ANALYSIS OF ADOPTION OF ROW PLANTING TEFF AND ITS IMPACT ON PRODUCTIVITY IN ANEDED DISTRICT, EAST GOJJAM ZONE, AMHARA REGION, ETHIOPIA

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Analysis of Adoption of Row Planting Teff and it's Impact on Productivity in Aneded District, East Gojjam Zone, Amhara Region Ethiopia

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"ACRONOMY AND ABBREVAITIONS"

ADARDO	Aneded District Agriculture and Rural Development Office
ATA	Agricultural Transformation Agency
CC	Contingency coefficient
CIA	Conditional Independence Assumption
CSA	Central Statistics Agency
CSA	Common Support Assumption
EDRC	Ethiopian Development Research Center
EDRI	Ethiopian Development Research Institute
GDP	Grosse domestic product
KM	Kernel Matching
MoA	Ministry of Agriculture
NGOS	Non-Governmental
NNM	Nearest Neighbor Matching
PADETES	Participatory Demonstration and Training Extensions System
PSM	Propensity Score Matching
Q/ha	Quintal per Hectare
RBoA	Regional Bureau of Agriculture
RM	Radiuses Matching
SM	Stratified Matching
SNNP	The Southern Nations, Nationalities and peoples regions
SPSS	Statistical Package for Social Science
SSA	Sub-Sahara Africa
Std.dev.	Standard Devastation
Std.err.	Standard Error
TLU	Tropical Livestock Unit
TOL	Tolerance
UNDP	United Nations Development Programme
VIF	Variance Inflation Factor

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ANALYSIS OF ADOPTION OF ROW PLANTING TEFF AND ITS IMPACT ON PRODUCTIVITY IN ANEDED DISTRICT, EAST GOJJAM ZONE, AMHARA REGION, ETHIOPIA

ABSTRACT

The study was conducted in aneded District with the objectives of identifying the factors that affect the adoption of row planting of teff, and its impact on productivity , using cross-sectional data of the production year 2020.From 144 sample hhs (59 adopter and 85 Non adopter households) has been determined by using two stage sampling. The study used both primary and secondary data. The primary data were obtained from a household survey of 144 farmers using a structured questionnaire. The data were analyzed by using descriptive statistics, and an econometric model (binary logit model) by using propensity score estimation. The result of binary logit model shows that households' education, farm size, livestock ownership, annual income, field visit days and training about row planting technology for running logit model of these variables found to be significant at 5% and family size and input access own time at10% level of significance in determining the probability of adoption of row planting of teff. The impact of adoption of row planting teff has no significant contribution on teff productivity been assessed using Propensity score match of logit model. The District agricultural office, other governmental and nongovernmental organization should be provide short term training program strengthened to equip farmers with the necessary knowledge, skill and attitude relevant for the adoption of the row planting of teff.As much as possible the governmental and nongovernmental organization should be develop new technology regarding of teff crop planting collaborate with regional and federal research centre' b\c the currently row planting of teff technology is not statically significance impact contribution on teff yield on the study area. On the other hand practice this technology fully package.

Key words: Adoption, Impact, Row planting, Teff Productivity, Logit and PSM

1. INTRODUCTION

1.1. Background of the Study

In Less Developed Countries (LDCs) in general and Sub-Saharan Africa (SSA) in particular, economic policy highly depended on agriculture. Poverty reduction and income growth can generally be achieved through agricultural growth that creates spillover effects to the remaining sectors (Collier & Stefan, 2014).Agriculture in Ethiopia's most important sector, basis for the country's food security and the livelihoods of nearly 85% of its people. It holds about 46% of the Gross Domestic Product (GDP), 90% of the total export revenue, 85% employment of the country's labor force and it also accounts 70% of raw materials requirement of the country's industries (UNDP, 2002). Agriculture takes the lion's share in the economic development of many developing countries, including Ethiopia. Agricultural policy of the years has focused on supporting the introduction of improved technologies to increase production and reduce food insecurity. However outcomes of such agricultural policies have been influenced by different factors of which low adoption of improved agricultural technology is a major constraint (Adunea & Fekadu, 2019)**.** Reducing poverty in developing countries like Ethiopia depends on the growth and development of the agricultural sector (Rodrik, 2008). The vast majority of the poor lives in rural areas are engaged in agriculture, and therefore activities designed to address the vulnerability of these rural poor are often geared toward improving agricultural practices as a means of increasing productivity, efficiency and ultimately income (Parvan, 2011). In Ethiopia, agriculture is the source of spurring growth and a means to overcome poverty; it can be enhanced by the adoption of improved agricultural technologies (Rodrik, 2008)

Teff is the most widely important cereal grain of Ethiopia, which is most probably adopted thousands of years ago before the birth of Christ (Seyfu, 1997) . As a result of this it is a part of the society's culture, tradition and food security. its high price in the market, reduction of post harvest management cost, fewer disease and pest problems and sustained demand from consumer are some of the specific advantages that makes Teff important and preferred by farmers (Seyfu, 1997).

Teklu & Tefera(2005) Expliand that (*Eragrostis tef*), a cereal crop that belongs to the grass family *Poaceae*, is endemic to Ethiopia and has been widely cultivated in the country for centuries. The crop is found in most of the country especially so in the highlands at altitude ranging from 1800 to 2100 meters above sea level as it can be grown under diverse agro-ecological conditions.

The main production areas are in Amhara and Oromia regions and, to a lesser extent, in Tigray and the Southern Nations, Nationalities and Peoples (SNNP) regions. Teff is resistant to extreme water conditions, as it is able to grow under both drought and waterlogged conditions (Teklu and Tefera, 2005; Bart, et al 2012). Teff is the country's most important staple crop in terms of both production and consumption, at least in value terms. During the 2012/13 *meher* rains, more than 6 million farmers allocated 22 percent of the national grain area to teff. CSA (2013) suggests on these teff lands, a total output of almost 4 million metric tons was obtained, accounting for 16 percent of all grain that output. In 2013, the average teff yield reached 1.4 tons per hectare—an increase of eight percent from 2012.

Devereux & Guenther(2007) The adoption of improved technologies for staple crop production is an important means to increase the productivity of smallholder agriculture, so as to foster economic growth and improved well-being for millions of poor households . Doss et al(2003) without essential descriptive information, about who is adopting technologies and who is not, it is difficult to formulate policies for increasing agricultural productivity. (Technology adoption is among the most revolutionary and impactful areas in agriculture sector. Agricultural innovations also play a significant role in fighting poverty, lowering per unit costs of production (Menale et al, 2011), boosting rural income, and reducing hunger (Maertens & Barrett, 2012). Agricultural technology adoption is a gradual process. Based on the Rogers' (1995) theory of diffusion of innovations, such technology adoption is influenced by many factors including the characteristics of the adopters, the innovations, and social circumstances .Shideed & Mourid,(2005)The rate of adoption of a new technology is also subject to its profitability, degree of associated risks, capital requirements, agricultural policies consideration, and socioeconomic characteristics of farmers)

Mesfin, et al (2004) were found that among cereals, Tef (Eragrostis tef) is indigenous to Ethiopia in its origin. It is a grain crop solely produced in this country for human

consumption purpose. It grows in most of the agro ecological zones of Ethiopia. The grain is an important crop used to make the Ethiopian staple food, Injera, which is consumed at least once a day in better off households and its straw serves as a feed for livestock and it is important raw material for the purpose of house construction. Quncho tef is one of the new tef crop varieties which are rapidly expanding to the most tef growing potential areas of the country with high genetic capacity (ATA., 2012). According to ATA, in recent years much of Ethiopian farmers have begun planting many of their grains in rows, which includes wheat, maize, barely and sorghum and they also started to realize.

ATA (,2013a) among the major bottlenecks that hampered teff crop's productivity, traditional way of planting operation contribute a lot. Hand broadcasting teff seeds is problematic to make sure a uniform spacing. Furthermore this practice hinders intercultural practices, and results sowing at high seed rates per hectare. Beside the above mentioned reasons, there was a limited international attention towards research on improved teff technologies.

To address this challenge, In recent years, a joint effort have been made by the ATA and MoA to improve teff productivity and straw yield by introducing new technologies such as row planting, transplanting, reduced seed rates, improved seed adoption and improved fertilizer application (ATA 2013 b).

Agricultural innovations also play a significant role in fighting poverty, lowering per unit costs of production (Kassie *et al*., 2011), boosting rural income, and reducing hunger (Maertens and Barrett, 2013). ATA, 2015).Teff having only local importance (Guush et al. 2011; Fufa et al, 2011).The study area, Aneded District is one of the well-known teff producer in East Gojam. According to the District level crop production ranking in Ethiopia done based on teff production in the years of 2009 – 2013, the study area (aneded District) ranked own 21th (James et al, 2015) levels. This study was conduct on aneded District Factor that affect adoption of teff row planting and examine the impact of row planting of teff on productivity.

1.2. Statement of the Problem

The adoption of more efficient farming practices and technologies that enhance agricultural Productivity like row planting is seen as best crops production practice by different agricultural Policy makers and extension personnel (Mesafint, 2017).The research systems

together with other stakeholders have played a major role in delivering improved technologies for increasing productivity in the country (Biftu, et al 2016). Efforts have also being underway by the national agricultural research system through which a number of technologies have been released for the farming community. In spite of these efforts, a productivity gain has not been impressive (Hassen et al, 2012; Musa et al, 2014). One major factor contributing to low productivity in the country is the low adoption rate of improved technologies. Among these is the low adoption of row planting despite its ability to contribute to high yields (Joachim et al., 2013). The development in cropping system helps for the improvement of standard of living of smallholder farmers who took the major part of the nations of Ethiopia. Despite the fact that farming technologies such as improved seed and chemical fertilizer is considered as contributing factors for development of the agriculture. Ethiopia has chronicle poverty and food insecurity problem for a sustained period of time. One of the reasons for the prevalence of food insecurity is low rate of adoption of improved farm inputs. In fact different agricultural technologies have been released to improve productivity and food production of smallholder farmers in the country due to this farmer's gained more experience from growing the new varieties in previous years, they continued adoption and increased areas under these varieties (Hailu, 2008). Paul A. & Shahidur,(2013) were found that the national adoption rate could not exceeded 11% in major farming inputs such as improved seed and chemical fertilizers. As a result, low crop production and household income remained to be endemic problems in the country.

According to Guush et al,(2011); Fufa et al,(2011)Teff production system used by the majority of farmers is very backward and traditional, most of the farmers in the country broadcast Teff seeds, i.e. scattering seed by hand, at high seed rates. This impedes Teff yields because of 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. This result in the reduction of Teff yield at the harvesting period. In response to this currently there are some works made in partnerships of Ministry of Agriculture (MoA) and Agricultural Transformation Agency (ATA) farmers are being introduced to modern technologies of row planting of Teff with reduced seed rate and application of other agronomic technologies.

Moreover, in 2011 new concept known as TIRR (teff, improved seed, reduced seed rate, row planting) was introduced; This new innovative productivity enhancing package promote to reduce seeding rate by 90 percent to use only 3 - 5 kg teff seed per hectare and planting the seeds in rows with 20 cm spacing, which resulted 70 percent average yield increase over CSA national average (ATA, 2015)

The traditional sowing method used for teff is considered as one of the main reasons why teff yields are low in Ethiopia. Therefore, research has been conducted on improving sowing technologies in teff production, with special attention to row planting. Row planting is a knowledge intensive – but not capital demanding – technology in which (i) seeds are sown in rows and (ii) the seed rate is reduced according to scientific recommendations. It requires extra labor that is mainly required early in the season, because of additional tilling for seedbed preparation and to construct rows in which the seeds are carefully sown. Moreover, fertilizer application is more labor intensive because – instead of broadcasting the fertilizer – farmers have to apply the fertilizer more carefully in the planted rows at appropriate rates. On the other hand, row planting is believed to make weeding easier, requiring less labor. (Joachim et al,2013).In an effort to improve teff productivity and production, after conducting a large scale trial and demonstrations of this new technology during the main planting season of 2011, the Ministry of Agriculture (MoA) through (RBoA) had introduced teff row planting in 2012 all over the regions. It's true to the study area .However, since the introduction of the technology in the country, contrary of the efforts of the extension system, the introduced teff row planting technology are not widely accepted by farmers. According to Aneded district Agricultural office report, teff row planting adoption is very low and recently it decreased a lot (ADARDO,2019). Out of total 33310 hectare of lands which were cultivated during 2019 main season (meher), 16194.25 hectares of land was covered using row planting technology. Whereas, 15151 hectares of teff land was covered from this 14.5 hectare with row planting method. Row planting of teff seed is considered to be superior compared to the traditional broadcasting method because a reduced seed rate decreases competition between the seedlings for water and nutrients but the practice on this area is low due to different factors. Moreover, the even distribution of the teff seedlings makes weeding easier and less costly. In research trials, row planting has been shown to increase teff yields

up to three times average yields and lowers seed costs, making it seemingly a good value proposition for teff farmers (Guush et al, 2011).

Teff planting methods such as broadcasting, row planting and transplanting are some of the factors that affect teff production. Most farmers practice traditional method of planting by broadcasting of teff seeds at a seed rate of 25 to 30 kg ha-1 (Tareke & Nigusse, 2008). Broadcasting wastes seeds unnecessarily (increases cost of production), creates excess seedling density and intensifies inter-plant competition (for nutrients, water, sunlight and carbon dioxide). Because of high plant density, plant lodging is likely to happen in a broadcast teff, eventually reducing the yield (Tarkegn & Nigusse, 2009) .

Bekalu & Tenaw(2015) Found were that compared to broadcasting method, row planting gives better yield. To minimize lodging, low seed rate, row planting, late sowing and application of plant growth regulators were used. Row planting of teff, rather than broadcasting method, improves production and productivity (ATA, 2013a)

According to Mekidelawit et al, (2018) explained that determinants of adoption row planting of teff as well as to examine the yield difference between row planting and broadcasting practice on Teff grain production . In this paper the yield difference between broadcast and row planting suggested based on descriptive statics this is not show the real difference Rather I try to used econometrics model to show the real difference between broadcasting and row planting this indicate one methodological gap and doesn't show the whole spectrum of the variable that incorporate in the study this indicate variable gap.

According to Geremew et al(2016) by using econometric estimation bivariate probit model were found that land holding of the house hold positively affect the adoption of row cropping of teff and intensity row cropping of teff where as farm experience negatively influence on The adoption of row cropping of teff. On the other hand by using logit and Tobit estimation farm experience positively influence on the adoption of row cropping of teff where as from Tobit estimation land holding on negatively influence on the intensity of row cropping of teff(Mesafint,2017).since there is contradict or still disagreement found among the authors so that is why to done for the sake of crosscheck this thesis on this issue. As per my knowledge or information is concerned, there was no study conducted so far in Aneded District on this issue though there was an attempt made on regional levels on specific

District. The adoption of more efficient farming practices and technologies that enhance agricultural productivity and improve environmental sustainability is instrumental for achieving economic growth, food security and poverty alleviation in *Amhara*, Ethiopia. Sawing in line/row planting/ of *teff* was implemented with few early adopters in Amahara in order to increase crop productivity and incomes for small scale farm household. However, its impact on these areas on yield per ha was not known and no effort had been made to evaluate the program and its activities hence creating an information gap that needed to be filed. In spite of the government's efforts to address the issue of low productivity, the raw planting still remains difficult to be practiced by the farmers in the study area due to different socioeconomic and institution factor, Rather used broadcasting of tef planting due to this practice loading ,computation between individual plants, damaged by insects flood and winds, wastage of seed rate are the main problems of use of broadcasting planting on the study area and in this area 100% of farmers practice row planting such as Maize, Wheat and bean but in teff row planting was rear that is one motive to done this issue. This study, therefore, was intend to assess the impact of the row planting on agricultural productivity, and factors that affect the adoption of new practice in Aneded District East Gojiam ,. Also, factors that affect adoption of row planting of teff are unknown and not systematically and empirically studied and documented in the study area. Thus, the Author is inspired and initiated to conduct research focusing on analyzing factors that affect the adoption row planting of teff and impact on yield per hectare.

1.3. Objectives of the Study

The general objective of this study is to Analysis of Adoption of row planting teff and its impact on rural household yield per hectare.

Specific Objective of the study are :-

1. *To* identify the factors that affects the adoption of row planting of teff in the study area
2. To Examine impacts of row planting on teff productivity.

1.4. Research Questions

Based on the objectives listed above, the following research questions are prepared:

1 What are the factors that affect adoption and implementation of sowing in row practice?

2. Does the practice of row planting of teff have significant impact on teff yield per hectare compare with the conventional sowing practice?

1.5. Significance of the Study

This study would fill the gap on studies on impact of row planting of teff in agricultural productivity since it is new agricultural technology to our region as well as to our country. This research will be providing an insight on the effect of sowing in line on agricultural productivity. In addition to this, the study is essential to understand the factors affecting the adoption of Teff row planting practice for the sake of increasing production and productivity in the study area at the same time why we are not adopt this technology on that study area. In addition, this research is new to be done it will facilitate further researches on this issue This mean that It may also served as a document to other researchers who want to conduct their research in this study area with related topic Moreover, this study may address policy implication to foster economic growth in District and Amhara region, Ethiopia. Therefore, this study may serve as a source of additional information which may be of significant use to policy makers and planners of the Aneded District East Gojame as well as the region during the implementation of row planting technology.

1.6. Scope of the Study and Limitations

Since it was not possible to cover the entire 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 Aneded District . The study focuses on assessing Row planting of teff its impact on yield per ha and factors that determine it . The study considers farmers who are practicing row planting of teff and who doesn‘t practice the new agricultural technology and its impact on the household yield per ha. Although a factor which is found to enhance adoption of a particular technology in one locality at one time might be found to hinder it or to be irrelevant for adoption of the same technology in another locality at the same or different time for the same or different

technology or the other way round. From these inconsistent results it is difficult to identify universally defined factors either impeding or enhancing adoption of technology, In addition to this, there are other limited factors like time, finance and human resources that restrict this study to the above-mentioned District.

1.7. **Organization of the Thesis**

This study is organized into five chapters. In chapter one introduction, statement of the problem, research questions, objectives, significance and, scope and limitations of the study are outlined. Concepts, definitions, theoretical and empirical literature review are discussed in chapter two. Chapter three describes the study area and research methodology applied. Chapter four deals with descriptive results and discussions, econometric analysis results and discussions, Chapter five, deal with summary, conclusion and recommendation.

2. LITERATURE REVIEW

2.1. Definition of Row Planting and Concepts

Planting with space' 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. As emphasized by ATA (2012) Crop 'planting with space' starts with growing seedlings in a nursery and planting these in the field with enough and identical spacing between each seedling. Or, the seed can be sown in rows with enough spacing between the seeds and between the rows. In Ethiopia, it is the practice with crops such as sorghum, maize and teff that, when these begin to grow, there will be some areas in the field where they are close together and other areas where there are gaps between the plants. Farmers lightly plough and lift the plants out from the densely-growing areas and re-plant them in the gaps. This is a traditional type of 'planting with space'.

Row planting as applied in conventional horizontal farming or gardening is a system of growing crops in linear pattern in at least one direction rather than planting without any distinct arrangement. According to ATA (2015), planting in row helps to reduce plant density and eases weeding, spraying and fertilizer application, making for fewer but stronger plants, producing more stems and grain. It can also help prevent plants from falling over, a common problem with teff. Another huge advantage for farmers is reduced cost of seed due to the smaller volume required.

2.2. Definition of Adoption and Concepts

Lila Bahadur & Siegfried,(2004) explianed that Adoption is a mental process through which an individual passes from hearing about an innovation to its adoption that follows awareness, interest, evaluation, trial, and adoption stages.

Adoption process is the change that takes place within individual with regards to an innovation from the moment that they first become aware of the innovation to the final decision to use it or not. However, as emphasized by Ray (2001), adoption does not necessarily follow the suggested stages from awareness to adoption; trial may not be always practiced by farmers to adopt new technology. Farmers may adopt the new technology by passing the trial stage. In some cases, particularly with environmental innovations, farmers may hold awareness and knowledge but because of other factors affecting the decision

making process, adoption may not occur. Dasgupta (1989) indicate that, the decision to adopt an innovation is not normally a single instantaneous act, it involves a process. The toward an innovation, to a decision to adopt or reject, to implementation of new idea, and to confirmation of the decision ((Ray, 2001).

Rogers, (1983) defines the adoption process as the mental process through which individual passes from first hearing about an innovation or technology to final adoption. This indicates that adoption is not a sudden event but a process. Farmers do not accept innovations immediately; they need time to think over things before reaching a decision. In other words, Adoption is not the final event of change but rather a decision-making process. Individuals pass through various learning and experimenting stages from becoming aware of a problem and its potential solutions to finally adopting or rejecting the innovations under considerations.

Two categories of adoption are; the rate of adoption and intensity of adoption, the former is the relative rate at which farmers adopt an innovation, as one of its pillars, the element of 'time'. Differently, the intensity of adoption indicates the level of use of a given technology at a point in time (Bonabana-Wabbi, 2002). According to Rogers (2003), the adoption of technology suggests the nonstop use of technology. Also, that adoption deduces a change from one state to another which is affected by factors that can either obstruct or foster the adoption of the technology or group of technologies that can come in a package. The adoption of technologies is a change in behavior that ultimately leads to acceptance or rejection of that technology. Adoption of enhanced technologies or innovations is a desire to change a prevailing situation (Dos, 2006).

According to Feder,et al (1985) adoption may be defined as the integration of an innovation into farmers' normal farming activities over an extended period of time. Dasgupta (1989) noted that adoption, however, is not a permanent behavior. This implies that an individual may decide to discontinue the use of an innovation for a variety of personal, institutional, and social reasons one of which might be the availability of another practice that is better in satisfying farmers' needs .Nkonya, et al(1997) Adoption is the degree of use of a new innovation in long-run equilibrium when a farmer has full information about the new technology and its potential; while the rate of adoption is defined as the percentage of farmers

who have adopted a new technology or the area under a new technology. The intensity of adoption is defined as the level of adoption of a given technology.

On the other hand, although farmers often reject an innovation instead of adopting it, non adoption of an innovation does not necessarily mean rejection. Farmers are sometimes unable to adopt an innovation, even though they have mentally accepted it, because of economic and situational constraints (Dasgupta, 1989).

The rate of adoption is defined as the percentage of farmers who have adopted a given technology. On the other hand, the intensity of adoption is defined as the level of adoption of a given technological package. Put it in a different way, the number of hectares planted with improved seed also tested as (the percentage of each farm planted to improved seed) or the amount of input applied per hectare represent the intensity of adoption of the respective technologies (Nkonya *et al*., 1997).

According to (Langyintuo & Mulugetta, 2005), the importance of adoption study is to quantify the number of technology users over time and to assess impacts or determine the number of technology users over time and extension requirements that would help us in monitoring and feedback in technology generation. It also provides further insights into the effectiveness of technology transfer.

2.3. Theoretical Literature Review on Adoption

2.3.1. Innovation-Diffusion Theory or Source–Communication–User Model

This model assumes that the technology introduced to farmers is appropriate in its given form and that what determines the adoption decision is the effectiveness of communication to the targeted users (farmers). Communication to the targeted user is achieved through extension, media, opinion leaders, on-farm or on-station demonstration, farmers' fields, training, seminars, and workshops (Odera, et al, 2000) . This theory has been criticized for prescribing a top–bottom approach.

2.3.2. Resource Constraint Model

Resource constraint model is concerned with the level of resource endowment as it impacts on adoption behavior. The theory assumes that the technology being introduced to farmers is appropriate in its given form and that what mainly determines adoption decision is the farmer's level of resource endowment. Factors such as farm size and liquidity constraint

affect decisions to adopt or not to adopt new technologies. The resource constraint model assumes only farmers' resource level is important in adoption decision and that farmer's knowledge about the technology and farmer's perception it is not important (Njane, 2007) .

2.4. Empirical Review Studies

2.4.1. Factors Affect Technology Adoption

A variety of factors which influenced the rate of agricultural technologies adoption has been broadly categorized into; economic, social and institutional factors (Akudugu et al. 2012). Land size, the initial cost of a technology or its expected benefits after adoption versus the cost incurred during adoption and the farmers‟ income levels from other off-farm economic activities are all the economic factors which have been identified. Social factors that have identified to influence the chances of adoption by a farmer include; the farmer's age, level of education, gender, and his social groupings. Institutional factors that influence and determine the rate of agricultural technologies adoption and uptake by farmers include; access to information about the technologies through the existing and accessible information sources, nature of policies and provisions enacted by the government and access and nature of the extension services provided.

They argued that farmers who identify the technology being consistent with their needs as well as suitable are likely to adopt technology since they find it as a positive investment to their environment. Adesina & Zinnah,(1993) Explained that the farmers' perception of a characteristic of modern rice variety significantly affected their decision to adopt it.

Akudugu et al,(2012) The farmers' age, level of education, gender, and his social groupings have been identified as social factors that influence the chances of Farmers' adoption . Farmer groups in overall finding have been demonstrated as an appropriate channel to enhance the early adoption of agricultural technologies and improve farm-level productivity (Ainembabazi et al., 2017). According to Kariyasa & Dewi(2013) older farmers are believed to have gained knowledge and experience over time and are better able to assess technical information than younger farmers. On the contrary, age has been found to have a negative relationship with the adoption of technology. Education of the farmer has been believed to have a positive effect on farmers' decision to adopt new technology. Adoption of new

technology is influenced by education level of a farmer because as his education level increases his ability to obtain; process and use (Namara, et al 2014).

Akudugu et al (2012 were found that In term of economic Land size, the initial cost of technology, expected benefits after adoption, the cost incurred during adoption and the farmers' income levels from other off-farm economic activities are all the economic factors which have been identified . Olumba & Rahji,(2014) The findings indicated that the farmers' age, educational status, household size, farm size, extension visit, and farmers' income showed a significant relationship with the farmers' level of adoption of the technologies

Institutional factors that influence and determine the rate of technologies adoption and uptake by farmers include; accessible information sources, and access and nature of the extension services provided, nature of policies and provisions enact by the government (Akudugu et al., 2012).

2.4.2. Adoption of Row Planting

The objective of the row planting program is to increase farm production and productivity through creation of awareness and technology adoption. However, the adoption decision of farmers and intensity of use of improved technologies are determined by many factors. The factors documented in literature include farming household specific characteristics, available farm resources, and access to credit, information and market. For example, Ethiopian Development Research Institute (EDRI) conducted a rural survey in 2001/2002 covering 1920 households in four regions (Tigrai, Amhara, Oromia and Southern People and Nationalities) to evaluate the progress made in adoption and diffusion of agricultural technologies through Participatory Demonstration and Training Extension System (PADETES). The result of the analysis shows that: Farmers with large land holding are more probable to adopt technologies as compared to those with small land holding. Elder farmers have lower probability of adopting new technologies. Information (extension contact) is found to be crucial determinant for technology adoption. Literacy level, proximity to extension service center and availability of family labor has shown positive relationship with rate of technology adoption

Several studies have been done on adoption of row planting. The finding from bivariate probit model estimation demonstrates that man equivalent, land size owned by the

household measured in timad, and tropical livestock unit positively and significantly influence the decision to adopt and apply row seeding of teff in Wolaita zone. However, farming experience of the household head was found to affect significantly the decision to adopt the technology negatively. Furthermore, when dealing with factors affecting continued use of the technology, sex of household head, number of adult equivalent, total land size owned, tropical livestock unit and number of trainings attended by farmers found to be positively and significantly influences the intensive use of teff row planting in Wolaita zone. In this regard, household head's farming experience, number of plots owned and better access to off-farm income negatively and significantly influences the continued use of the specified technology in the study area (Geremew, et al, 2016)

Worku & Yishak,(2017)The binary logistic regression results of study indicate that sex of the household head, household size, and education status of the household heads, oxen ownership, and participation in agricultural training positively affects the adoption of wheat row planting technology.

According to Mesafint(2017) Results from the econometric Logit and Tobit models indicated that, explanatory variables from Logit and Tobit models respectively, were significantly influencing teff row planting adoption. Namely: Age, farmers experience, total annual income, access to credit, training and perception are those variables from logit estimation side where as education level, farming experience, training, access to input supply and perception towards row planting are those variables from tobit estimation side were positively influence adoption row cropping of teff. On the other hand, land holding variable from Tobit estimation side and age of household head variable from both sides have negative influence on adoption of teff row planting.

According to Mekdelawit et al(2018)The binary logistic regression results of High education level, large land holding size, large livestock holding in tropical livestock unit and large household labor size, membership in local leadership position and participation in training had positively affect the adoption of Teff row planting . Where, as the age of the respondents increase the adoption of Teff row planting method decreased. The study also identified the average yield difference obtained from broadcasting and row planting

methods. The mean yield obtained from broadcasting method was 12.3 q/ha. On the other hand, the average yield of row planting method was 20.8q/ha.

2.4.3. Improved Technologies and Teff Yields

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). Several factors explain this low yield. First, modern input use in teff production —such as inorganic fertilizer and improved seed—is low. Latest national estimates show that only two percent of teff farmers used improved seeds, although more than one third applied fertilizer for teff production (CSA 2012). Second, plant lodging, to which teff is susceptible, is perceived to be detrimental for teff grain production, especially during the grain-filling period (Guush et al. 2011). Third, land is repeatedly ploughed before sowing to prepare the seedbed and control weeds, but this leads to increased erosion and lower soil fertility (Balesh, et al 2008; Fufa,et al 2011) . Fourth, soil erosion has led to nutrient (mainly nitrogen and phosphorus) deficiencies in the drier areas of the country ((Habtegebrial, et al, 2007). Finally, there are significant post-harvest and processing losses (Fufa et al. 2011).

In 2009, based at the Debre Zeit Agricultural Research Center, Tareke Berhe began experimenting with teff row planting and later confirmed that reduced seed rate and row planting could potentially double teff yields. At the time, the ATA argued that the lack of modern planting technologies, limited agricultural extension resources, and a resistance to adopting practices resulted in low adoption rates for these types of technologies. Starting in 2011, the Ministry of Agriculture (MoA), ATA, and the Regional Bureaus of Agriculture initiated a large-scale trial of this approach. Demonstrations were made with 1,430 farmers and 90 Farmer Training Centers (FTCs), which resulted in 50-80% yield improvement compared to the national averages. Based on the success of these initial trials, the Transformation Council and the Ministry of Agriculture encouraged the (RBoA) to popularize these technologies in high-yielding zones during the 2012 planting season. As the federal and regional infrastructure has expanded, as well as capacity and resources for agricultural extension expanded, adoption has only moderately risen. Yet,

according to the ATA [25], most of the farmers who adopted new teff row planting experienced yield increases, across all regions.

2.4.4.Teff Production and Row Planting in Ethiopia

Teff is usually harvested grain in Ethiopia, where it was first domesticated between 4000–1000 BC (Rose, 2011). Teff flour is preferred in the production of injera a major staple food in Ethiopia (Gamboa & Ekris, 2008). Teff is one of the most important staple crops in Ethiopia. The cultivation of teff in Ethiopia has partly been motivated by its relative merits over other cereals in the use of both the grain and straw ((Miller, 2010).In the main production season (meher) of 2012-2013, teff was produced by more than 6 million farmers, resulting in total production of over 4 million metric tons on 2.7 million hectares of land. This accounted for the largest share of cereals cultivated in Ethiopia (CSA 2012). In 2011/12 production season, it was estimated that teff made up of 20% of all the cultivated area in Ethiopia, covering about 2.7 million hectares and grown by 6.3 million farmers. The second most important crop was maize at 15% of all cultivated area. However, given the relatively low yields of teff; the total national production of teff is 3.5 million ton which was lower than maize with 6.1 million ton and sorghum with 3.9 million ton (CSA, 2012). Guush, et al, (2011) were found that on the consumption side, teff is more readily eaten by urban households than by rural households, relying on national household consumption data that urban consumption per capita is as high as 61Kilogram per year. This compares to 20 Kilogram per capita per year for rural areas. Teff is therefore an economically superior crop commodity that is relatively more consumed by the rich than by the poor. The lower consumption by the poor is also partly explained by the high prices ofteff which are typically twice as high as the price of maize (Bart et al., 2012).

Teff is a major staple food with excellent nutritional value (high protein and fiber content, complex carbohydrates and gluten free). It accounts for 11 to 15 percent of all calories consumed and 23 percent of urban food consumption (Guush et al. 2011).

It has been argued recently that low teff productivity is partly caused by the way farmers sow teff seed. 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 seed rates and to plant seed in rows or to transplant seedlings (as is often done for rice, for example). Reducing the seed 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 the seeds, land management and especially weeding can also be done more readily and the incidence of lodging is reduced (Guush et al. 2011, Chanyalew & Assefa, 2013). According to Mitiku (2008), there was significant increase in yield components of tef with decreased seed rates from highest to lowest (35, 30, 25, 20, kg/ha). On the other hand, the lodging percentage of the crop was increased by increasing the seed rates.

2.5. Conceptual Framework of the Study

From the previous studies, it is confirmed that the adoption of Teff row planting practice is expected to improve Teff grain yield per hectare with reduced seeding rate. At household level the adoption of Teff row planting practice is determined by different factors. Those factors included in this study are shown in the conceptual framework in Figure 1 below.

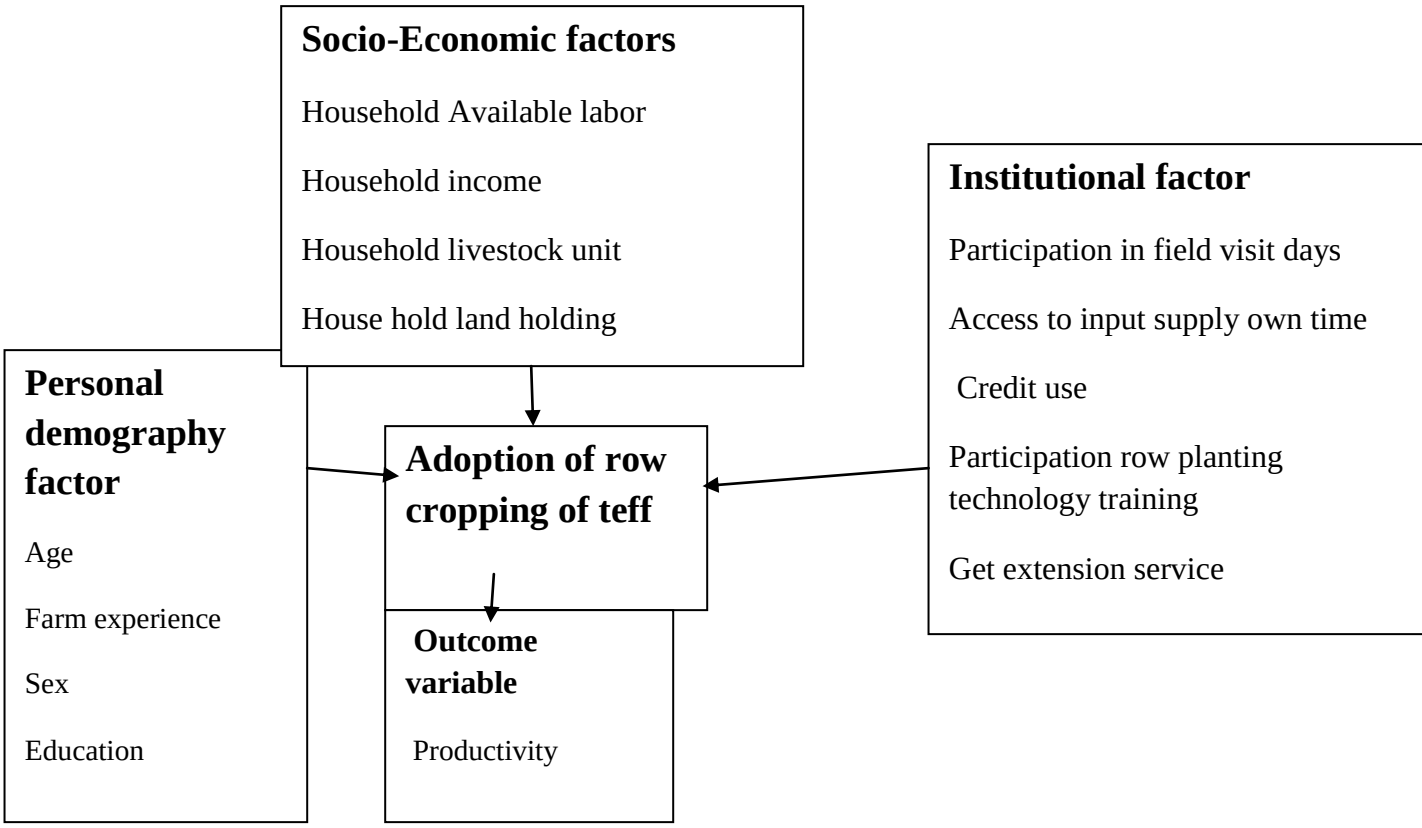


Figure 2-1: Conceptual frame work (Source own modification)

3. “RESEARCH METHODOLOGY”

This chapter discusses the research methodology were used in the study including location and description of the study areas, data types and data sources, methods of sampling, methods of data collection and analysis and also variable definition and hypothesis

3.1. Description of the Atudy Area

Aneded is one of the Districts in the Amhara Region of Ethiopia. Part of the East Gojjam Zone, Aneded is bordered on the south by the Abay River which separates it from the Oromia Region, on the southwest by Baso Liben, on the northwest by Guzamn, on the north by Sinan, and on the east by Awabel. Towns in Aneded include Amber. Aneded was part of Awabel District

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), this District has a total population of 91,224, of whom 45,408 are men and 45,816 women; 1,778 or 1.95% are urban inhabitants.

As it is common among highland of the country, mixed farming is also common activities of Aneded District farmers. The major sources of cash income for sample households in the study area are sale from crop production, sale from livestock and livestock products. Teff is produced for both home consumption and it is also major cash crop for sample households. In the study area Teff is a dominate of the total value production of all crops or in short the name of the District ye teff baharan But the District mostly practice the usual method of planting that is broadcasting. Therefore doesn’t produce the actual potential.

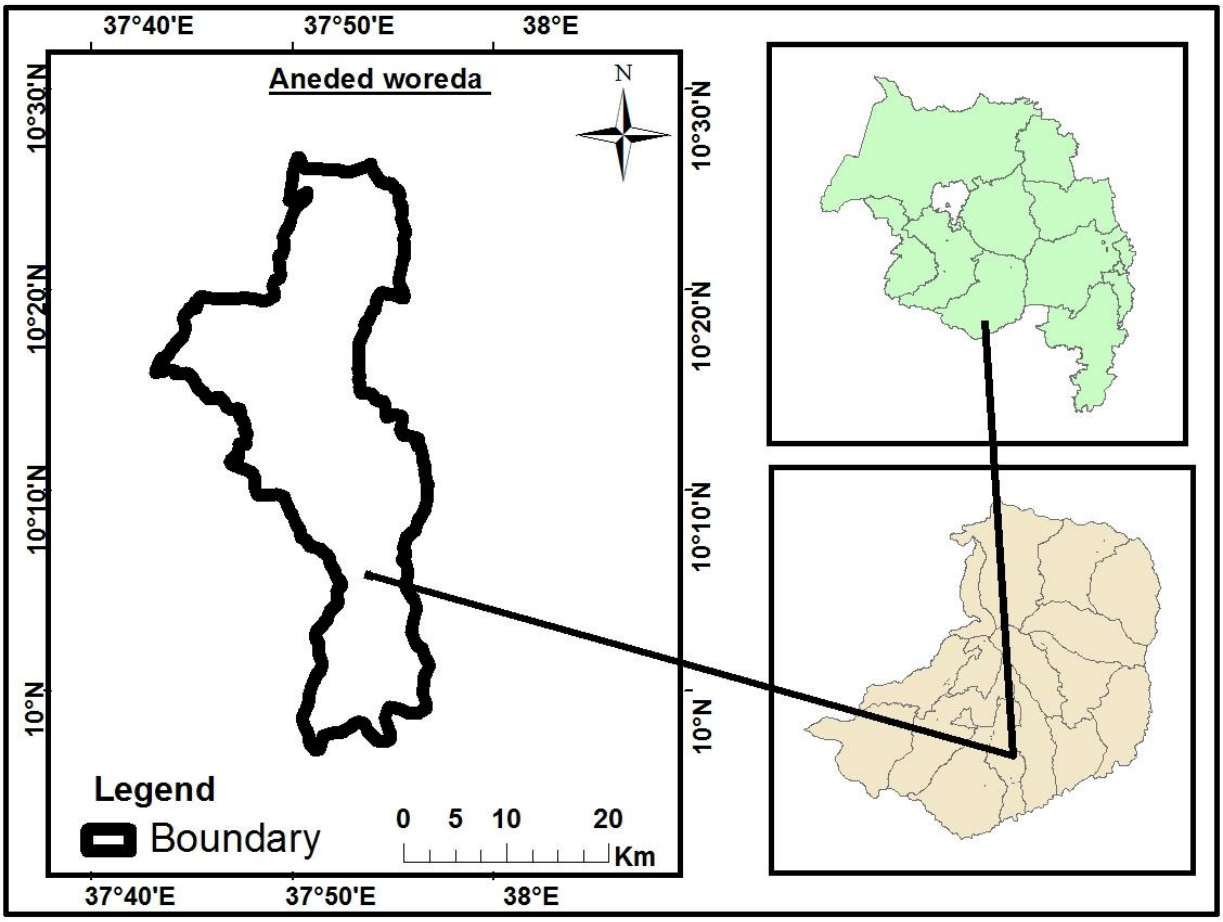


Figure 3-1: Location of the study area

3.2. Research Design

A research design is a systematic plan to study a scientific problem. According to the specification of causal research design (Oppewal, 2010) the researcher tries to isolate the "cause" (independent variables) and examine whether it has any effects on dependent variable – row planting adoption. Cross-section research design was used in this study. In this design data were collected at a single point in time. According to (Saumier, 2003) , this type of research design is used in descriptive research design and in determination of relationship of variables. This research design was used because of the limited time and finance in field work and the fact that it was deemed to be adequate for addressing the study objectives

3.3. Data Source and Methods of Data Collection

Both qualitative and quantitative data were collected from primary and secondary sources. Primary data for the study were collected from select sample households, focus group discusses), and key informants (DAs, District officials and village and cooperative leaders) through structured questionnaire. Beside these, secondary data were collected from various secondary sources to complement the primary data. These sources reviewed different literatures, policy and strategy documents from relevant federal and regional government offices such as central statistics agency (CSA), zonal and District level Agriculture and rural development bureaus, Ethiopian Agricultural Transformation Agency (ATA), and published and unpublished sources.

A household survey questionnaire was used to generate quantitative data and key informant interview and focus group discussion were employed to collect the qualitative data to supplement the quantitative study and used to address issues which were not touched by the quantitative part

.

3.4. Sampling Procedure and Sample Size Determination

To select sample respondents from the *District*, Two stages stratified sampling technique were employed. The fact that this District was appropriate because sowing in row of *teff* is practiced widely and *teff* coverage from the total cultivated land in the *District* is better than other. The total cultivated area of the District is around 33310 ha, out of this 15151 ha is covered by tef and 14.5 ha is row planted (ADARDO, 2019). In the first stage, using purposeful sampling technique six kebeles (*yewobi,gudalma ,jamma,znkr.chedefo and,malgash* ,) selected from 19 *kebeles* based on only their practice of row planting 3.125,1.5,2.25,2.25,3.5and 1.875 ha respectively . Hence these *kebeles* have both households practicing the row planting and those do not practice row planting. At last the household heads list was existed in the kebele adminstreastion in a clear form adopter and non adopter identified then followed by a systematic random sampling technique to select sample households from non adopter household category from the *kebele* administration. Households were stratify in to two strata: those households who adopt row planting technology and those farmers who practice the conventional farming system or non adopter of row planting of teff.

The sample size for this particular study was identified by using rule of thumb suggested by (Green, 1991) . He suggested that, n≥50+8m (where n is sample size of the study and m is number of independent variables). From this, the sample size for this study should be greater than or equals to 138 as there are eleven identified independent variables. But for the purpose of this study, 144 households (59 adopter of row planting and 85 non adopter of row planting) were determined as a sample size of the study. The main reason for this used to get enough number of samples that enabled generalization on research objectives. To determine respective samples from six *Kebeles* for non adopter stratum, sampling proportion to population was used. Finally, representative sample for non adopter stratum selected through systematic random sampling techniques. In the adopter stratum totally the household 59 in the six kebeles so in this case no need of sample technique take as it is.

Table 1: The Number of respondents in each kebele

No.	Kebeles	Household heads			Sample taken		
		Adopters	Non-Adopters	Total	Adopters	Non-Adopters	Total
1.	**Yewobi**	**10**	**948**	**958**	**10**	**12**	**22**
2.	**Gudalma**	**8**	**1337**	**1345**	**8**	**17**	**25**
3.	*Jamma*	**8**	**1557**	**1565**	**8**	**20**	**28**
4.	*Znkr*	**9**	**911**	**920**	**9**	**11**	**20**
5.	*Chendefo*	**7**	**606**	**613**	**7**	**8**	**15**
6.	*Malgash*	**17**	**1349**	**1366**	**17**	**17**	**34**
Total	Total	**59**	**6708**	**6767**	**59**	**85**	**144**

Source: kebeles' administrative offices and own computation (2020)

3.5. Data Analysis Techniques

The studies were employed descriptive statics and econometric model were used to analyze the collected qualitative and quantitative data by using SPSSS and STATA version13 soft wares.

3.5.1. Descriptive Statics

The descriptive analysis is applied to discuss the situation of adoption of row planting in the study area meaning that A Descriptive statistics were used for the description of different demographic, socioeconomic, institutional and situational characteristics of the sample respondents. These are mean, percentage, standard deviation and minimum values and maximum value were used along with the econometric model to analyze the collected data.

3.5.2. Econometric Model

Descriptive statistics often fail to predict the combined effect of the explanatory variables on the dependent variable (Aldrich and Nelson, 1984). Thus, this gap is to be bridged by the help of selecting and using appropriate econometric models.

The Probit and Logit models are commonly used models in adoption study. The Probit probability model is associated with normal probability function. And the logit model with logistic probability distribution respectively. The advantage of these models over the linear probability model is that the probabilities are found between 0 and 1. Both Logit and Probit models may give the same result. The logistic function is used because it represents a close approximation to the cumulative normal distribution, mathematically easily used model and is easier to work with. Therefore, the Logit model is selected for this study. The model is fitted using method of row planting of teff technology as dependent variable, socioeconomic variables as independent variables which are influence practice of teff row planting and the outcome variable, teff productivity and it would be important to shows the factors that influence the farmers' adoption . The dependent variable is binary, taking values of 1 if the farmer adopters and 0 otherwise. However, the independent variables are both continuous and discrete. The justification for using logit is its simplicity of calculation and that its probability lies between 0 and 1. Moreover, its probability approaches 0 at a slower rate as the value of independent variable gets smaller and smaller, and the probability approaches 1 at a slower and slower rate as the value of the independent variable gets larger and larger (Gujarati, 2008).

3.5.2.1. Specification of the Econometric Model for Adoption

Based on (Gujarati, 2008) the logit model can be specified as follows:

If Pi is the probability of adopting teff row planting and Xi is the factors influencing the adoption:

Pi = E (Y=1 \Xi = $\beta 1 + \beta 2 + \beta 2$Xi ----------(1)

Equation (one) can be represented as:

Pi=E(Y=1/Xi=$\frac{1}{1+e^{-(\beta 1+\beta 2Xi)}}$ ---------- (2)

If Zi is equal to $\beta 0 + \beta 1 + \beta 2$Xi, ------- (2) can be written as:

Pi=$\frac{1}{1+e^{-Zi}}$=$\frac{e^{z}}{1+e^{z}}$ and this represents logistic distribution function ----------(3)

If Pi is the probability of adopting teff row planting then (1 – Pi) is the probability of non adopting the row planting which is:

1-Pi=$\frac{1}{1+e^{zi}}$ ---------- (4)

Therefore,$\frac{Pi}{1-Pi}$=$\frac{1+e^{zi}}{1+ei^{-z}}$=$e^{Zi}$----------(5) is odds ratio in favor of adopting the practice.

Taking the natural logarithm of --------- (5), gives

Ln ($\frac{p_i}{1-p_i}$) = z_i =$\beta 0 + \beta 1 + \beta 2$ ---------- (6)

Farmers were categorized as adopters and non-adopters. Defining Y as adoption of the technology (teff row planting), and the adoption decision as a function of a set of farmers` characteristics and technology-specific attributes. Theoretically, the Logit model is expressed simply as:

Y = B0 + B1X1 + B2X2 + U……BnXn ----------(7)

Where:

Y = Likelihood of Adoption, (Analysis of adoption of teff row planting technology).

B0 = intercept;

B1……..n = estimated parameters;

X1……..n = Set of independent variables.

U---------- is the stochastic (error or disturbance) term

3.5.2.2. Specification of the Propensity Score Matching Analysis (PSM)

Propensity Score Matching (PSM) method was applied to estimate the robust impact of row planting technology adoption on Teff yield per hectare at household level. In evaluating the impact of row planting technology adoption on teff yield of adopter households (treated group) and non-adopters (control group), it is obvious that a researcher faces selection bias estimation problem. Thus, to evaluate the impact of a treatment on performance indicators, it is indeed to draw a counter factual group that can serve as a comparison group. Heckman et al. (1998) suggested that the counter factual can be compared with the treated group to evaluate the impact of the treatment on the performance indicators. In the context of this study, the treated groups counter factual would be the situation where Teff is produced in the absence of the participation in row planting. However, in reality a household cannot hold both a treatment and control group status at a time.

As a result, counter factual for the treated is possible by constructing a treatment factual group that resembles the treatment group in the absence of treatment. In order to eliminate selection bias, there is a need to compare the performance levels of both treated and control groups which are statistically comparable (Rosenbaum and Rubin, 1985; Khandker et al., 2010). Consequently, in dealing with selection bias problem the implementation of propensity score matching (PSM) is advised.

According to Tagel (2008)To address the observable characteristics Propensity score matching is appropriate to utilize. Choosing an appropriate model and analytical technique depends on the type of variable under consideration. Here the dependent variable of interest is binary that takes a value of 1 and 0. Assessing the impact of any intervention requires making an inference about the outcomes that would have been observed for program participants had they not participated. Rosenbaum & Rubin(, 1983).The appropriate evaluation of the impact of the program requires identifying the average treatment effect on the treated (ATT) defined as the difference in the outcome variables between the treated households and their counterfactual. Counterfactual refers to what would have happened to the outcome of program participants had they not participated (; Daniel *et al.,* 2008).

Access to the impact of sowing in line of *teff* was not randomized. As a result, the impact of sowing in line of *teff* on household yield was estimated using propensity score

matching as a method of estimating the counterfactual outcome for sowing in line of *teff* beneficiaries. Setboonsarng et al (2008) were found that Estimating the propensity score and making that the balancing condition satisfied is the first step in propensity score matching (PSM) based on observed household characteristics. The magnitude of a propensity score ranges between 1 and 0; the larger the propensity score, the more likely the household is to participate in the Program .

According to Rosenbaum and Rubin (1983), let YRP be the outcome of row planting of *teff* beneficiaries and $Ynon\ RP$ outcome of the non- row planting off *teff* beneficiaries. For each household, only YRP or $Ynon\ RP$ is observed, which leads to a missing data problem. In estimating the propensity score, the dependent variable was used participation in the row planting of *teff* practice and let Ti denotes the participation indicator equaling 1 with probability of π if the household is practicing sowing in line of *teff* beneficiaries and 0 with probability of 1- π otherwise. Let X denotes a vector of observed individual characteristics used as conditioning variables. The most common evaluation parameter of interest is the average impact of the treatment on the treated (ATT) given as:

ATT = E $YRP - Ynon - RP$ T = 1, X) = E(YRP T = 1) − E($Ynon\ RP$ T = 1 ---------- (8)

This parameter estimates the average impact among sowing in line beneficiaries. The data on row planting beneficiaries identify the mean outcome in the treated state. E(YRP Ti = 1, X)

The mean outcome in the non-row planting beneficiaries $E(Ynon - RP$ Ti = 1, X) is not observed.

Let P=denote the probability of participating in the practices of sowing in line of *teff*, i.e., the Propensity Score. Propensity Score Matching (PSM) constructs a statistical comparison group (non- row planting of *teff* beneficiaries) by matching observations on sowing in line of *teff* beneficiaries to non- sowing in line of *teff* beneficiaries on similar values of propensity score. Once the propensity score is estimated, the data is split into equally spaced intervals of the propensity score. Within each of these intervals the mean propensity score of each covariate do not differ between participants and non-participants. The effectiveness of PSM estimators as a feasible estimator for impact evaluation depends heavily on two assumptions (Rosenbaum and Rubin, 1983):

i) Conditional Independence Assumption (CIA):

Conditional Independence Assumption (CIA): meaning outcomes of the adopters and non-adopters are independent of the treatment status or after controlling for observable characteristics. The CIA states that given a set of observable covariates (X) which are not affected by participation (sowing in line of *teff)*; potential outcomes i.e. is the household Yield are independent of participation assignment. That is the row planting beneficiaries' outcome and non- row planting beneficiaries'outcome is independent of the treatment status.

$YRP, Ynon{-}RP \perp \mathrm{T}|X$ ---------- (9)

$E(\ YRP\ |P, \mathrm{T}i = 1\ ) - E(\ Ynon{-}RP\ |P, \mathrm{T}i = 0)$ ----------(10) This implies that the non-row planting beneficiaries' outcomes can be used as an unbiased estimation of the counterfactual outcome for the row planting beneficiaries. non-row planting beneficiaries have the same average outcomes as row planting beneficiaries would have had if they did not receive the program, after controlling for all pre-program observable household and community characteristics that are correlated with the program participation and the outcome variable (Daniel O,et al, 2008).

ii) Common Support Assumption (CSA):

Common support condition (CSC): Entails the existence of sufficient overlap in the characteristics of the treated and untreated units to find adequate matches (common support)

The CSA means that no explanatory variable is allowed to perfectly predict treatment. If the above two assumptions are satisfied, then, after conditioning on propensity score, the $\boldsymbol{YRP}$distribution observed for the matched non- row planting beneficiaries can be substituted for the missing $\boldsymbol{Ynon{-}RP}$ distribution for the row planting program.

$0 < P = Pr\ \mathrm{T}=1|X < 1$ ---------- (11)

Matching individuals based on observed covariates might not be desirable or even feasible when the dimensions of the covariates are many. To overcome the problem of dimensionality, instead of matching along X, we can match along P(X). Given that the propensity score is a balancing the probability of participation conditional on *X* was balanced such that the distribution of observables *X* were the same for both participants and non-participants. Consequently, the differences between the groups are reduced to only the attribute of participation assignment, and unbiased impact estimates can be

produced (Rosenbaum and Rubin, 1983). Simultaneous adoption of the above two assumptions Equation [9] and [11] gives: $YRP,Ynon{-}RP \perp \mathrm{T}|P\ X$ ---------- (12) As long as outcomes are independent of participation given observables, then they also do not depend on participation given propensity score. Therefore, the multidimensional matching problem is reduced to a one-dimensional problem. The distribution of potential outcomes will be balanced among participants and counterfactuals (Rosenbaum and Rubin, 1983; Heckman *et al*., 1998).

Building on these underlying assumptions, Propensity Score Matching provides a valid method for estimating $E(\ Ynon{-}RP \mid \mathrm{Ti}{=}1,X\ )$ and obtaining unbiased estimates of ATT ((Heckman, et al, 1998) (Smith & Todd, 2005). Following the (Krasuaythong(2008) the parameter of interest here is the average treatment effect on the treated (ATT). Therefore, applying the composite assumption the true ATT, based on PSM can be written as follow:

$ATT\ psm = E\ p\ x\ YRP{-}\ Ynon{-}RP \mid\mid \mathrm{T}i{=}1,X$

$= E\ p(x)\ E(\ YRP{-}\ Ynon{-}RP \mid \mathrm{T}i{=}1,P(Xi)$

$= E\ p\ x\ E\ YRP \mid\mid \mathrm{T}i{=}1,P\ Xi - E\ Ynon{-}RP \mid\mid \mathrm{T}i{=}1,P\ Xi$ ----------(13).

The perception is that two individual households with the same probability of participation will show up in the participants and non-participants samples in equal proportions on the basis of propensity scores. Where the first term on the right hand side of the above expression (12) can be estimated from the row planting beneficiaries and the second term from the mean outcomes of the matched (i.e. based on propensity score) non-row planting beneficiaries. The probability of participation in the row planting can be derived by binary response models.

Liebenehm et al(2011) were found that various methods to predict propensity score produce similar estimates, for computational simplicity in this study logit model *was* applied. The propensity score response probabilities strictly between zero and one. Once the propensity score is estimated, the data is split into equally spaced intervals of the propensity score. Within each of these intervals the mean propensity score of each covariate do not differ between participants and non-participants

3.5.2.3. Matching Estimators of the ATT Based on the Propensity Score

Estimation of the propensity scores and making sure that the balancing condition to be satisfied is the first step in Propensity Score Matching techniques (PSM) to estimate the ATT of the outcomes of interest. Even if there are various matching estimators in the literatures to estimate the ATT based on propensity score and can be used separately. For example nearest neighbor matching estimator was used by (Daniel O,et al, 2008) and (Yibrah, 2010) their consideration in tandem have advantageous because they can be used as a way of measuring the robustness of the results of impact estimates (Becker & Ichino, 2002). Therefore, in this study the Nearest Neighborhood matching (NNM), Radius matching (RM), stratification matching and kernel matching was employed.

3.6. Statistical and Specification Tests

Before execute the ultimate model regressions, all the hypothesized explanatory variables were checked for the existence of statistical problems such as multicollinearity problems. Basically, multicollinearity may arise due to a linear relationship among explanatory variables and the problem is that, it might cause the estimated regression coefficients to have wrong signs, smaller t-ratios for many of the variables in the regression and high R2 value. Besides, it causes large variance and standard error with a wide confidence interval. Hence, it is quite difficult to estimate accurately the effect of each variable (Gujarati, 2004;). There are different methods suggested to detect the existence of multi collinearity problem between the model explanatory variables. Among these methods, variance - inflating factor (VIF) technique is commonly used and is also employed in the present study to detect multicollinearity problem among continuous explanatory variables (Gujarati, 2004). In Gujarati (2004) it was defined that VIF shows how the variance of an estimator is inflated by the presence of multicollinearity (Gujarati, 2004). Mathematically, VIF for individual explanatory variable (Xi) can be computed as

$VIF=11-R2$ --------- (14)..... Where R2 is the coefficient of correlation among explanatory variables. According to Gujarati (2004), the larger the value of VIF indicates the more collinearity among one or more model explanatory variables. As a rule of thumb, if the VIF of a variable exceeds 10, which will happen if a multiple R-square exceeds 0.90, that variable is said be highly collinear (.Gujarati, 2004). Alternatively, we can use the inverse of VIF (1/VIF) called Tolerance (TOL) as a measure of

multicollinearity. The closer is TOL of one explanatory variable (Xi) to zero, the greater the degree of collinearity of that variable with the other regressors. On the other hand, the closer TOL of Xi is to 1, the greater the evidence that Xi is not collinear with the other regressors (Gujarati, 2004).

Similarly, contingency coefficient (CC) method was used to detect the degree of association among discrete explanatory variables ((Healy, 1984). According to Healy (1984), the 28 discrete or dummy variables' are said to be collinear if the value of contingency coefficient(CC) is Greater than 0.75 (Healy, 1984).

Matimatically:-

CC=X2n+X2 ----------(15)

Where CC-is contingency coefficient

n-is sample size

X2- is chi-square value

3.7. Definitions of the Variables and Hypothesis

Dependent variable

Adoption of Teff row planting practice is the dependent variable. It is a dummy variable, Adoption of teff row planting technology: farmers who were using teff row planting during 2019/20 G.C crop season were considered to be adopters (1) or otherwise non-adopters (0).

Outcome Variables for the Impact Analyses

Teff productivity computed bydividing the total teff yield/output produced by the total area of land cultivated by row and broadcasting method for teff during the season 2011/12 E.C on the household. It is a continuous variable measured in yield per hectare.

Independent variable

Independent (explanatory) variables: The explanatory variables that importance in this study were identified from previous studies and the nature of the study area. These variables are expected to result in variation in adoption of Teff row planting practice by farmers in the study area . These include household's personal and demographic variables, socio- economic variables, and institutional variables. These explanatory variables are defined as follows

Sex of the Household Head (SHH): Considers gender of household head; It is a dummy variable to be used as (1 if male, 0 for Female). The sex difference is one of the factors influencing adoption of new technologies. Due to many socio-cultural values and norms, males have freedom of mobility and participation in different extension programs, conferences and consequently have greater access to information. Therefore, it hypothesized that will male farmers are more likely to adopt row planting technology.

Households age (HHA)**: -**It is a variable that indicate a number of years starting from birth. It is continues variable that measure in a year of the respondent. It is assumed that as farmer age increases the probability of adoption is expected to decrease because as the farmer's age increases , it is expected that the farmer becomes conservative (Mekdelawit et al, 2018) .It hypothesize that it will be affect row planting adoption negatively with the increase in age of farmers .

Education (EDH): education is assumed to increase farmers' ability to obtain, process, better understanding to solve production constraint and use information from different sources relevant to the adoption of row planting. Education is therefore expected to increase the probability of adoption of row planting in teff production. It is also treated as a dummy variable and measured as: =0, if the farmer is Illiterate, = 1, if the farmer Literate means that start from read and write b/c all are farmers. Adoption is expected to correlate positively with education (Mesafnit, 2017). It is hypothesize that it will affect positively adoption of row planting with the increase in education level of farmers.

Total Annual Income (TAIN): 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 treated as a continuous variable. It is measured in Birr. This is believed to be the main source of capital for purchasing agricultural inputs and labor. According to Mesafint (2017) households with relatively higher income are expected to better understanding and adopt row planting technology. It will be hypothesized to that affect row planting adoption positively with the increase in income level of farmers

Farm size (FAS) : It refers to the area of land that the farm household owned and cultivated. it is continues variable and measured in a hectare. It is an indicator of wealth and social status and had influence within community. It is substantial economic resources. Since farmland is one of the important resources, which enable farmers to invest in the adoption of new agricultural technology. It is also an important factor to adopt Teff row planting method to increase its production and productivity. In line with this, a farmer with large farm size can adopt more agricultural innovation and the reverse is true for small farm size farmers (Geremew et al,2016) and (Mekdelawit et al ,2018).It hypothesize that will affect positively the adoption of row planting.

Family size (FAS): The number of family that availability of active and productive family member in the household. Availability of labor force is likely to influence the gross margin of the adoption of the innovation. it is continues variable that measured in terms adult equivalent unit A farmer with larger family labor more likely the probability of the adoption of row planting(Mekdelawit et al,2018).It is hypothesize that will affect positively the adoption of row planting.

Number of Livestock (NOLT):). 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 a continues variable that measured in terms Tropical Livestock Unit (TLU) It is to influence the adoption of the row planting practice positively because it is a proxy variable for wealth status (Mesafint, 2017)and(Mekdelawit et al ,2018).It is hypothesize that will affect positively the adoption of row planting.

Credit Use (CUS): It is got loan from governmental organization and nongovernmental organization. Farmers who have used to credit may overcome their financial constraints

and buy inputs. It is a dummy variable measured in terms of whether respondents have access to credit use in terms of availability of credit sources and possibility of getting credit use 1 and otherwise 0 haven't credit use. Farmers without cash and haven't credit use will find it very difficult to attain and adopt new technologies .so farmers used credit positively adopt row planting (Mesafint,2017,Mekdelawit et al,2018).It is hypothesize that will affect positively the adoption of row planting.

Training on Row Planting Technology (TRPT). training is one of the means farmers to get exposure about row planting technology such as method, importance and other information which farmers acquire new knowledge and skills. It is a dummy variable that measred1 if a farmer participation on training of teff row planting technology otherwise 0.So it develop positive adoption behavior (Mesafint,2017,Mekdelawit et al.2018). It is hypothesize that will training about row planting technology affect positively the adoption of row planting.

Access to Technology Input Supply own time (AISU): As availability of planting technology own time that means at the sowing time increase, farmers' use of row planting would be enhanced. This is a dummy variable that measured if the household head has access to technology input supply 1otherwise 0. On the contrary, if planting technology is not adequate at the time of sowing, farmers use traditional broadcasting method(Mesafint,2017) It is hypothesize that will affect positively the adoption of row planting.

Get Extension service(s) (GEA): Farmer get information from the experts that important for the sake of adoption of new technology**.** This is a dummy variable that measured if the farmer get extension service 1 otherwise 0 farmers never contact throughout the year. Farmer get extension service has positively influence on adoption of row planting(Mesafint,2017).It is hypothesize that will affect the adoption of row planting **.**

Participate Field visit days(PFVD) .This mean that a household ever get a chance and see row planted demonstration sites in his neighboring or elsewhere organized by their local government This is a dummy variable that measured 1participate field visit days otherwise 0. This indicate ,higher probability adoption of row planting of teff

(Ejegayehu, 2016) .It hypothesize that will affect positively influence on the adoption of row planting of teff.

Summary of Variables and Hypothesis

Table 2: Variable hypothesis

Variables	Variable code	Type of variable	Measurement	Expected sign
Dependent variables				
Adoption of teff row planting ADTRP (y) – yes = 1, no= 0		Dummy		
Impacts of productivity that is yield per hectare		Continues		
Independent variable				
1. Sex oh Household	SHH	Dummy	Male=1,Female=0	+ve
2. Household Head's age	HHA	Continues	In year	-ve
3. Education	EDH	Dummy	Literate=1.Illtreate=0	+ve
4. Total Annual Income	TANI	Continues	In birr	+ve
5. Farm size	FAS	Continues	In hectare	+ve
6. Family size	FAS	Continues	Adult Eqv.	+ve
7.Number of Livestock units	NLU	Continues	TLU	+ve
8. Credit use	CRU	Dummy	Yes=1,no=0	+ve
9.Training on Row Planting Technology	TRPT	Dummy	Yes=1,no=0	+ve
10.Access to technology input supply	AISU	Dummy	Yes=1,no=0	+ve
11.Get Extension service	GES	Dummy	Yes=1,no=0	+ve
12 Participation Field visit days	PFVD	Dummy	Yes=1,no=0	+ve

4. RESULTS AND DISCUSSION

In this chapter, the results of the study were presented and discussed in detail to address the objectives of the study. The major findings of the study were discussed in this chapter. Both descriptive statistics and econometric analyses used to analyze the primary data regarding, economic factors and institutional/access related variables of sample households. Econometric analyses used to identify the probability of adoption of row planting of teff and impact of the adoption on teff productivity. The analyses have been done in the light of the objectives of the study. Section 4.1 is about the descriptive analysis of the model variables. Section 4.2 deals about the result of the econometric analyses.

4.1. Descriptive Results

The descriptive statistics of respondents were presented for both continuous and dummy variables. Among the total 144 respondents sampled for the study, 59 (41%) were adopters of row planting teff, while the remaining 85 (59%) were non adopter of row planting of teff.

4.1.1. Descriptive statistical result for continuous variables

Age of the household head: The age structure of the respondents showed that the minimum and maximum age was 27 years and 70 years respectively. The average age of respondents was 43.66 years while the average age of the adopters of row planting and non- adopters of row planting were 44.98 and 42.74 years respectively. As the t-test shows, there is statistically significance difference between the average age of adopters of row planting and non-adopter (t=1.770, p=0.079). (Table 3).

Family size: The minimum and maximum family size was 1.75 and 7.65 persons respectively, while the average family size of respondents was 4.72 persons. The average family size of adopters of row planting was 5.52 while the non-adopter were 4.16. Statistically there is significance difference between the average family size of adopter of row planting and non- adopter (t=7.570, p=0.000). This is due to row planting is labor intensive practice and it needs high labor for seeding of Teff on the farm". Therefore, the

respondent who has large Family size has better chance to adopt Teff row planting method than lower family size (Table 3).

Farm size: The minimum and maximum farm size of respondents was 4 tmiad (1 ha) and 23 tmiad(5.75 ha) respectively. The average farm size of the respondent was9.31 timad(2.33 ha).The average farm size of adopter of row planting of teff was 11.68(2.92 ha) while the non-adopter were 7.67 timad(1.92 ha). The t-test result indicated that there is statistically significance difference between the average farm size of adopters of row planting of teff and non-adopter (t=8.02, p=0.000). b\c respondents who had large farm size found to adopt teff row planting technology which is mainly resulted from the fact that they did want to take risk of applying teff row planting technology than their counterparts (Table 3).

Number of livestock: it was measured in Tropical Livestock Unit. The minimum and maximum livestock ownership of respondents was 2.16TLU and 13.68 TLU respectively. The average livestock ownership of the respondent was7.99 TLU. The average livestock ownership of adopter of row planting of teff was 10.30 while the non-adopters were 6.38 TLU. The t-test result indicated that there is statistically significance difference between the average livestock ownership of adopters of row planting of teff and non-adopter (t=9.67, p=0.000). larger livestock holding may have the opportunity to plough at any time with a minimum labor cost, especially for oxen so one of the chance to the probability of adoption of row planting than their counterparts.

Annual income: The minimum and maximum annual income of respondents was 24600, birr and 216,000 birr respectively. The average annual income of the household 102122.92,birr . The average annual income of the household Adoption of row planting of teff was 124301.69, Birr while the average annual income of non -adopters was 86728.23 Birr. The t-test result indicated that there was statistically significance difference between the average annual income of adoption of row planting teff and non-adopter (t=6.39, p=0.000). This is believed to be the main source of capital for purchasing agricultural inputs and labor. Households with relatively higher income are expected to better

purchasing inputs for row planting and adopt row planting technology than their counter parts Table3.

Table 3:Summary of descriptive statistical result for continuous variable

The adoption of row planting of teff of respondent

Total sample					**Adopter**		**Non-adopter**		
Variables	Min	Max	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	t-value
Age	27	70	43.66	7.53	44.98	6.27	42.74	8.20	1.770*
Family Size	1.75	7.65	4.72	1.26	5.52	1.00	4.16	1.09	7.570***
Farm size	4	23	9.31	3.54	11.68	3.00	7.67	2.94	8.02***
TLU	2.16	13.68	7.99	3.07	10.30	2.42	6.38	.2.36	9.67***
Annual income	24600	216000	102122.91	39228.11	124301.69	36283.89	86728.23	33546.33	6.39***

***, **,* significant at 1%, 5%and 10% respectively n=144

Source: own survey, 2020

4.1.2. Descriptive statistical result for dummy variables

Sex of the household head: Out of 144 respondents interviewed, 129(89.6%) and 15 (10.4%) were males and females respectively. This shows that majority of the respondents were males. The smaller number of females is due to the few numbers of female headed households in the study area. Majority of male respondents, 59 (41%) were found to be adopters of row planting of teff while the other 70 (48.6%) of respondents were non adopter of row planting of teff . From the total female respondents, 0 (0%) of them were adopters of row planting of teff while 15 (10.4%) of them were non adopter of row planting of teff . The chi-square result showed that there is statistically significance

difference (χ^2=11.622, p=0.000) between adopter of row planting teff and non-adopter of row planting of teff with respect to sex of the household head. The result showed that significant number of male household heads was found to be adopters of row planting of teff than female household heads. This mean that The sex difference is one of the factors influencing the adoption of row planting technologies This is due to many socio-cultural values and norms males have the chance freedom of mobility and participation in different extension programs ,conferences and consequently have greater access to information to access and use new technologies such as row planting of teff (Table 4).

Educational status of the respondent: The result of this study showed that majority, 91 (63.2%) of the respondents were literate while the remaining 53 (36.8%) were ill-treat . From the total respondents, 53 (36.8%) of respondents who were adopter of row planting of teff and 38 (26.4%) of respondents who were non-adopter of row planting of teff reported as they were literate. On the other hand, 6 (4.2%) of respondents who were adopter of row planting of teff and 47 (32.6%) of respondents who were non- adopter of row planting of teff reported as they were ill-treat . The chi-square result showed that there is statistically significance difference (χ2=30.489, p=0.000) between adopter of row planting teff and non-adopter of row planting of teff with respect to education of the household head or The Chi-square result indicates that there is association between adoption of the row planting practice and educational status of the household heads. This implies education helps farmers to get the probability of adoption row planting of teff through awareness creation and information to make appropriate decision to practice this technology (Table 4).

Credit use: The result of this study showed that majority, 75 (52%) of the respondents had used credit while the remaining 69 (48%) had not use credit. From the total respondents, 44 (30.6%) of respondents who were adopters of row planting of teff and 31 (21.5%) of respondents who were non-adopters of row planting of teff reported as they had use credit. On the other hand, 15 (10.4%) of respondents who were adopt row planting of teff and 54 (37.5%) of respondents who were non-adopter of row planting of teff reported as they did not use credit. The chi-square result showed that there is statistically significance difference (χ^2=20.263., p=0.000) between adopters of row

planting of teff and non adopters of row planting of teff with respect to credit use. Farmers who have access to credit may overcome their financial constraints and therefore buy inputs. This implies finance is the important element in using new technologies. Farmers with access to credit can minimize their financial constraints and buy different farm tools such as inputs to practice row planting of teff than those with no access to credit (Table 4).

Get extension service: The result of this study showed that majority, 89 (61.8%) of the respondents had to get extension service while the remaining 55 (38.2%) had not to get extension service. From the total respondents, 41 (28.4%) of respondents who were adopters of row planting of teff and 48 (33.3%) of respondents who were non-adopters of row planting of teff reported as they get extension service . On the other hand, 18 (12.5%) of respondents who were adopt row planting of teff and 37 (25.7%) of respondents who were non-adopter of row planting of teff reported as they did not to get extension service . The chi-square result showed that there is no statistically significance difference (χ^2=2.501, p=0.114) between adopters of row planting of teff and non adopters of row planting of teff with respect to get extension service

Participation in training: the respondents 64 (44.4%) had participated on trainings about row planting teff technology while the remaining 80 (55.6%) majority of the respondents did not participate in trainings on row planting of teff technology. From the total respondents, 47 (32.6%) of respondents who were adopter of row planting of teff and 17 (11.8%) of respondents who were non –adopter row planting of teff reported as they had participate in trainings. On the other hand, 12 (8.3%) of respondents who were adopter of row planting of teff and 68 (47%) of respondents who were non- adopter reported as they did not participate in trainings about row planting teff technology. The chi-square result showed that there is statistically significance difference (χ^2=50.205, p=0.000) between adopter of row planting and non-adopter of row planting of teff with respect to participation in training. Participation in training can help respondents to get awareness and then broaden their thinking ability. As households participate in trainings, then they can develop the method of row planting and yield difference between broadcast and row planting. So the household had been the probability of adopt row planting teff

technology on training participation than non- participation on training of row planting of teff technology. This mean that equips farmers' with new knowledge and skills, which help them to perform new practices properly The reason could be that, trained farmers could develop their knowledge to practice and make them confident to implement row planting(Table 4). .

Access to Technology Input Supply own time: Majority of the respondents 117 (81.2%) had on access technology input supply own time about row planting teff technology while the remaining 27 (18.8%) of the respondents did not on access technology input supply own time on row planting of teff technology. From the total respondents, 56 (38.9%) of respondents who were adopter of row planting of teff and 61 (42.3%) of respondents who were non –adopter row planting of teff reported as they had access technology input supply own time . On the other hand, 3 (2.1%) of respondents who were adopter row planting of and 24 (16.7%) of respondents who were non- adopter reported as they did not on access technology input supply own time about row planting teff technology. The chi-square result showed that there is statistically significance difference (χ^2=12.252, p=0.000) between adopter of row planting and non-adopter of row planting of teff with respect to access input supply own time. As availability of planting technology own time that means at the sowing time increase, farmers' use of row planting would be enhanced. On the contrary, if planting technology is not adequate at the time of sowing, farmers use traditional broadcasting method rather than use row planting of teff(Table4).

Participation Field visit days : Majority of the respondents 74 (51.4%) had participated on Field visit days about row planting teff technology while the remaining 70 (48.6%) of the respondents did not participate in Field visit days on row planting of teff technology. From the total respondents, 49 (34%) of respondents who were adopter of row planting of teff and 25 (17.3%) of respondents who were non –adopter row planting of teff reported as they had participate in Field visit days . On the other hand, 10 (6.9%) of respondents who were adopter of row planting of teff and 60 (41.7%) of respondents who were a non- adopter reported as they did not participate in Field visit days about row planting

teff technology. The chi-square result showed that there is statistically significance difference (χ^2=40.111, p=0.000) between adopter of row planting and non-adopter of row planting of teff with respect to participation in Field visit days .This mean that a household ever get a chance and see row planted demonstration sites in his neighboring or elsewhere organized by their local government This indicate ,higher probability adoption of row planting of teff(Table4)

Table 4:Summary of descriptive statistical result for dummy variable.

Variables		Adopter	%	Non-Adopter	%	N	Chi-square value(χ^2
Sex	Male	59	41	70	48.6	129	11.622***
	Female	0	0	15	10.4	15	
Education	Literate	53	37	38	26.4	92	29.156***
	Illiterate	6	4	47	32.6	52	
Credit use	Yes	44	30.6	31	21.5	75	20.263***
	No	15	10.4	54	37.5	69	
participate to extension service	Yes	41	28.4	48	33.3	89	2.501
	No	18	12.5	37	25.7	55	
Participation on training	Yes	47	32.6	17	11.8	64	50.205***
	No	12	8.4	68	47.2	80	
Input supply own time	Yes	56	38.9	61	42.3	74	12.252***
	No	3	2.1	24	16.7	70	
Field visit days	Yes	49	34	25	17.3	74	40.111***
	No	10	7	60	41.7	70	

***, **,* significant at 1%, 5%and 10% respectively n=144

Source: own survey, 2020

In order to support the quantitative nature of the data the qualitative nature of the data were stated by The FGD also has identified and underlined major barriers of the development of adoption of row planting of teff, The way of delivering this technology through political intervention, problems of fully package application due to voluntarism action about the students around those Kebles with out training, the problem of the occurrence of risk absorb in the study area, Complex nature of the technology related to labor intensive and problems of seed preparation as well as the nature of the soil in most kebeles is not comfortable for row planting of teff in the study area. So due to the above problems was the major barriers to adopt row planting of teff as the focuses group said.

4.2. Results of Econometric Analyses

In this section, the econometric results of hypothesized independent variables resulted from binary logit model were explained. This model was used to identify potential independent variables affecting the adoption of row planting teff.

4.2.1. Results of Multicollinearity Tests and Heteroskedasticity Tests

Before running the binary logistic regression analysis, multicollinearity diagnostics test was checked for the existence of multicollinearity problem among and between each independent variable. Variance inflation factor for continuous variables and CC for dummy variables were checked. As can be seen from the results in (Appendix 4) the values of the VIF for continuous variables were found to be small (i.e. VIF values less than 10) indicating that there was no serious problem of multicoliniarity among the independent variables. The result of the CC also reveals the absence of multicoliniarity problem. According to the test result, multicollinearity was not a serious problem both among the continuous and discreet variables. (i.e. CC values less than 0.75) among independent variables (Appendix 5).Therefore, all as independent variables were entered into the binary logistic regression analysis.

Heteroscedasticity refers to the variance of the error terms in a regression model in an independent variable. If heteroscedasticity is present in the data, the variance differs across the values of the explanatory variables and this will make the OLS estimator unreliable due to bias. It is therefore imperative to test for heteroscedasticity and apply corrective measures if it is present. Various tests help to detect heteroscedasticities such as Breusch Pagan test and White test. Breusch-Pagan test, which used in this study helps to check the null hypothesis versus the alternative hypothesis. A null hypothesis is that where the error variances are all equal (homoscedasticity), whereas the alternative hypothesis states that the error variances are a multiplicative function of one or more variables (heteroscedasticity). If the probability value of the chi-square statistic is less than 0.05. Therefore the null hypothesis of constant variance can be rejected at 5% level of significance. It implies the presence of heteroscedasticity in the residuals. The chi-square statistic of the Breusch-Pagan test for Logit model was 0.25 which is insignificant

leads to the acceptance of the null hypothesis (Constant variance) mean that no heteroscedasticity problem (Appendix 6).

4.2.2. Factors Affecting the Adoption of Row planting of Teff

Goodness of fit of the model with the dataset was checked to see that the model fits the data well or not. The value of Log likelihood ratio value -29.597 for the adoption of row planting of shows that the overall goodness of fit of the model is significant at 1% probability level. The goodness-of- fit is tested by the Pseudo R^2. The result shows that Pseudo R^2 is 0.6963.

Out of eleven independent variables eight were found to be statistically significant and influencing the dependent variable was run in the model. These variables were family size of the household head ,farm size, education of the household head, annual income , access to Input supply own time , Livestock ownership, Field visit days, and Training about row planting technology . The coefficients of other three variables such as age, credit use, get extension service were not statistically significant at the conventional probability levels implying that they were less important in influencing adoption of teff row planting. The sign of included variables in model showed a similar result as the expected result of the researcher hypothesis except annual income variable which has negative sign. Among the explanatory variables included in the model seven were found to affect the adoption teff row planting positively. Whereas variables such as annual income were influence the adoption teff row planting negatively.

The effect of the significant variables on the adoption of teff row planting is discussed in detail below.

Table 5:Estimation of binary regression model.

Variable	Coefficient	Std. Error	Odd Ratio	Z	P>z	Marginal Effect
AGE	-0.021	0.59	0.9796969	-0.35	0.728	-004
EDU**	1.889	0.853	6.615745	2.22	0.027	0.362
FAMILSIZE*	0.878	0.510	2.405669	1.72	0.085	0.192
FARMSIZE**	0.452	0.195	1.572131	2.32	0.020	0.099
TLU**	0.467	0.231	1.594637	2.02	0.043	0.102
INCO**	-0.0000398	0.0000193	0.9999602	-2.06	0.039	-8.70e-0.6
CREDIT use	0.912	0.750	2.489733	1.22	0.224	0.196
EXTESION	1.078	0.818	2.937781	1.32	0.188	0.222
FILD VIST**	1.446	0.724	4.24521	2.00	0.046	0.306
INPUT*	1.819	0.936	6.166302	1.94	0.052	0.303
TREANING**	2.264	0.754	9.621799	3.00	0.003	0.478
Constant	-13.430	3.664	1.47e-0.6	-3.66	0.000	

Logistic regression Number of obs =144
LR chi2(11) = 135.72
Prob > chi2 = 0.0000
Log likelihood = -29.593861 Pseudo R2= 0.6963

***,**and * significant at 1%,5% and 10% respectively

Source; Model out put,2020

Education of the household head (YEDUHH): education had positively and significantly affects the adoption of row planting teff at 5 percent probability level. Other things being kept constant, Weighted log odds ratio in favor of adoption of teff row planting increase by a factor of 6.6 for farmers who were literate than who were illiterate . This implies that household heads who educated is about seven times more likely to participate in row planting technology as compared to household heads who are illiterate .on the other hand households who were literate 36% higher to adopt row planting teff technology than illiterate households.

Education has a positive effect on the adoption of row planting of teff this mean that the educated farmers of the house hold higher probability of the adoption row planting of teff than non educated farmers of the respondent , because educated people are more aware of about row planting teff technology such as how to operate the package it, and understanding the nature of teff through improve attitude ,skill and knowledge about

how to obtain it, and how to use it. This result is consistent with the finding of (Geremew *et al*., 2016 and(Mekidelawit, et al, 2018)of education of the household head positively affected the adoption of row planting of teff respectively .

Annual income (INCOME): Annual income had a negative relationship with the adoption of row planting of teff significant at 5 percent probability level. Other things being kept constant, Weighted log odds ratio in favor of adoption of teff row planting decrease by a factor of 0.9,as the amount of income increase by one ETB. This implies that annual income of the farmer increase by one ETB, the probability of adoption of row planting tef decrease by-8.70-06 amount.

This implies that the likelihood to the adoption of row planting of teff decrease with increase annual income. where this finding was un expected from the hypothesis. This can be for the reason that respondents with more income are likely to buy urban pleace,Wefcho house and expand, treading activities and other business activities besides to agriculture activities due to this the intention of the probability of adoption of row planting technology lower than lower income respondent. This result was inconsistence from the previous finding(Mesafint,2017).

Family size: it had positive and significantly affect on the adoption of Teff row planting method at 10% significance level. Other things being kept constant, Weighted log odds ratio in favor of adoption of teff row planting increase by a factor of 2.4,as family size of a respondent increases by one adult equivalent unit. This implies that family size of a respondent increases by one adult equivalent unit, then the probability of the respondent to be the adoption of teff row planting increases by 19 percent.

The information gathered from FGD and key informant 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 respondent who has large Family size has better chance to adopt Teff row planting method than lower family size. The finding is agreement with previous report by (Yonas, 2014) and (Mekidelawit, et al, 2018 who noted that, having more working family member increases the probability of participating in row planting of Teff at 5 probability level. Existence of higher number of working family labor encourages them to participate in the program .

Farm size: it had positive and significantly affect on the adoption of Teff row planting method at 5% probability level. Other things being kept constant, Weighted log odds ratio in favor of adoption of teff row planting increase by a factor of 1.6, as farm size increases by one hectare . This implies that farm size increases by one hectare, then the probability of the respondent to be the adoption of row planting increases by 10 percent. Similar findings has been reported by a study conducted , the land size owned by the household measured in timad positively influenced the decision to adopt and apply row seeding of Teff (Geremew et al., 2016) and (Mekidelawit, et al, 2018). b\c respondents who had large cultivated land size found to adopt teff row planting technology which is mainly resulted from the fact that they did want to take risk of applying teff row planting technology While on the contrary the adoption and intensity of adoption row planting of teff was found land size negatively influence on the adoption of row planting of teff, (Mesafint, 2017)

Number of livestock: it was measured in Tropical Livestock Unit. It had positive and significantly affect on the adoption of Teff row planting method at 5% significance level. Other things being kept constant, Weighted log odds ratio in favor of adoption of teff row planting increase by a factor of 1.6,as number of livestock owned by a household increases by one interims of TLU. This implies that the number of livestock owned by a household increases by one interims of TLU, then the probability of the respondent to be the adoption of row planting increases by 10 percent. B/C the positive relationship indicates that households with larger livestock holding may have the opportunity to plough at any time with minimum labor cost, especially for oxen and purchase input. This result is consistent with the finding reported by (Yonas, 2014) and (Mekidelawit, et al, 2018).

Access to input supply own time: Access to input supply own time positively and significantly affects on the adoption of row planting at 10 percent probability level. Other things being kept constant, Weighted log odds ratio in favor of adoption of teff row planting increase by a factor of 6.2 for farmers who were access to input supply own time than who were not access to input supply own time . This implies that household heads got input supply own time who is about six times more likely to participate in row

planting of teff technology as compared to household heads who are not access to input supply own time.on the other hand households who were access to input supply own time 30% higher to adopt row planting of teff technology than not access to input supply own time households . B\C As availability of planting technology own time that means at the sowing time increase, farmers' use of row planting would be enhanced. On the contrary, if planting technology is not adequate at the time of sowing, farmers use traditional broadcasting method. This result is consistent with the finding reported by (Adunea & Fekadu, 2019**).** Adoption determinants of row planting for wheat production.

Participation of Field visit days :- Participation to Field visit days had positively and significantly affects on the adoption of row of planting at 5 percent probability level. Other things being kept constant, Weighted log odds ratio in favor of adoption of teff row planting increase by a factor of 4.2 for farmers who were participation of field visit days than who were not participation of field visit days . This implies that household heads got participation of field visit days who is about four times more likely to participate in row planting of teff technology as compared to household heads who are not participation of field visit days .on the other hand households who were participation of field visit days 31% higher to adopt row planting of teff technology than not participation of field visit days households. Moreover, a field visit day has an influence on the probability of adoption of teff row planting . Respondent with more chance to participate in field visit days were more likely to engage in row planting use than that of their counterparts.. Hence, it serves as easy way to own best technical knowledge and trust more in regard to the benefits of that new technique in their plots as well as. plays a great role in obtaining experience and skill in different ways. This result is consistent with the finding reported by (Ejegayehu, 2016) on the Effect of wheat row planting technology adoption on small farms.

Participation in training: training had positive and significantly affect on the adoption ofTeff row planting method at 5% significance level. Other things being kept constant, Weighted log odds ratio in favor of adoption of teff row planting increase by a factor of 9.6 for farmers who were participation of in training than who were not participation in training . This implies that household heads got participation of in training who is about ten times more likely to participate in row planting of teff technology as compared to

household heads who are not participation of in training about row planting of teff technology .on the other hand households who were participation of in training 48% higher to adopt row planting of teff technology than not participation of in training households.

Farmers who got training on Teff row planting had higher probability of adopting row planting method compared to those who did not get training. Training is one of the extension events and the means of teaching and learning process where farmers get practical skill and technical information for adoption of new agricultural technologies This may be explained by the fact that farmers who have an opportunity to participate frequently in training regarding row planting given at farmer training center (FTC) and attend training at demonstration site of teff row planting gain better knowledge and technical skill on the application of row planting. This result is consistent with the finding reported by(Mekidelawit, et al, 2018) on the same study and(Adunea & Fekadu, 2019) Adoption determinants of row planting for wheat production.

4.2.3. **Propensity score matching estimation on Impact of Adoption of Row planting of Teff Productivity**

4.2.3.1. The program effect

This study sample t-test to check the adoption of row planting of teff program has a significant impact on teff productivity .The mean value of teff productivity (in Quintal/hectare) of the adopters equals to 28.3729 Q /ha and the non-adopter households is 19.3059 Q/ha, the result shows that adopter of row planting of respondent Teff productivity is higher by more than 9.067 quintal/ha compared with the non-adopter respondents . The difference in teff row planting productivity is significant at 1% significant level. This indicates that adopter have better teff productivity than non-adopters

Table 6:Mean of teff productivity before matching:

Adoption of row planting of teff		N	Mean	Std.Dev	Std.EM	T-test
Quintal per hectare	Adopter	59	28.3729	11.91189	1.55080	5.027***(0.000)
	Non-adopter	85	19.3059	9.67080	1.04895	
	Difference		9.06700	2.24109	1.87223	

Source; own survey, 2020

***Denotes significant at 1% probability level

4.2.3.2. Estimating PSM

The pseudo – R2 value of the binary logit model which was used to estimate PSM of adopter and non-adopter groups is =0.6963and (Table 7). This low R2 value indicates/implies that the selected household doesn't have much different characteristics and easy to find a good match between adopter and non-adopter groups.

In this study, the participant households in adoption of row planting of teff is the treatment variable, it takes the value 1 otherwise 0 (for non- participants or the control group). The Logit result of participation in adopting row planting of teff is presented in table 7. The observable household characteristics used for estimating propensity score matching are Households' Age, Education of the household, Family size, Farm size, livestock ownership of the household, annual income, credit use, get extension service, field visit days, input access own time and training accesses about row planting technology.

Table 7:Logit estimation for propensity score for the study area.

Adoption	Coef.	Stdr.Err	Z	P>z	Marginal Effect
Age	-.020512	.0590797	-0.35	0.728	-004
Education**	1.889452	.8526661	2.22	0.027	0.362
Family size*	.8778282	.5098843	1.72	0.085	0.192
Farm size**	.452432	.1951157	2.32	0.020	0.099
Live stock ownership**	.4666463	.2307281	2.02	0.043	0.102
Income**	-.0000398	.0000193	-2.06	0.039	-8.70e-0.6
Credit	.9121755	.7500783	1.22	0.224	0.196
Extension	.9121755	.7500783	1.22	0.224	0.222
Field visit day**	1.445791	.7235494	2.00	0.046	0.306
Input *	1.819099	.9364505	1.94	0.052	0.303
Training**	2.264031	.7538384	3.00	0.003	0.478
Cons	-13.43012	3.664496	-3.66	0.000	
Number of obs =144 Logistic regression, LR chi2(11) =135.72; Prob > chi2 =0.0000; Log likelihood = -29.593861; Pseudo R2 =0.6963and The region of common support point is [.0048192; .7182298)					

***, ** and* are statistically significant at 1, 5 and 10%, respectively.

Source; own survey Model out put,2020

According to (Grilli & Rampichini, 2011) the necessary steps when implementing propensity score matching are: Propensity Score estimation, Choose matching algorithm, Check overlap/common support and testing matching quality

After running the model and propensity score is estimated as indicated in Table 8 below, the program participant households' propensity score was varied between .0048192and .9992744 with mean propensity score of .8549186, while control group households' propensity score varied between.0003134 and .7182298 with the mean of propensity score of .7182298

The main criterion for estimating the common support region is to delete all observations whose PSM is higher than the maximum PSM of adopters and lower than the minimum in the non-adopters (Caliendo and Kopeining, 2005). Therefore, based on this calculated propensity score common support region .0048192 and7182298) was developed by using minimum and maximum criteria and any household that have below minimum and above maximum was discarded from the sample.

Table 8: Estimated Propensity Scores Distribution

Group	No of observation	Mean	Std. Dev.	Min.	Max.
Treated HHS	59	.8549186	.2544666	.0048192	.9992744
Control HHS	85	.1007036	.1664876	.0003134	.7182298
Total HHS	144	.4097222	.4255368	.0003134	.9992744

Source: Computed from own survey data (2020)

The binary logit model also define/determine region of common support and ATT for both treated and control groups. Accordingly all the controlled households are included on support, while from the total treated observation 48 households or 81.36% are off support and the remaining 11 households (18.64%) are on support.

To conduct ATTs different matching algorithms are available among these matching algorithms the one with best estimates of propensity score should be selected. The choice of matching method involves a trade-off between matching quality and its variance. According to Caliendo, M., and S. Kopeing (2008) the final choice of a matching estimator was guided by three basic criteria such as balancing test, pseudo-R2 and matched sample size. Specifically, a matching estimator which balances all explanatory variables (i.e., results in insignificant mean differences between the two groups), bears a low R2-value and results in large matched sample size is the most appropriate estimator. Based on the above mentioned criteria to determine the best matching estimator among Alternative matching estimators such as nearest neighbor matching, radius matching, caliper matching, and kernel matching. were tried in matching the treatment and control households based on the common support region for this specific study, There fore performance criteria such as balancing test of covariates matched insignificant, low pseudo R2

value, insignificant LR chi-square, high p - value and large size of matched sample by discarding only 48 unmatched farmers from total of 144 sample farmers. Accordingly to this criteria, a radius caliper(0.25) matching method with of 0.25 was found to be the best estimator of the data of teff crop yields,. As a radius caliper(0.25) matching method the pseudo R2 is 0.064, insignificant LR chi-square is 1.96, p - value is 0.999 and large matched sample size by discarding only 48 unmatched farmers then from total sample farmers is 96 .Finally, according to Table 9 , radius matching with a caliper of 0.25 was selected based on performance criteria. Therefore, the estimation results and discussion for this study are the direct outcomes of the radius matching algorithm based on a caliper of 0.25.

Table 9: Choosing criteria among different matching estimators.

Matching Algorithm	**Choosing criteria of matching**		
	Balancing test*	Pseudo-R^2	Matched sample size
Nearest-Neighbor			
NN(1)	11\11	1.000	92
NN(2)	11\11	1.000	94
Radius caliper			
0.01	11\11	0.645	92
0.25	11\11	0.064	96
0.5	11\11	0.202	96
Kernel			
Band width 0.1	11\11	0.152	96
Band width 0.25	11\11	0.077	96
Band width 0.5	11\11	1.000	96

Source: Computed from own survey data (2020)

4.2.3.4. Treatment Effect on the Treated (ATT)

Estimation of average treatment effect on the treated (ATT) shows that row planting technology of Teff crop has no significant effect on the product of adopter farmers with significant t-statistic(-0.1) since which is less 1.96 i.e. insignificant .

Generally the result of this study reveals that there is a no statically significant difference between adopter (Treated) and non- adopter (Control) households. This indicates that, the adoption of row planting of teff has a no significant contribution to teff productivity of the participants' households even if the treated group most of unmatched on this study.B/C in the study area their is a problem of fully practice on that package in the

study area this means there is no technical skills to practice this technology simply practice by the students with out training, the way of delivering this technology through political intervention with out trust the local farmers about the technology, The nature of the technology by it self complex nature such as labor intensive, the nature of the commodity by it self it is very small to practice in row it is difficult as well as lack of mechanization sowing in row, most of the sample kebeles the nature of the soil is not comfortable to practice this technology, cost benefit is not greater than broadcasting as amhara research centers reports as well as simple nature of broadcasting planting of teff due to the above reasons day to day the adoption technology is decrease so that is why insignificant contribution row planting of teff on productivity in the study area.

Table 10: *Results of* Average treatment on the treated.

Outcome Variable		**Treated**	**Controls**	**Difference**	Std. Err.	t-value
Land Productivity	Unmatched	28.3728814	19.3058824	9.066999	1.80353065	5.03
	ATT	21.0909091	21.5646941	-.473784968	3.80971443	-0.1

Source ;own survey model out put:2020

5. SUMMARY CONCLUSION AND RECOMMENDATION

5.1. Summary

The study was conducted in Aneded District , Eeast Gojjam zone, Ethiopia. The objectives of the study were to identify the factors affect the adoption of row planting of teff and to examine impacts of row planting on productivity. From, a total of 19 teff producer Kebeles were identified with the help of District agricultural experts and DAs. From the total kebeles identified six Kebeles were purposively selected that only practice row planting of teff. Finally, a total of 144 household heads were selected systematically randomly using probability proportional to size from the selected Kebeles.

Both qualitative and quantitative data were collected from primary and secondary sources to fulfill the objectives. Primary data were collected from respondents through structural questioner interview and discussions. Reports of different organizations, published and unpublished research journals, books and thesis; the annual reports and documents of Aneded District office of agriculture was used as secondary sources of data. Qualitative data was used to capture all relevant information required to have an in-depth view of the research under study. The qualitative data was analyzed through interpretation, triangulation and description of views . Descriptive statistics such as mean, percentage, frequency and SD were employed for quantitative data analysis. Moreover, statistical tests such as chi-square test and t-test were applied to test the degree of association between independent and dependent variables. Binary logistic regression model was used to identify factors affecting the adoption of row planting and using psm estimators to run the impact on productivity.

Among the total 144 respondents sampled for the study, 59 (41%) were adopters of row planting teff, while the remaining 85 (59%) were non adopter of row planting of teff.

The model result indicated that from the eleven independent variables eight of them, family size of the household head, education of the household head, annual income,treaning about row planting technology , Participation field vist days, input access own time,farm size and livestock owner ship were significant determinants of row planting of teff . The average treatment effect on the treated (ATT) result after matching also shows there is no a statistically significant difference between treated and control group in-terms of teff productivity

5.2. Conclusion

The study was identified The Potential factors that influence the adoption of Row planting of teff and its impact on productivity in the study area. Those findings are useful to rethink about the determinants of adoption of new technologies like row planting of teff. Therefore, the result can be used by policy makers to promote technological change that is directly needed for the economic development of the country.

The explanatory variables: Households' Education, family size, farm size, TLU, field visit days, input access own time and training were found to positively and significantly influence the probability of adoption of row planting of teff in the study area. On the other hand, the variable Households' annual income negatively and significantly influenced on the probability of adoption of row planting of teff .

Under Quasi-Experimental research design, the researcher used propensity score matching estimators. The binary logit model was used to estimate the propensity score matching of participant with non-participant households. The matching techniques employed were the nearest neighborhoods matching, radius matching,caliper matching, and kernel matching. Among the algorithms used radius matching(0.25) was found to be the best estimator of data based on balancing test, pseudo R2 and sample size.

The study proved: the adoption of row planting of teff program has no a significant impact on teff productivity of adopter households in the study area. The average treatment effect on the treated (ATT) result after matching also shows there is no a statistically significant difference between treated and control group in-terms of teff productivity. This means there is no statically significant contribution of row planting of teff on productivity in the matched group.

The FGD also has identified and underlined major barriers of the development of adoption of row planting of teff The way of delivering this technology through political intervention with out trust of local farmers, problems of fully package application due to voluntarism action about the students around those Kebles with out training, Complex nature of the technology related to labor intensive and problems of seed preparation as well as the nature of the soil in

most kebeles is not comfortable for row planting of teff in the study area. So due to the above problems was the major barriers to adopt row planting of teff as the focuses group said.

5.3. Recommendation

Basedon the results of this thesis, the following core points which are presented as recommendations in order to improve the adoption of Teff row planting method in the process of Teff grain production. It is better to encourage row planting practice adoption with in amendment of practice to adopt the adoption of row planting of teff even if the technology is in significant contribution on teff yield per hectare..

Education had significant positive effect on the adoption of row planting method. Education enhances farmers' ability to perceive, perused, interpret, and respond to new events in the context of risk. Therefore, the District education office; other governmental and non-governmental organizations should be give emphasis strengthening rural farmers education at Different levels on the adult education for farmers to improves farmers' awareness about the adoption of technologies and increases their access to adopt row planting in the study area.

Household labor had a significant positive effect on the adoption of Teff row planting method. The most important problem in practicing row planting of Teff crop is its labor requirement meaning that labor intensive. Thus, immediate demonstration of available technologies and practices that help to reduce work burden on farmers is essential. Therefore, governmental and non-governmental organizations should be emphasis in order to increase support from family members, the *District'* educational and agricultural bureaus in collaboration should be provide training about students in the school about the benefits of row planting of teff crop and how to practice the full package; this may increase labor support that household heads obtained from their family and develop the habit of working together around the community to fill the gap of a family labor shortage.

Forcing farmers to adopt any kind of agricultural technology will not bring the expected outcome rather it may aggravated their rigidity not to accept any new farming technologies. Therefore in order to improve farmers of adoption of teff row planting method DAs should be provide farmers with more practical trainings under farmers' direct participation in the demonstration centers.

Participation in a training program on the benefit and techniques of Teff row planting had a positive and significant effect on the adoption of Teff row planting method. Therefore, The District agricultural office, other governmental and nongovernmental organization should be provide short term training program strengthened to equip farmers with the necessary knowledge, skill and attitude relevant for the adoption of the row planting of teff method for the sake of improve productivity of the crop and contribute towards food security in the area.

Those farmers who had large landholding size adopt Teff row planting method 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, The District agricultural office; other governmental and nongovernmental organization should be provide agricultural intensification program strengthened. In other words producing maximum yield from existing plot of land by promoting the use of row planting, improved seed and inorganic fertilizer should be the focus. Of course, it requires improving knowledge, skill and attitude of the farmers in the area. On the other handwhen row planting technology is to become appropriate to the poor with fragmented landholding and small labor support because of risk of crop failure. Therefore, governmental and non-governmental extension programs have to provide farmers with safety net programs and other incentives in order to minimize risk of adoption of row planting.

Having many livestock (in TLU) in the house was associated with adoption of Teff row planting method . Thus, the house hold purchase inputs through selling livestock and use the traction power for seed preparation own time so increase the probability of adoption of row planting of teff.There fore the District agricultural office; other governmental and non-governmental organization programs should be advice to improve livestock production..

Similarly, Access input supply own time had a significant positive effect on the adoption of Teff row planting method .b/c planting season of a crop is a very important for productivity becomes to delay agricultural input to the farmer obstacle to practice adoption of row planting of teff Therefore the District agricultural office ;other governmental and non-governmental organization include the multipurpose cooperative should be provide agricultural inputs own

time to increase the probability of adoption of row planting of teff by planting crops own the required plantation time.

Participation field visit day had a significant positive effect on the adoption of Teff row planting method ’b\c when the farmers practice field visit days increase the probability of adoption of row planting of teff that is see is believing. Therefore the District agricultural office, other governmental and non-governmental organization should be arrange field visit days to know about the nature of technology that means seeing is believing, so increase the chance of the probability of adoption of row cropping of teff.

The research recommended that adopting row planting technology as a package (row and spacing, improved seed, fertilizer rates and or compost, early hand weeding and hoeing, tilling repeatedly) is vital as a policy in enhancing teff yield . Complementary agricultural technology adoption best yield results when they are taken up as a complete package together, rather than in the individual elements to give high teff yield.

As much as possible the governmental and nongovernmental organization should be develop other new technology regarding of teff crop collaborate with regional and federal research center’ b\c the currently row planting of teff technology is not statically significance impact contribution on teff yield. if this conditions is not practice use this technology with the required fully recommendations until getting better than this technology.

Finally, since it was not seen in this paper, further researchers, who has willing to conduct research on economic profitability of adoption of row planting of teff .

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7. APPENDICES

Appendix 1: **Questionnaire for data collection**

Dear répondent! This survey questionnaire is designed with the objective of collecting information on the Row planting technology adoption of farmers and its impact on productivity . It means only for research purposes. For this purpose your genuine responses to each of the survey questions are highly useful.

There are no "right" or "wrong" answers. Your responses will be confidentially used for this research purpose only.

We highly appreciate for your willingness to participate as a respondent in this survey.

For all closed type questions please put < Encircle > ***mark where appropriate and please strictly follow the instruction given in each part of the questionnaire***

for Enumerators

1. Introduce yourself before starting interview and tell the purpose of the study.
2. Encircle all closed questions when answered by respondents and write additional answers in the space provided.

General information I. Supportive Information

- Date of interview _____
- Region _____
- Woreda _____
- Name of kebele _____
- Name of enumerator _____
- Name of the village_____
- Signature of enumerator _____

2. Demographic Characteristics

2.1. Name of the respondent: _____

2.2. Age of the respondent _____

2.3. Sex: 1= Male___ 2=Female___

2.4. Education level

No	Education level	Mark (√) in your level	Remarks
1.	Illiterate		
2.	Read and write		
3.	1-12 grade(specify)		

4. Certificate and above (specify)

5. Other

2.5. How long have you been in farming (farming experience)? in years _____

2.6. Row planting experience of the household head in years_____

2.7 Marriage status

married..... Divorced----------

Unmarried..... widowed. ----------

2.8. Religion: Orthodox Christian..... Muslim.....

Protestant..... Others (specify): .....

2. 9 Number of total family members. Male..... Female..... Total ……

3. Socioeconomic Characteristics

3.1. Land ownership in 2019/2020 G.C (total farm size owned (in hectare) _____

3.2. The land size allocated/covered by teff crop in 2019/2020 cropping season----------(hectare)

3.3. The land size allocated/covered by row planted teff in 2019/2020 cropping season ----------

-----(Hectare)

Land allocation	Land size in hectare
	Using broadcasting technique
1.Land Coverage of teff crop	
2. Land covered by wheat	
3. Land covered by barley	
4. Land covered by Maize	
5. Vegetables and others	
6. Total	

3.4. Livestock ownership (At the end 2019/2020G.C)

Type of animal	Number	Type of animal	Number
1. Cows		2. Sheep	
3. Oxen		7. Chicken	
5. Heifers		8. Donkey	
7. Calves		9. Horse	
9. Bulls		10. Goats	
11. Others		12. Total	

3.5. Household labor availability in (At the end 2019/2020G.C)

No	Age specify	Sex		*Activities participated in teff production
		Male	Female	
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

Teff production activities includes: - 1) Land preparation 2) sowing 3) Weeding 4) Harvesting 5) Threshing 6) Transportation 7) Storage 8) Marketing 9) others (specify

3.6. production and annual income of the household in 2019 /2020 G.C

3.6.1 In which income group do you locate yourself in the community?

Annual income table

No.	Income group	Amount	Specify the amount
1.	High income	≥ 100000	

	group		
2.	2. Middle income group	2. 20000-100000	
3.	3. Low income group	≤20000	

3.6.2. Teff production and annual income of from sale of teff Crop by the household in 2019 /2020 G.C

Method of planting teff	**Seeding Rate (Kg/Q of seed/ha)**	**Price of the seed in birr per (Kg/Q)**	**Yield (Kg/Q)**	**Amount Consumed (Kg/Q)**	**Unit(Quintal) Price in birr**	***Purpose sold**	***To whom it sold**
Row planting							
Broadcasting							

*__Purpose sold__1) For purchasing farm inputs 2) For settling debts 3) For buying clothes for family 4) To buy food grains 5) Others (Specify) ----------

*__To whom__ 1) to whole seller 2) to retailer 3) to direct consumers 4)cooperative5/farmers6) Others (Specify) ----------

3.6.3. Production of other crops and annual income from sale of crop by the household in 2019 /2020 G.C

Types of Crops Grown	**Seeding Rate (Kg/Q) of seed/ha**	**Price of the seed in birr per (Kg/Q)**	**Yield (Kg/Q)**	**Amount Consumed (Kg/Q)**	**Unit(Quintal) Price in birr**	***Purpose sold**	***To whom it sold**
1. wheat							
2. barley							
3. Maize							
4. other cereals							

Vegetables							

*__Purpose sold__1) For purchasing farm inputs 2) For settling debts 3) For buying clothes for family 4) To buy food grains 5) Others (Specify) ----------

*__To whom__ 1) to whole seller 2) to retailer 3) to direct consumers 4)cooperative5/farmers6) Others (Specify) ----------

3.6.4.. Income from sale of livestock/2019/2020 G.C /

Type of animal	Number sold	Unit price	Total sale price	*Purpose
1. Cows				
2. Oxen				
3. Heifers				
4. Calves				
5. Bulls				
6. Goats				
7. Sheep				
8. Chicken				
9. Donkey				
10. Horse				
11. Others				
12.Total				

*Purpose includes 1) For purchasing farm inputs 2) For settling debts

3) For buying clothes for family 4) For buying food grains 5) Others (Specify) ----------

3.6.5. Income from sale of livestock products/2019 /2020G.C

Product type	Amount collected (Lit,kg,No)	Consumed	Sold	Unit Price	Total Revenue	*Purpose sold	
1.Milk(liters)							
2.Butter(Kg)							
3.Egg(Number)							
4.Others							
Total							

*Purpose includes 1) For purchasing farm inputs 2) For settling debts

3) For buying clothes for family 4) For buying food grains 5) Others (Specify) ----------

3.6.6. Do you have Income from bee-hive? 1/ Yes ˇ 0/ No

3.6.7. If yes, the average revenue in 2011/12 E.C was _____birr

3.6.8. For how long you are practicing beehive? _____years

3.7. Did you face any labor shortage during the last crop season in row planting? _____

1=Yes 2=No

3.7.1. How did you solve the above problems?

1=through local organization (cooperation with the nearest farmers)

2=through hiring the daily labor

3=through family labor

4=others, specify_____

3.7.2. On an average how many days_____ and labors (man days)_____

needed to plant one hectares of teff land?

3. 8.Income from participation in off-farm activities.

3.8.1. Do you have off-farm activities? _____

1=Yes 2=No

3.8. 2. If yes, in which of the following activities? (Fill the following tables).

Types of off-farm activities	Average Income per year	*Purpose used

	(in birr)	
1.Petty trade		
2. Selling local beverage		
3. Fuel wood and charcoal selling		
4. Local mattress preparation		
5. Timber production		
6. Labor hire out		
7. Pottery		
8. Weaving		
9.Others(specify_____		
Total		
***Purpose used include** 1) To purchase household items ˇ2) to purchase farm inputs ˇ4) to settle debts ˇ 5) to buy food ˇ 6/other(specify)		

4.Institutional Factors

4.1. Credit accessibility

4.1.1. Have you obtained credit for teff production in 2011/2012 years? 1=Yes….. 2=No ….

4.1.2 If your answer for question number 4.1.1. is yes, from where do you get it ----------

4.1. 3. How much did you get? _____ amount (in Birr) _____if no, why _____

4.1.4. For what purpose did you use the credit? (rank if you have multiple answers)

1) For purchasing fertilizer….. 2) For purchasing improved seeds….. 3) For purchasing chemicals……. 4) For purchasing of labor (ploughing, planting, weeding, harvesting)…….. 5) Other purpose (Specify) _____

Ranks_____

4.2. Extension services, Frequency of Contact with extension Agent(s),

Training on Row Planting Technology

4.2.1. Do you get advisory services from extension agents? _____ 1=Yes 2=No…….

4. 2.2. Averagely how frequently do the extension agents visit you? 0) never ˇ1) Once in a week ˇ 2) twice in a week ˇ3) monthly ˇ4) yearlyˇ other (specify)_____

4.2. 3. When does extension agent visit you? _____ A) During land preparation B) During Sowing

C) During weeding…… D) When disease/ pest occur…… E) during harvesting F) others (Specify)

_____

4.2.4. Do you visit extension agent? 1) Yes ˇ 2) No ˇ

4.2.5. If yes, when do you visit? 1) During sowing for technical advice ˇ 2) During input Provision to obtain inputsˇ 3) It depends (any time when there is technical problem)

4.2.6. Access to and frequency of use of mass media on agricultural extension programs related teff production.

Mass media	Do you have?		How often you use them for attending agricultural programs/obtaining messages				
	Yes(1)	No(0)	never	rarely	occasionally	often	Very often
Radio							
Television							
Mobile phone							
Others(specify							

4.2.7. What are your other sources of information and how often you use/ have contact with them?

Source of Information	How often you contact them					***Rank your sources information**	***Means of information exchange**
	Never(1)	Once in a year(2)	Monthly(3)	weekly(4)	Daily(5)		
1.Researcher							
2. Contact Farmer							
3. Fellow Farmer							
4. PA leader							
5. NGOs							
6. Cooperative							
7.Neighbor/Friends							
8.Agri. experts							

9.Mass media							

*Means of information exchange: 1) Demonstration 2) Field day/visit 3) Training

4) Written materials (leaflets, manuals, and so on) 5) Others (Specify) ----------

***Rank your sources of information** based on Accessibility, timeliness, reliability of their Information

4.2.8. When have you first heard about row planting? _____G.C.

4.2.9. From who/ which source? _____ categories from the above table (value from 1 - 9)

4.2.10. Have you participated in field day/ visit in the last three years? _____ 1) Yes 2) No

4.2.11. If yes, how many times? _____, and Who arranged for you? 1. ADARDO 2. Research org. 3. NGO 4. Others (Specify) _____

4.2.12. What benefit did you get from the field day? (rank if you have multiple answers)

I. Production increment

II. Getting suitable planting techniques

III. Getting comparative advantage of planting techniques

IV. Others specify _____

4.2.13. Have you ever received training in teff row planting in the last Three years? _____

1) Yes 2) No

4.2.13. If yes, how many times _____, and who arranged for you? _____

1.ADARDO 2. Research org. 3. NGO 4. Others _____

4.2.14. Do you have field vist days demonstration site in your kebele? _____ 1) Yes 2)No

4.2.15. If the answer `yes` for question number 4.2.14 is `yes` in what way do you benefit from it?

(rank if you have multiple answers)

I. Training about new technologies

II. Advice and crop and livestock production

III. Counseling

IV. Information access

V. Others specify _____

4.3. Membership of farmer's association

4.3.1. In which of the following organization are you member and leader? Please tick

Organization	Membership (1) 1=member2=nonmember	Committee member(2)1=yes,2=No	Leader (3) 1 = yes, 2 = No
Seed multiplication Group			
Idir			
PA leader			
Saving and credit group			
Marketing cooperative			
Other/specify			

4.4. Access and utilization of farm inputs for teff production (2019/2020 G.C. production season)

4.4.1.Which type of agricultural inputs do you use for teff production & what are the sources**?**

Categories of Inputs	**Types of Inputs**	**Market**	**MoA**	**Research centers**	**NGO**	**Other source (Specify**	***Reason for not use/apply (If you don't use**	

							)	
Fertilizers	**DAP**							
	Urea							
Chemicals	**Fungicide**							
	herbicides							
	Insecticide							
Seed	**Seed**							
Others(specify)								
*Reason for not use/apply 1/high price 2/ not timely available 3/effect on animals& human being 4/ lack of credit 5/lack of information 6/ Farm land is fertile 7/manual-traditional method is better & cost effective 8) 0ther (specify)								

4.4.2. What type of mechanization did you use to plant teff in rows? _____

1=row seeder machine

2=water plastic

3=hand

4=if other, _____

4.4.3. Have you ever used row seeder machine _____

1=Yes 2=No

4.4.4. Did you use row seeder machine during the last cropping season?

1=Yes 2=No

4.4.5. if not, why you didn't use (Multiple response allowed)?

1=High cost of technology

2=Unavailability of the technology

3= No information about the technology

4=Assumed to be not profitable

5=Shortage of cash

6=Lack of credit

7=No willingness to use

8=others, specify_____

4.4.6. Under what arrangements is the row seeder utilized? _____

(1 = sole owner, 2 = shared owner, 3 = rented in, 4 = borrowed)

4.4.7. If 2 above, how many others are the row seeder shared with? _____

4.4.8. If 3 above, at what price is the row seeder rented in (ETB)? _____

Checklist used for conducting focused group discussion.

As you probably know, agriculture office is trying to popularize an improved technology, which should significantly increase yields. The office is also providing best practices from other areas who adopt row planting of teff. Even Agricultural agents are also supporting the farmers in different dimensions. However,

- the majority of the farmers are not adopting row planting .why?
- Why are so a small number of farmers adopting the row planting?
- Is the row planting make profitable to farmers?
- Do the farmers experienced complexity in practicing row planting?
- What are the general impressions about the row planting?
- Which method of sowing did you use in tef production and why?
- What are the advantages of using broadcasting method?

Check List for Key informants

1. What is row planting? What makes different from broadcasting? What are the effect of row planting ?

2 What was the most important factor in your decision to use teff row planting?

3. What roles and responsibilities of agricultural expert do you think to adopt teff row planting and enhance teff yield per ha?

4. What do you believe about the row planting of teff not mostly adopt by the farmer but other cereals adopt by most of the farmer? Why? In addition to this the above focus group question include in the key format because focus group discussion for triangulation or support key informant

Thank you

Appendix 2: Conversion Factor used to calculate Adult Equivalent (AE)

Age Category(years)	Male	Female
<10 Years	0.60	0.60
10-13	0.90	0.80
14----16	1.00	0.75
17-50	1.00	0.75
>50	1.00	0.75

Source:Storck,et al.(1991)

Appendix 3: Conversion Factor for Tropical Livestock Unit (TLU)

Animal Category	TLU	Animal Category	TLU
Ox	1.100	Sheep	0.01
Cow	1.00	Goat	0.09
Heifer	0.50	Donkey	0.50
Bull	0.60	Horse	0.80
Calves	0.20	Mule	0.70
Poultry	0.01		

Source:Storck,et al.(1991)

Appendix 4: VIF(Variance of Inflators) and Inverse Of Variance

Variable	VIF	1/VIF
HHAge	1.240	0.806
HHfamilysize	2.523	0.396
HHfarmsize	4.675	0.214
HHTLU	2.580	0.388
HHincome	5.371	0.186
Mean VIF	3.278	

Source: Model output, 2020

Appendix 5: Contingency coefficient for dummy variable

1	2	3	4	5	6
1.00	0.218	0.342	0.257	0.140	0.187
0.218	1.00	0.275	0.171	0.134	0.143
0.342	0.275	1.00	0.344	0.999	0.210
0.257	0.171	0.344	1.00	0.121	0.279
0.140	0.134	0.999	0.121	1.00	0.132
0.187	0.143	0.210	0.279	0.132	1.00

Source model output 2020

1= Education of the household head 2= access input supply own time 3= Participation in training 4=field visit days participation 5=get extension service 6=credit use

Appendix 6: Breusch-Pagan / Cook-Weisberg test for heteroskedasticity for logit Regression

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity for logit Regression

Ho: Constant variance	
	Logit regression
Variables: fitted values of adop	Probability of adoption
chi2(1)	1.32
Prob > chi2	0.2506