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Economic Analysis of Broadcasting and Row Planting Systems for Eragrostis *teff* Production: The Case of Hidabu Abote District, North Shoa Zone of Oromia Region, Ethiopia

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Abstract: In most parts of Ethiopia, *teff* is one of the major important cereal crops for achieving food security and increasing household income. Despite its economic importance and widespread use throughout the country, *teff* productivity is very low, and people are not receiving the benefits that they deserve. To address these issues, Ethiopia's government initiated and implemented row planting *teff* technology to boost *teff* output, which farmers have been manually implementing for many years. However, to the best of the researcher's knowledge, there is no empirical study in the country comparing the economic impact of row planting on *teff* crop income per hectare to the traditional broadcast planting approach. To fill this gap, the study focused on the economic analysis of broadcasting and row planting *teff* technology among smallholder farmers in the context of Hidabu Abote district, North Shoa zone. The study uses cross-sectional data that were collected from 181 respondents in the district. The data were analyzed using descriptive and cost benefit analysis. The finding of cost-benefit analysis showed that the net profit of the farmer under row planting technology was much higher than the broadcasting method of *teff* farmers. As a result, the study's findings can be safely applied to any development intervention, and policymakers should consider them when developing policies and strategies to increase the usage of *teff* row planting.

Keywords: Adoption, Broadcasting, Row planting, Hidabu Abote, *teff*

1. Introduction

1.1. Background of the Study

Agriculture remains the backbone of Ethiopia's economy and still expected to play a dominant role in the years to come. It provides employment opportunity to 72.7% of the labor force and the sector contributing 35.8% to the country's GDP and around 80% of the national export earnings was obtained from this sector [8]. Increasing agricultural productivity is absolutely necessary to feed the increasing population by increasing land productivity.

Teff is one of Ethiopia's most important crops, with small-scale farmers producing it significantly better than any other cereal. According to the National Academy of Science (1996), *teff* is nutritionally equivalent to, if not superior to, the other major grains: wheat, barley, and maize. *Teff* grains are high in potassium and phosphorus and include 72.1-75.2 percent carbohydrate, 14-15 percent protein, 11-33 mg iron, and 100-150 mg calcium. As indicated in the same report, the low level of anemia in Ethiopia seems to be associated with the level of *teff* consumption as the grains contain high iron. *Teff* has got high lysine content compared to all cereals with the exception of rice and oats. It is highly adaptable to a wide range of soil types. It has the ability to perform well in black soils and, in some cases, in low soil acidities. In addition, *teff* has the capacity to withstand waterlogged, rainy conditions, often better than other cereal grains [1].

Despite its importance and widespread distribution, the productivity of *teff* in the country is quite [10, 15]. *Teff* yielded 16.63 quintals per hectare during the 2016 crop season; maize yielded 36.75 quintals per hectare; wheat yielded 26.75 quintals per hectare; and sorghum yielded 25.25 quintals per hectare [8]. It was discovered that *teff* productivity is quite poor when compared to other cereal crops. *Teff* productivity is low due to a lack of adoption of modern technology and the use of conventional *teff* producing methods.

According to ATA [2], Ethiopian farmers' *teff* production capacity is being affected by improper planting practices caused by technical incapability and the high cost of inputs. [12], also pointed out that farmers' *teff* productivity remained low due to poor planting practices. Thus, because of the uneven distribution of seeds, manual weeding is difficult, and plant competition with weeds reduces *teff* development, the broadcasting method of *teff* planting reduces *teff* productivity in the country.

However, in order to address the country's low *teff* productivity and production, the government has encouraged and began the use of new planting techniques [10]. Farmers might potentially increase their *teff* yield by planting *teff* in rows [1]. [13] also revealed that the encouragement of row planting technology had been one of the areas of intervention to improve the productivity of *teff*. Hence, using and improving the existing row planting technology would considerably increase the productivity of *teff* producing smallholder farmers in Ethiopia. Conversely, most of farmers are still utilizing the traditional one in different location of the country.

There are various research that focus on the impact and implementation of *teff* row planting technology in Ethiopia. For example, [4] looked into the factors that influence farmers' adoption of row planting technology and yield enhancement in *teff* production, while Tadele (2017) looked into the adoption and intensity of *teff* row planting. The first two studies are solely focused on adoption, whereas the latter includes the intensity of adoption and bridges the gap between the first two conclusions. Furthermore, only [9] and [16] investigated the impact of row planting *teff* on household wellbeing in various locations. According to their research, *teff* row planting technology yielded and earned more *teff* than the broadcast planting approach. Though, among smallholder farmers in the country, there is little empirical knowledge on cost-benefit analysis of broadcasting and row planting strategies for Eragrostis *Teff* production. Following the above gap, before studying the farmer’s intensity of adoption and continued application of farmers the economic analysis of broadcasting and row planting systems for Eragrostis *teff* production among smallholder farmers in the study area is necessarily investigated.

Hidabu Abote district is located in the North Shoa zone of Ethiopia's Oromia region. The majority of the farmers in the area are rural, and they rely heavily on *teff* for both consumption and income. *Teff* productivity, on the other hand, was unable to meet the required level. *Teff* broadcasting is a method of *teff* planting that is used in the area. This is a serious issue for farmers who want to boost their *teff* yield. Furthermore, there was a study gap, notably in the study field, in terms of the researcher's knowledge.

Some of the above discoveries were investigated at the national, regional, and/or zonal levels. While an investigation on location-specific regarding appropriate agricultural technology is essential to improve the adoption system and to support the assumption on adoption decision. Therefore, in this study, the farmer’s adoption decision and the cost benefit analysis was employed to provide empirical evidence of evaluating the net profit of both row planting and broadcasting methods of *teff* producers in the study area.

1.2. Objectives of the Study

The general objective of this study is to assess the economic analysis of the row planting technology adoption among smallholder *teff* crop poducers in the case of Hidabu Abote district.

To identify factors affecting the use of *teff* row planting technology in the study area.

To evaluate cost and benefit difference on the application of row planting and broadcasting technology on *teff* crop production.

2. Methodology

2.1. Description of the Study Area

Hidabu Abote district is one of the 13 district in North Showa Zone known for predominantly growing *teff*. It is located, north of Dera district, South of Degem, East of Degem, and West of Wara Jarso district. Hidabu Abote district with the capital Ejere town has a total area of 454km^2 and about 42 km from the town of North Shoa (Fitche) and 147 km from Addis Ababa. The total area of the district is 48,600 hectare from this 32,917 hectare is used for agricultural land. The woreda is known by high potential area for *teff* production. There are 19 *kebeles* and 1 urban *kebeles*. The number of agricultural households in the district was 20,406, from this (18,000) male headed (89%) and 2400 female-headed (11%), while the total population of the district was 104,442 from which 51,030 are males and 53,412 females. Geographically Hidabu Abote district extends from 9°47’ - 10°11’ north latitudes and 38°27-38°43’ east longitudes (HAWAO, 2018).

The average annual rainfall of the district is 800 mm-1200mm with low variability. It is bimodality distributed in which the small rains are from March to April and the main rainy season from July to September. Hence, crop and livestock production is not constrained by the distribution of rainfall. Altitude in district ranges from 1160m to 3000m above sea level (masl). The temperature of the district is minimum 13°C and maximum 20°C. The soil types of the area is sandy soil 14%, clay soil 51%, and silt 35%. The agro-climate/ecological zone of the area is, highland 6%, mid-altitude 50%, and lowland 44%.

In the study area agriculture contributes much to meet major objectives of farmers such as food supplies and cash needs. The sector is characterized by it is rain-fed and subsistence nature. It is the mixed farming type where crop and livestock productions are undertaken side by side. Hidabu Abote is one of the potential *teff* producing distirct in

Oromia region and ranked the 5th from top 25 *teff* producing district at the national level, and it ranked to the 4th in Oromia region and the 1st in North Shoa administrative zone. Furthermore, *teff* is the major crop produced in mid-altitude area in the district and which is the major source of income for households.

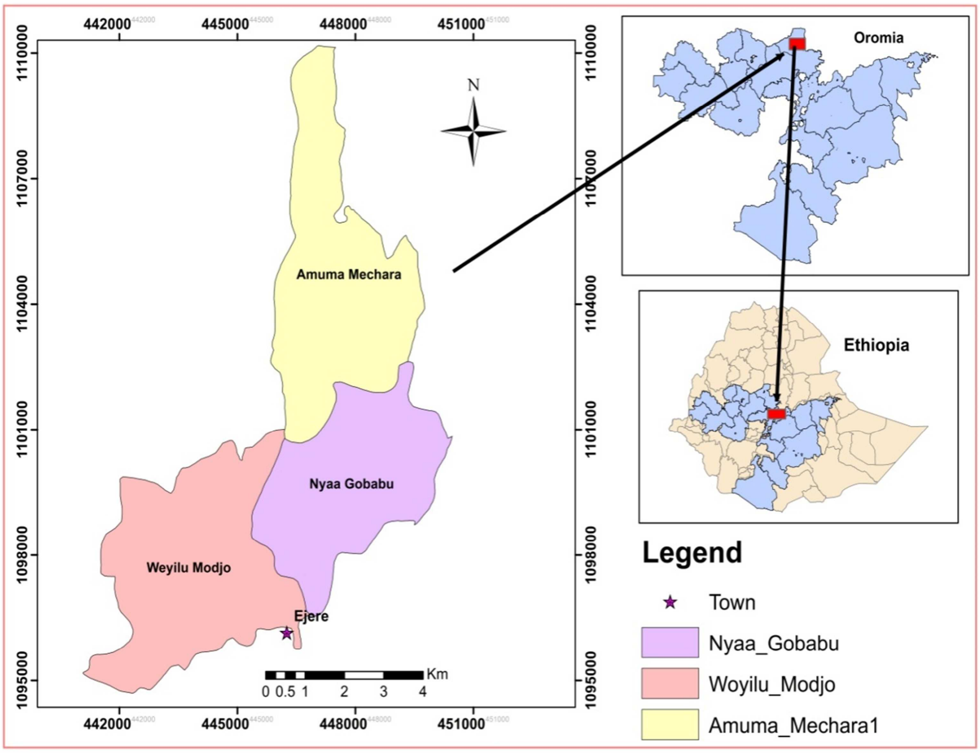

Figure 1. *Map of the study area.*

2.2. Sampling Methods and Sample Size Determination

The data used in this study consists of household sample survey data collected in the rural area of Hidabu Abote district in North Shoa zone. The multi-stage sampling technique was employed to select the sample respondent. In first stage, Hidabu Abote district has three agro-ecological zones: lowland, mid-altitude, highland. The dominant *teff* producing agro-ecological zone is mostly mid-altitude area. Hence, the target farming households are from this area. Out of the total *kebeles* found in mid-altitude agro ecology of the district the potential *teff* producing *kebeles* were identified. Hence, these *kebeles* have both households practicing the row planting with improved *teff* seed and those practices broadcasting planting method with improved *teff* seed.

In the second stage, based on time, accessibility, and considering how well the sample size is representative, three *kebeles* were selected by using a random sampling technique. Moreover, selection of the three *kebeles* is also possible because of the total distributions of the farm households of the area are socioeconomically, culturally and institutionally similar for the potential *teff* producer *Kebeles* in the district. Moreover, the administration, technology diffusion procedures and plans of development by the leaders are almost the same for these selected *kebeles* and so any household from any *Kebeles* can be representative of each other. Then, the farmers in each randomly selected *Kebeles* were stratified into adopter and non-adopter categories giving the relative homogeneity of sample respondents' adoption status. Due to heterogeneity of the population the sample size was determined using the formula developed by [5].

$$n = \frac{pq(z)^2}{e^2}$$

Where n is the sample size for the study, z is the selected critical value of desired confidence level which is 1.96; p is the estimated proportion of an adopters of row planting *teff* attribute that is present in the population of *teff* potential producers in the district which is 0.36, q=1-p =0.64 and due to heterogeneous characteristics of the farmers the precision level e value of 0.07 was used. In the final stage, $n = 180.63 \approx 181$ farm households consisting of 72 row planting adopters and 109 non-adopters were selected from the identified list using simple random sampling technique taking into account probability proportional to size of the identified households in each of the three selected *kebeles*.

2.3. Method of Data Collections and Methods of Data Analysis

The research design that was used in this study is the cross-sectional design. Both primary and secondary data were used for this study. Primary data was collected with the help of the survey by means of the structured interview schedule for the quantitative data.

2.4. Methods of Data Analysis

After coding and feeding the collected primary data into the computer, SPSS version 20.0 software package was employed for the data analysis. The data were analyzed using both descriptive statistics and inferential statistics.

Descriptive and Inferential Statistics.

Descriptive statistics such as mean, standard deviation, and percentages, were used to describe different categories of sample units with respect to the desired socioeconomic characteristics. Figures, graph and tables were also used to analyze the quantitative data gathered through questionnaires based interview from the respondents were summarized in a manageable manner by grouping the same responses into the same category. This was supported by the results obtained from the econometric model used in the study.

Economic analysis of row planting technology versus broadcasting of *teff* farmers.

As mentioned under introduction and empirical parts of this study the economic visibility between broadcasting and row planting method of *teff* is not so far identified. Therefore, in this study cost benefit analysis was employed to identify the reliable economic profit difference of the *teff* farming practices by the smallholder farmers. First, both costs of inputs used (labor cost and inputs cost) and revenue (*teff* output) obtained from technology by the farmers was determined based on the average common price. Then both effects were combined in a simple cost-benefit-analysis framework to analyze whether the broadcasting or row planting is profitable to the farmers in the study area. This was done by measuring the average profits farmers obtained per hectare of *teff* in each scenarioin the study area.

3. Results and Discussion

Factors affecting application of modern *teff* production technologies.

In the study area many factors did affect farmers’ level of use of *teff* production through row planting these are categorized in to household related factors, institutional factors and technological factors.

Household Related Factors.

Household size: The mean adult equivalents of sample adopters and non-adopters homes in this study were 4.66 and 3.83 adult equivalents, respectively, with standard deviations of 1.28 and. 833. Adopters have greater adult equivalent than non-adopters, according to the adult equivalent finding. In fact, row planting technology necessitates additional labour, particularly during sowing. As a result, the adult equivalent of household size demonstrates that there is a statistically significant mean difference between both adopter categories at a level less than 1% significant.

The education level: The results suggest that household adopters of row planting had a mean educational level of 2.38 years with a standard deviation of 2.96, whereas non-adopters had a mean educational level of 1.83 years with a standard deviation of 2.56. This shows that adopters of the row panting technology are more educated than non-adopters. As a result, the more educated the farmer, the more likely he or she is to employ this technology. At a 10% level of significance, an independent sample t-test revealed a statistically significant mean difference between adopters and non-adopters farmers in terms of educational level.

Institutional Related Factors.

Participation on training: Participating in training allows you to assess the technology's fit for the specific place and decide whether or not to use. It assists farmers in implementing new technologies through trials under the supervision of extension agents and other technical specialists. According to the findings, 47.2 percent of adopters and just 9.1 percent of non-adopters participated in training out of the total sample respondents. Furthermore, 52.8 percent of adopters and 90.9 percent of non-adopters did not participate in the same year's training experiment.

At a 1% level of significance, the percentage difference between the groups for this variable was judged to be statistically significant.

Access to mass media: One strategy to improve farmer adoption of new agricultural production technology is to provide them access to the media. It raises awareness of the technology and encourages people to express an interest in using it. At a 1% level of significance, the chi-square value suggested that there is a statistically significant difference between adopters and non-adopters of *teff* row planting. Furthermore, 72.2 percent of adopters and 53.6 percent of non-adopters use various forms of mass media, whereas 27.8% of adopters and 46.4 percent of non-adopters lack access to mass media.

Access to credit service: Credit is a source of funding for low- and middle-income people to purchase agricultural inputs. As a result, 56.9% of adopters and 47.3 percent of non-adopters were able to obtain the credit, whereas 43.1 percent of adopters and 52.7 percent of non-adopters were unable to access the credit. As a result of the chi-square analysis, it was discovered that access to financial services has a statistically significant relationship with adoption decision at a level of significance of less than 1%. Farmers who have access to credit have the ability to acquire agricultural inputs because credit solves the farmers' liquidity problem. This means that farmers who have access to credit are more likely to use row planting technology than those who do not. Extension contact: Adopters had an average extension contact of 3.93 per month with a standard deviation of 1.43, whereas non-adopters had an average extension contact of 2.43 per month with a standard deviation of. 99 in the same year. This means that extension agents can influence farmers' decisions on whether or not to plant *teff* in rows. The mean difference between the groups in terms of frequency of extension contact was found to be statistically significant between adopters and non-adopters at the 1% significance level in this study.

Access to improved *teff* seed: According to the findings, 88.9% of row planting adopters and 54.5 percent of non-adopters were able to obtain enhanced *teff* seed during *teff* production, while 11.1 percent of adopters and 45.5 percent of non-adopters were unable to obtain better *teff* seed during *teff* production.

The percentage difference between the groups is significant at the 1% significance level, according to the chi-square analys.

Technological Related Factors.

Cost of the row planting technology: - Farmers' perceptions of various qualities of a specific technology may influence their decision to embrace it. The hypothesis was investigated using sample households' preferences for row planting of *teff*. Farmers' perceptions of the technique's cost, as well as the low, medium, and high costs of improved row planting technology, were evaluated. As a result, 34.7 percent, 36.1 percent, and 29.2 percent of adopters thought row planting was less expensive, medium-cost, and expensive, respectively, when compared to *teff* broadcasting methods. statistically significant at the 1% probability level. Economic Analysis of Broadcasting and Row Planting Method of *Teff* Farmers.

Whenever a farmer conducts a profitability analysis of any agricultural technology, production expenses and revenues must be factored into the equation. *Teff* production costs are costs associated with production and the production process in the case of farmers. In this study area, the two *teff* farming systems had their own costs and benefits, which were divided into labor expenses for *teff* farmers, input costs for fertilizer and seeds, and money or output farmers got from the main *teff* grain product and *teff* straw Byproduct. During data collection in the study area, measurements and payments were made using the common average value price. A common value paid for laborer in the study area was 75 Birr per day. Moreover, the common value of improved *teff* seed was 2,200 Birr per quintal at the time of survey data, urea fertilizer was 914.89 Birr per quintal and DAP fertilizer was 1,267.24 Birr per quintal. Moreover, the comparison of *teff* producers profitability depends on the average outcome and cost used per hectare of land.

Average labor cost of *teff* farmers under broadcasting and row planting methods.

The study found that the main issue with using the row planting approach is that it involves a lot of labor. As a result, most poor farmers and farmers with small families found it impossible to use the row planting technique to cultivate *teff*.

The research also showed that labor was the most expensive input for *teff* grain farmers that used row planting. The respondents paid an average of 10,050 Birr per hectare in total labor costs. The following figure depicted that the average labor cost farmers incurred per hectare on their *teff* farms under broadcasting and row planting methods.

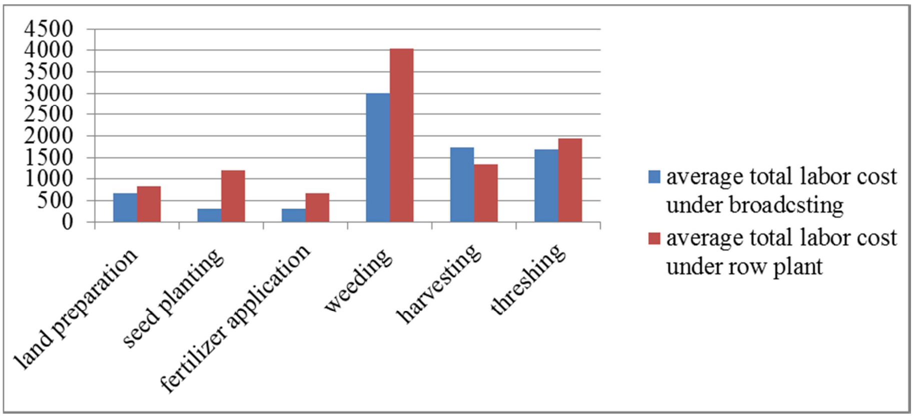

Figure 2. *Average farmers Labor cost of row planting and broadcasting teff per hectare Source: own survey result, 2018.*

Average input cost of *teff* farmers under broadcasting and row planting methods.

The study's findings revealed that the respondents' choice of *teff* farming style had an impact on the cost of input application. According to the findings, *teff* farmers' average total input costs in the broadcasting approach are higher than those in the row planting method. Furthermore, the overall average cost per hectare for input application in *teff* cultivation by traditional broadcasting and row planting farmers was 2241.18 Birr per hectare and 1657.34 Birr per hectare, respectively; however, the difference in input costs between the two planting methods is modest. As the finding of the study revealed that the highest farmers input costs for *teff* cultivation through traditional broadcasting method emanated from the cost of seed, it accounted the average of 462 Birr per hectare of the average total cost as compared within 132 Birr per hectare of the row planting *teff* farmers. Additionally, for the *teff* farmer's use of the broadcasting method the highest inputs cost was needed for fertilizer cost and in average the respondents incurred the average cost of 673.53 Birr per hectare of Urea and 1,105.65 Birr per hectare of Dap were used. Whereas the average fertilizer cost under the row planting method of *teff* was less accounting only average of 673.53 Birr per hectare of Urea and 931.39 Birr per hectare of Dap cost was incurred by the farmers. Therefore, seed and fertilizer cost were high significant differences between adopters and non adopters of row planting technology of *teff*. This implies that quantity of fertilizer and seed use is inversely related to row planting of *teff*.

Table 1. *The average total inputs cost farmers incurred per hectare of land under teff row planting and broadcasting methods.*

Types of inputs	**Row planting methods of *teff***		**Broadcasting methods of *teff planting***	
	Average input (kg/ha)	**Total average cost (Birr/ha)**	**Average input (kg/ha)**	**Total average cost (birr/ha)**
Teff seed	6	132	21	462
Fertilizer (Urea)	64.56	593.95	73.21	673.53
Fertilizer (Dap)	73.92	931.39	87.75	1,105.65
Total cost		1,657.34		2,241.18

Source: own survey result, 2018

Average *teff* output under row planting and broadcasting methods by the farmers.

The study found that the type of production system used by the farmers had a significant impact on *teff* productivity. The average total outcome farmers acquired per hectare of land in the broadcasting technique of *teff* production was 8.73 quintals per hectare, and the average total revenue of *teff* output famers production in birr was 19,200 Birr per hectare, as shown in table 2. According to the data, the outcome of *teff* straw produced by broadcasting farmers was better than the straw produced by row planting farmers due to its high quality for animal fodder, resulting in an average gross income of 3,529.33 Birr per hectare from the straw *teff* output under *teff* bOn the other hand, by using the row planting in the average of 13.35 quintals of *teff* grain harvested per hectare by the farmers. The result also predicted that the *teff* output farmers obtained through row planting methods of *teff* was much better than the amount of *teff* output achieved through broadcasting method. Additionally, the value of *teff* straw product achieved through row planting was very low compared to that produced using broadcasting, it contributed of 2,427 Birr per hectare of the average total gross income of the farmers under *teff* row planting technology.

Table 2. *Average teff output per hectare between row planting and broadcasting teff farmers.*

Types of Output	**Row planting method of *teff***		**Broadcasting method of *teff planting***	
	Average output (quintals per hectare)	**Average revenue (Birr per hectare)**	**Average output (quintals per hectare)**	**Average revenue (Birr per hectare)**
Teff grain	13.35	29,363.89	8.73	19,200
Teff straw		2,427		3,529.33
Average Output		31,790.89		22,729.33

Source: own survey result, 2018

The study's findings also revealed that the production of *teff* grain produced by farmers using the row planting approach is significantly higher than that generated by farmers using the broadcasting method. Furthermore, the results of *teff* and its straw product farmers obtained through row planting are much higher in quantity than those produced through broadcasting method, but the quality of *teff* straw produced by broadcasting method is more valuable in its use for livestock fodder and construction material, according to the information obtained from the interview. Average economic profit of the farmers under broadcasting and row planting of *teff*.

As shown in Table 3, the average total labor cost of both row planting and broadcasting *teff* farmers differs significantly, implying that the row planting method is more expensive in terms of labor cost. Because this arises from the very beginning of agricultural practice, farmers are prone to losing hope in its implementation. While the cost of inputs differed somewhat between the two methods, the difference was not significant. The average total *teff* farmers cost per hectare in row planting was 11,707.34 Birr per hectare, while the same cost was 9,891.18 Birr per hectare while using *teff* farmers broadcasting method. However, the study result revealed that the net income of farmers output of row planting technology was much higher than the broadcasting method of *teff* farmers.

Table 3. *Average net profits of row planting and broadcasting teff farmers.*

Types of the cost incurred by the farmers	**Row Planting Method of *Teff* Farmers**	**Broadcasting Method of *Teff* Farmers**	**Significance test**
			t-test
Average cost			
Average labor cost	10,050	7,650	6.93***
Average inputs cost	1,657.34	2,241.18	
Average total cost	11,707.34	9,891.18	-28***
Average Revenue			
Average *teff* crop revenue	29,363.89	19,200	30***
Average straw revenue	2,427	3,529.33	-14.37 ***
Average total revenue	31,790.89	22,729.33	
Average total Net profit	20,083.55	12,838.15	

Note: Significance difference at *** (1%) probability level
Source: own survey result, 2018

4. Conclusions and Recommendations

In most parts of Ethiopia, *teff* is one of the most extensively grown and consumed cereals. In contrast, the contribution of the already approved technology is not widely appreciated among the recipient farmers, making it difficult to make informed decisions and justifying additional *teff* production increase in the districts. In terms of its contribution, the national agricultural research system's research-extension program has disseminated many yield-increasing row planting of *teff* technology. However, the economic benefit as well as the adoption of the technology being extended by the research system has not been more identified. Therefore, this study was conducted with the aim of producing empirical data that can provide clear understanding on the economic analysis of broadcasting and row planting of *teff* technology adoption among smallholder farmers. The study was based on the data obtained from rural household survey data. The collected data were analyzed using descriptive statistics.

According to the descriptive result, household size, education level of household, row planting of *teff* training, access to improved *teff* seed, extension contact, access to mass media, access to credit and cost of technology affected the farmer's use of the row planting of *teff* significantly. The result of cost benefit analysis indicated that the amount of net profit farmers earned from production of *teff* crop through modern row planting technology by the farmer is significantly higher than that was produced through the traditional broadcasting method. However, the input cost of *teff* production through row planting technology is greater than that of broadcasting method. This cost difference exhibited on the labor cost under row planting technology is significantly greater than the labor cost applied through the traditional broadcasting method.

Following are some recommendations based on the aforementioned findings that should be considered by the relevant government bodies in the research region. In the current study, the findings revealed that farmers' access to mass media has a positive and significant impact on their decision to adopt the row planting of *teff* technology. Organizing farmers to share and discuss ideas from various mass media sources, such as radio, with their own local development group is critical to filling information gaps. The implication is that farmers' better technology package should be promoted through the media to increase technology adoption.

The study also found that farmers' adoption decisions for row planting *teff* technology are influenced by extension contact in a positive and significant way. This means that extension improves the capacity to obtain and utilise production-related data. As a result, farmers' understanding of the benefits of employing *teff* row planting technology must be raised through improved extension services. Furthermore, the destrict agricultural extension office must provide extension services to keep extension personnel's theoretical and practical understanding of recently developed row planting technology up to date.

Furthermore, the study's findings demonstrated that access to finance services had a positive and significant impact on farmers' decisions to adopt the *teff* row planting technology. Farmers' ability to obtain appropriate income at the time of planting and weeding is constrained. As a result, relying on loan availability became the last resort. This fact will necessitate the creation of a specific line of credit for the purchase of agricultural inputs. As a result, policymakers and bankers would be wise to lend to smallholder *teff* farmers while ensuring a high loan recovery rate and low cost of credit.

Farmers should be encouraged to form their own savings and credit cooperatives in their rural communities. Due to the use of manual labor, row planting technology necessitates a higher level of labor cost and skill during planting and weeding than the broadcasting approach. As a result, in order to increase farmer adoption of row planting, the concerned government agricultural bureau should supply farmers with more effective types of row seeder machine in using *teff* row planting to reduce the time and labor needs of the technology. Furthermore, any development agents should provide training on how to use row planting technology.

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