Teff row planting practices. The most important problem in practicing row planting of Teff crop is its labor requirement. Thus, immediate demonstration of available technologies and practices that help to reduce work burden on farmers is essential. Therefore, governmental and nongovernmental organizations should give emphasis on the provision of credit for farmers to improve their financial capital to purchase improved row planting technologies like row seeder machine and hire labor and that fill the gap of a family labor shortage.

Participation in a training program on the benefit and techniques of Teff row planting had a positive and significant effect on the Teff row planting Practices. Therefore, short term training program should be strengthened to equip farmers with the necessary knowledge, skill and attitude relevant for the implementation of the method thereby improve productivity of the crop and contribute towards food security in the area.

Those farmers who had large landholding size accept Teff row planting practices in a better way compared to those who had small land holding size and this was significantly associated at 5% significance level. However, there may not be a possibility of expanding land holding size. So, agricultural intensification program should be strengthened. In other words producing maximum yield from existing plot of land by promoting the use of improved seed and inorganic fertilizer should be the focus. Of course, it requires improving knowledge, skill and attitude of the farmers in the area. Furthermore, it requires availing the required technologies, improving access to credit and market information.

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7. APPENDIXES

Appendix I Interview Schedule

General Objective

The general objective of this paper is to investigate the determinants of row planting of Teff crop production in Hulet Eju EneseWoreda

Specific objectives

- ✓ To identify factors affecting the application of Teff row planting technology in the study area
- ✓ To examine yield difference between row planting and broadcasting practice on Teff grain production
- ✓ To assess challenges and opportunities of Teff row planting technologies

Date/month/year of interview_____

Name of kebele _____

Village of the respondent _____

Name of data collector _____signature_____

Name of supervisor _____ signature_____

S/ NO	Question	Response	Skip
Part I. Demographic Characteristics and Socio-Economic Characteristics			
1	Age of the HH head?	_____	
2	Sex of the HH head	0. Female 1. Male	
3	Educational level of the HH head?	0. Did not attend formal education 1. attended formal education 2. attended secondary	

		education
4	Have you been member of local leadership?	0. No 1. Yes
5	Household labor size	0-10 years old M ____ F___ 11-13 years old M ___ F___ 14-16 years old M____F__ 17- 50 years old M___ F__ > 50 years old M ___ F___
6	How many total size of your land holding in hectare.	________________

Part II: Crop and Livestock production and household income

7 Household's annual farm income from sale of crops 2021

Major crops grown in 2021	Annual harvest	Consumed	Sold	Unit price	Total revenue
Total income					

8 Number of livestock owned and income ____________

9 Do you have your own livestock?
0. No
1. Yes

10 If yes, for Q no. 9 please provide the detail of livestock you have?

Types of livestock	Number owned	Local bread	Exotic breed	No sold	Unit price	Total revenue

a	Cow	
b	Heifer	
c	Oxen	
d	Calves	
e	Sheep and goat	
f	Horse and mule	
g	Donkey	
h	Poultry	
11	Average monthly income (birr) from sale of livestock products:	1. Milk _____ 2. butter _____ 3. egg_____ 4. honey (per annum) _____ 5. Total_____

Part III: Household income from farm activity

12	Annual household gross income of the respondent in 2021 in Ethiopian birr	_____
13	Did you produce Teff on 2021 cropping season?	0. No 1. Yes
14	If 'yes' for Q no. 13, the amount of Teff crop yield in kuntal?	_____

Part V. Teff planting methods

14	Did you apply row planting method of seeding on Teff crop production in 2021 cropping season?	0. No 1. Yes

No	Methods of planting	Area covered with Teff (land/ha)	The amount of Teff yield crop yiled (qu/ha)

1 Row planting

2 Broadcasting planting

3 Total

Part VII: Credit Service

15 Have you received any type of formal credit? 0. No 1. Yes

If yes for QNO. 21, how much is it? _____

What is the purpose of credit use? _____

16 Do you have off-farm activities?

Appendix II Checklist for FGD and Key Informants

1. What are the benefits of row panting method?
2. What are the disadvantages of this method?
3. What are the challenges faced in using this method?
4. Did you share knowledge and skills? When? How
5. What are possible strategies to improve the existing problems?
6. What mechanization did you use to plant Teff in rows?

Appendix III Multi-co Linearity Test for Continuous variable

vif

Variable	VIF	1/VIF
NLHH	1.15	0.871111
HLS	1.12	0.896037
AHH	1.11	0.897229
LHHH	1.10	0.911335
HHI	1.08	0.927758

Mean VIF	1.11

Source: Own computation (2015).

Appendix IV Multi-co Linearity Test for dummy variable

	SHH	ELHH	MLL	RCHH	HPinT
SHH	1.0000				
ELHH	0.0435	1.0000			
MLL	-0.0281	-0.0604	1.0000		
RCHH	0.1005	0.5282	0.2252	1.0000	
HPinT	0.0919	0.2438	0.4665	0.4430	1.0000

Source: Own computation (2015).