Onfarm Validation of Agricultural Technologies for Supporting Tef Extension Package Formulation in Ethiopia

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Abstract
Tef is an important crop in Ethiopian production system because of its dual function both as a staple crop that improves food security and as an income-generating crop. However, the grain yield is low, at 1.75kgha^{-1}. The objectives of this research were; to compare biological superiority of the treatments with full technology package; to conduct partial budget cost-benefit analysis of the treatments and to improve the full package of recommendations by incorporating benefits derived from the production with identification of possible ways to reduce the cost of production by constructing partial budget model. Economic constraints and opportunities for improving tef production systems in Ethiopia must be understood as the basis for research and developing interventions. The field experiment comprising three interventions packages on the tef production system namely: extension package, Agricultural transformation Agency of Ethiopia package and the research package (which had been split in to two sub packages which were row and broadcast planting) application was laid out in a randomized complete block design with the replication(farmers/ locations as replication). The field experimental plot size was 500m^2. This study presented both the agronomic yield comparison of the four packages and the partial budget analysis (PBA) framework for the economic analysis of different tef package treatments for their benefit returns. The result indicates that research package on broadcast planting and raw planting systems were found to be superior in grain yield 1580kgha^{-1} and 1550 kgha^{-1}, respectively. Similarly research row sowing and broadcasting recommendations were gave higher above ground biomass 10167kgha^{-1} and 10000kgha^{-1}, respectively as compared to the ATA and Extension package practice. Thus, the result indicates that seed rate of 10-15 kgha^{-1} both broad cast and row sowing gives better grain yield and shoot biomass providing the highest return with marginal rate of return , whereas ATA package was found to be the least economically viable treatment having minimum MRR. The partial budget analysis revealed that net returns of treatments extension package, research row planting package and research broadcasting package exceeded the net return of the control- ATA package by Ethiopian birr (EB) (0.32), 1.09 and 1.65, respectively (US$ 1 = EB 27.49). The decrease in cost for treatment of extension package relative to the control-ATA package was EB 1.03; the added net benefit from this treatment was EB 0.75 per unit, giving a marginal rate of return of 137%. The decrease in cost of treatment research with row planting package relative to treatment of the control-ATA package was EB 71%, while the increase in net return was EB 32.6 per unit of production, giving a marginal rate of return on the increased expenditure of 218%. The relative decreasing cost of treatment research tef broadcast planting was EB 60.7% per unit of production as compared to the control-ATA package, while the increase in net return relative to treatment the control was EB 3.38 for a marginal rate of return of 1795%. Given the high cost of capital, treatments of the control-ATA and the extension package cannot be recommended as they indicate negative benefit cost ration with (0.51) and (0.31) respectively while 1.09 and 1.65 for research row planting and broadcast planting, respectively yet; the broadcast planting of tef production indicated superior in returns of EB 0.65 for EB 1 invested in the production at small scale level. Considering the lack of appropriate tef row planting at the moment, broadcast planting with 10-15 seed rate should be used as tef production package in the country.
Keywords: Tef; Partial budget, Marginal cost, Benefit cost ratio, Yield, Variable cost
DOI: 10.7176/JBAH/10-17-01
Publication date: September 30th 2020

1. Introduction

Tef (Eragrostis tef) is the most important cereal crop of Ethiopia. The crop is annually grown on over 3.02 million hectares of land, accounting for about one-third of the total cereal acreage and about one-fifth of the gross cereal grain production in the country (CSA, 2015). It is grown by about 6.6 million smallholder farmers. *Tef* offers numerous advantages over the other cereals grown in the country with respect to both husbandry and utilization of both the grains and the straw. The crop grows under wider range of ecological conditions from sea level up to 3000meters above sea level and performs better than the other cereals under adverse and margin-al conditions. *Tef* constitutes the main daily staple food for over 70 million Ethiopians providing good nutrition for the consumers. Furthermore, *tef* straw has a much value as the grain because of its use for fodder, bedding and construction material. Thus, it is valued for the quality of grain and fodder that it provides, both of which have a high market price (Assefa *et al*., 2011).

Tef is a very nutritious cereal grain. Its nutritional content is generally comparable to that of the major world cereals like wheat, barley, rice, maize and sorghum. In fact, it is superior in many aspects particularly in minerals such as iron, calcium, magnesium and zinc. In recent years, *tef* has become popular as health and performance food in the global market. Since the grains are gluten-free, it is useful as food for humans suffering from gluten protein allergy ailments known as celiac disease (Spaenij-Dekking *et al*., 2005). Its low glycemic index characterized by slow release type starches make it particularly suitable for diabetic people. Moreover, its high iron content is associated with the low prevalence of hook-worm (Ethiopian Nutrition Survey, 1959) and pregnancy related anemia in people consuming *tef* as staple food. As *tef* is gluten-free and rich in amino acids and minerals, especially iron and calcium, it is widely marketed in Europe and the USA-in organic stores as well as via the Internet-and appreciated by the Ethiopian communities. In cooperation with American and European institutes, Ethiopia is breeding *tef* with higher yields-by traditional selection, hybridization, and marker-assisted breeding (Heiniger, U., 2016).

As Ethiopia's population is ever increasing, so too will the demand for grain. Moreover, *tef* is one of the most important crops for Ethiopia's agricultural economy, both in terms of consumption and production (Worku *et al*. 2014). Its high nutritional qualities and the absence of gluten make *tef* increasingly known even outside Ethiopia, which increases the demand for *tef* (Andersen and Winge 2012). The area of *tef* has been increasing gradually from time to time partly because of the general increase in the total cultivated area and partly at the expense of the area of the other cereals. At the same time, both the production and productivity have also increased due to the development of new varieties.

Scientific research on *tef* was started in 1950's. Over the years commendable achievements have been made with respect to the development of improved technologies involving varieties along with improved management practices, generation of information and promotion of improved technologies. The mean *tef* yield is lower (1.58 t ha^{-1}) than other cereal crops such as maize (3.4 t ha^{-1}), sorghum (2.4 t ha^{-1}), wheat (2.5 t ha^{-1}), and barley (1.97 t ha^{-1}) (CSA, 2015). And this is far lower than the potential yield of 6 t ha^{-1} estimated by Ketema (1997), primarily because of low access to technology/innovations (Assefa *et al.,* 2011). The need for a new and updated national *tef* research is felt in order to tackle priority problems of *tef* through concerted up-to-date research and increase its productivity and production and thereby contribute to the overall agricultural transformation plan of Ethiopia.

Cost of production statistics generally only benefits the data suppliers indirectly through improved policy-making, better administrative decisions and more efficient markets. However, there is also potential for the data supplier, namely the farmers themselves, to reap direct benefits. At the farm level, Cost of production data contributes to improve the economic assessment of farm operation. They allow the producer to question his own operation and to benchmark it against the best practices of farms in the same region with similar characteristics. This, in turn, can lead to better informed decisions at the farm-level and improved market efficiency and performance.

A recommendation is information that farmers can use to improve the productivity of their resources. A good recommendation can be thought of as the practices which farmers would follow, given their current resources, if they had all the information available to the researchers. Farmers may be able to use a recommendation directly, as in the case of a particular variety. Or they may adjust it somewhat to their own conditions and needs, as in the case of a fertilizer level or storage technique. The agronomic data upon which the recommendations are based must be relevant to the farmers' own agro ecological conditions, and the evaluation of those data must be consistent with the farmers' goals and socioeconomic circumstances.

Cost of production statistics provide farm extension workers with evidence to support their training and outreach activities, which helps evaluate an individual farm's management practice against norms for the region. It also allows better targeting to the largest payoffs for their activities, which, in turn, elevates productivity.

Objectives

- To compare biological superiority of the treatments with full technology package.
- To conduct cost-benefit analysis of the treatments as well as full technology package.
- To improve the full package of recommendations by incorporating gainful information derived from treatments.

2. METHODOLOGY

2.1. Field Experiment

Four different packages were taken for comparison of returns these were; Extension Package- which was an old recommendation of the research and it's still applied by Ministry of Agriculture extension system, Agricultural transformation agency (ATA) of Ethiopia system which is the new recommendation, New agronomic research finding of row sowing method recommendation and New research broadcasting recommendations with different seed rate, fertilizer, herbicide, insecticide, and agronomic management system were used as treatments (Table 1).

The experiment were carried out at five locations (four on farm and one on station) which were used as replication and each plot size of 20mx25m (500m^2). The variety used was *Kora*.

Table 1: Treatments used for different agronomic practices for *tef* production

Parameter	Extension package	ATA package	Research row sowing recommendation	Research broad casting
Variety	Kora	Kora	Kora	Kora
Plot size	25m x 20m	25m x 20m	25m x 20m	25m x 20m
Seed-rate (g/plot)	250 with 20cm b/n rows	250 with 20cm b/n rows	750g/plot with 20cm b/n rows	15 kg/ha broad casting
Nutrition	5000g/plot-NPS-(basal) 4000g/plot-UREA-as split application Package	5000g/plot NPS (basal), 5000g/plot KCL and 4000g/plot UREA (both as split application)	5000 g/plot NPS (basal) and 4000g/plot UREA (as split application)	5000 g/plot NPS (basal) and 4000g/plot UREA (as split application)
Weed	Pallas 45 OD 20ml/plot + hand weeding	Pallas 45 OD 20ml/plot +hand weeding	Hand weeding	Hand weeding
Insecticide	karaten 20ml/50m^2	karaten 20ml/500m^2	No	No
Agronomic management	*Tef* seed planted in the furrow (furrows made by the passage of the local plow as rows)	*Tef* seed planted in the furrow (furrows made by the passage of the local plow as rows)	bed were made and rows were made	Broadcasted

Source: stated recommendation package to verify 201

2.2. Data and Methods of Analysis

Relevant agronomic data were collected from the experimental trial. Primary data on grain yield, above ground biomass and straw was calculated. Mean comparison of the four packages were done for agronomic traits collected (Table2). On the other hand, cost data were collected on labor and oxen rent, and application rates of inputs such as seed, fertilizer and pesticides were based on recommendations used for the trial. Data were initially calculated for each farmer separately and then combined across three locations. All costs and revenues were quantified based on 500m^2 and converted to hectare base; furthermore mean extrapolated to the hectare basis.

Because of the wide variety of cost concepts, it is not possible to deal with all of them in a single section; for reason only the following items was dealt with for short term benefit:-

- Variable costs
- Total and average costs
- Marginal costs
- Gross margin
- Benefits cost ratio

Variable costs: **-** Variable costs are a function of output and are only incurred if there is production. There is therefore a relationship between the volume of production and costs. For this study variable costs are seed, fertilizer, pesticide, wage rate, and oxen rent if production decisions have to be made on the quantities of variable inputs that must be used to maximize benefit over the short term, only variable costs are relevant since fixed costs remain constant.

Total costs: - Total costs are the sum of the total fixed and total variable costs, for this study of the short-term analysis variable only variable cost was taken.

$$C_{pT} = C_S+C_F+C_P+C_{oR}+C_L \quad (1)$$

Where:-

C_{PT}= cost of production of *tef*

C_S= cost of seed

C_F = cost of fertilizer

C_P = cost of pesticides

C_{OR}= cost of oxen rent

C_L= cost of labor- (which includes cost of planting, cost of fertilizer application, cost of hand weeding, cost of insecticide spraying, cost of herbicides spraying , cost of harvesting and cost of threshing)

Average costs: - Average or unit costs are the costs per unit such as cost per kilogram or quintal, per hectare, per liter. Average variable and average total costs can, depending on the circumstances, be calculated by dividing the specific cost amount by the corresponding units.

$$AVC= {TVC}/{yield\ of\ tef} \quad (2)$$

As in short run analysis focus on the operational cost analysis and the fixed cost is constant then;

$$AVC= {VC}/{yield\ of\ tef} \quad (3)$$

The assumption is that for this research the fixed cost is constant and taken the variability among the costs that can be used for validation of benefits for different practices; so that ATC equals to AVC.

Marginal costs: - marginal costs are the extra or additional costs attached to the last unit of output marginal costs are calculated by dividing the change in costs (△ costs) by the change in output (△ yield), that is:

Marginal costs are only determined by an increase in variable costs. As long as marginal income is bigger than marginal costs, the benefit will be increased.

$$MC = \frac{\Delta TC}{\Delta Q} \quad (4)$$

Tells us how much cost rises per unit increase in yield of tef.
Marginal cost for any change in output is equal to shape of total cost curve along that interval of yield.

If the MC> AVC then the average cost is rising for kilogram of *tef* yield per plot or per hectare.
If the MC=AVC then the average cost is at its lowest point.
If MC<AVC then the average cost is falling for kilogram of yield.
Benefit cost ratio: - is an indicator, used in cost-benefit analysis, which attempts to summarize the overall value for money of a *tef* production treatments. It is an important tool to assess economics of farming. It is the ratio of all net value of *tef* produced after deducting the costs of different inputs after their summation in the production process.

$$BCR=\frac{GB-TVC}{TVC} \quad (5)$$

Where;
BCR= benefit cost ratio
GB= gross benefits
TVC= total variable cost

Marginal rate of return: - technically, the marginal rate of return is the marginal return or the amount of revenue per additional item, divided by marginal cost (the cost per additional item produced). In other words, it's the amount of additional revenue that a *tef* production can expect to earn per each additional birr that it spends on production. Using marginal rate of return, a farmer can determine whether or not its operations has a benefit or loss.

Marginal rate of return becomes most powerful when it's used as a decision-making tool. As long as a marginal rate of return is greater than one, a farmer can make a profit by producing one additional unit. Because marginal rate of return tends to decrease as more and more units are produced, a farmer will maximize its benefits by expanding production until its marginal rate is one. Basically, this is where marginal revenue equals marginal cost (MR=MC). If a company produces beyond this point, the marginal rate of return drops below one (MR<1), and the company will be spending more per each additional item than it is bringing in revenue.

3. RESULTS DISCUSSION

Research both broadcasting and row sowing recommendations gave better grain yield 1580kgha^{1} and 1550kgha^{-1}, respectively. Similarly research row sowing and broadcasting recommendations were gave higher shoot biomass 10167kgha^{-1} and 10000kgha^{-1}, respectively as compared to the rest treatments. It indicates that straw yield for the two research practices were better than the ATA and Extension package practice. The result indicates that seed rate of 10-15 kgha^{-1} both broad cast and row sowing gives better grain yield and aboveground biomass. From this experiment, the two-planting methods row sowing and broadcasting revealed the same results considering the lack of appropriate planting machine for *tef* in Ethiopia for the time being. Therefore, we can conclude that the research recommendation and farmers practice are better for tef production than the ATA and Extension package recommendations (Table 2). According to Hailu, G. *et al.* (2017); the major drivers for productivity differences appear to be the levels of input use, so this research applied different package system of inputs for productivity and validated that the research broad casting has more advantage.

Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.10, No.17, 2020

Table 2: Comparison of mean yield, shoot biomass and straw output kg per hectare

Treatments	Yield	Shoot biomass	Straw
Extension package	1083	7583	6500
ATA Package	993	6958	5965
Research row sowing	1550	10167	8617
Research broad casting	1580	10000	8420

Source: own data computed 2017

On station level analysis of treatments indicate that the net revenue for treatment of extension package, ATA package, research with row planting and research with broad cast planting system show a positive return from the farming investment for production of *tef*; which was found 44,640.20, 31,000.20, 54,164.20 and 58,371.20 birr per hectare. The return from the treatment of research with broadcasting planting system application has 27,371 birr returns of benefits when compared to the ATA package treatment. Considering the first household on farm trial had a loss of (19,989.80) and (23,604.20) birr per hectare in the first and second treatments while he had a positive net return of 46,789.20 and 50,991.20 birr hectare from third and fourth treatments; which indicate that recommendation of treatment four is superior to the household on farm *tef* production as compare to the rest of the application modalities. On the other hand application of treatment packages on the second household on farm trial though all the management system had a positive return still research broadcasting had a good net benefit returns when equated to the rest with gross net benefit of 58,371.2 birr per hectare (Table 3 and 4).

Table 3: Benefit cost analysis for on farm extension and ATA package

Category	Extension				ATA			
Inputs/costs	DZARC	Farm[1]	Farm[2]	Average	DZARC	Farm[1]	Farm[2]	Average
Seed	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
Fertilize	96.29	96.29	96.29	96.29	152.29	152.29	152.29	152.29
Pesticide	58.70	58.70	58.70	58.70	58.70	58.70	58.70	58.70
Labor-cost birr/plot	742.00	742.00	742.00	742.00	742.00	742.00	742.00	742.00
Oxen birr/plot	774.50	774.50	774.50	774.50	774.50	774.50	774.50	774.50
Total-inputs-cost birr/plot	1,677.99	1,677.99	1,677.99	1,677.99	1,733.99	1,733.99	1,733.99	1,733.99
Yield kg/plot	80.00	10.50	72.00	54.17	64.50	5.00	79.50	49.67
Grain-value birr/plot	1,760.00	231.00	1,584.00	1,191.67	1,419.00	110.00	1,749.00	1,092.67
Straw-value birr/plot	2,100.00	447.50	2,327.50	1,625.00	1,865.00	443.75	2,165.00	1,491.25
Total-Revenue birr/plot	3,860.00	678.50	3,911.50	2,816.67	3,284.00	553.75	3,914.00	2,583.92
Net revenue birr/plot	**2,182.01**	**-999.49**	**2,233.51**	**1,138.68**	**1,550.01**	**-1,180.24**	**2,180.01**	**849.93**
Net revenue (birr/ha)	**43,640.20**	**-19,989.80**	**44,670.20**	**22,773.53**	**31,000.20**	**-23,604.80**	**43,600.20**	**16,998.53**

Source: own data computed 2017

Note: *Tef* grain price 2200 birr/ql; straw price= 500 birr/ql, and plot area = 500 m^2

Table 4: Partial budget cost analysis for extension and ATA packages

Research recommendation								
Category	Research row				Research broad-cast			
Inputs/costs	DZARC	Farm[1]	Farm[2]	Average	DZARC	Farm[1]	Farm[2]	Average
Seed	19.50	19.50	19.50	19.50	19.50	19.50	19.50	19.50
Fertilize	96.29	96.29	96.29	96.29	96.29	96.29	96.29	96.29
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor cost birr/plot	583.00	583.00	583.00	583.00	386.9	386.90	386.90	386.90
Oxen birr/plot	549.50	549.50	549.50	549.50	549.5	549.50	549.50	549.50
Total-inputs-cost (birr/plot)	1,248.29	1,248.29	1,248.29	1248.29	1052.19	1,052.19	1,052.19	1052.19
Yield (kg/plot)	82.00	69.50	81.00	77.5	81.00	74.00	82.00	79
Grain value (birr/plot)	1,804.00	1,529.00	1,782.00	1705	1782.00	1628	1804.00	1738
Straw value (birr/plot)	2,152.50	2058.75	2251.25	2154.167	2188.75	1973.75	2152.50	2105
Total Revenue (birr/plot)	3,956.50	3,587.75	4,033.25	3859.167	3970.75	3601.75	3956.50	3843
Net revenue (birr/plot)	2,708.21	2,339.46	2,784.96	2610.877	2918.56	2,549.56	2904.31	2790.81
Net revenue (birr/ha)	**54,164.20**	**46,789.20**	**55,699.20**	**52,217.53**	**58,371.2**	**50,991.2**	**58,086.2**	**55,816.2**

Note: *Tef* grain price 2200 birr/ql; straw price= 500 birr/ql, and plot area = 500 m^2, ql= quintal which equivalent to 100kg

Based on the trial record sheet kept by researchers' close observation, the total variable costs were determined using the respective input prices. On average, the total variable cost for inputs in *tef* production was found 33,559.80 birr per hectare with the application of package. From the gross total variable cost the oxen rent has incurred 15,490.00ha^{-1} birr which is covering the 46.2% and 14840 birr for labors which 44.2% out of the gross. The total variable cost for treatment of ATA package, research with row planting and research with broad cast varies accordingly with 34,679.80, 24,965.80 and 21,043.8 birr per hectare respectively. The highest yield per hectare in kilogram was recorded in treatment of research with application of broadcast planting which was 1,580 while research with row planting was 1,550; at the same time yield for extension package and ATA package was found 1,083.33 and 993.33 kg per hectare; and *tef* market price per kg in the sample district was 22 birrs (Table 5).

Net gross revenue with the assumption that if the farmer sells its entire yield the gain per hectare was found for each treatment- for extension package, for ATA package, research with application of row planting and research with application of broadcast planting system had gross revenue of 56,333.33, 51,678.33, 77,183.33 and 76, 860 birr per hectare; this state that research applying row planting has the upper rate of gross benefit while the net benefit was found 22,773.53, 16,998.53, 52,217.53 and 55,816.2 birr per hectare *tef* production. When the treatment four is equated to treatment two the first has on average a net benefits of 38,817.67 birr per hectare for *tef* production (Table 5).

Table 5: Partial budget cost analysis for different recommendations per hectare based

Category Inputs/costs	Extension$_1$ mean/ha	ATA$_2$ mean/ha	Research row planting$_3$ mean/ha	Research broad casting$_4$ mean/ha
Seed	130.00	130.00	390.00	390
Fertilize	1,925.80	3,045.80	1,925.80	1925.8
Pesticide	1,174.00	1,174.00	0.00	0.00
Total Labor cost	14,840.00	14,840.00	11,660.00	7738
Plowing	2,120.00	2,120.00	4,240.00	318
Fertilizer application.	1,060.00	1,060.00	1,060.00	1,060.00
Weeding	1,060.00	1,060.00	1,060.00	1,060.00
Insecticide spr.	2,120.00	2,120.00	2,120.00	2,120.00
Herbicide spr.	2,120.00	2,120.00	2,120.00	0.00
Harvesting	2,120.00	2,120.00	2,120.00	0.00
Threshing	3,180.00	3,180.00	3,180.00	3,180.00
Other tasks	1060.00	1060.00	0.00	0.00
Oxen cost	15,490.00	15,490.00	10,990.00	10990
Total inputs cost	**33,559.80**	**34,679.80**	**24965.8**	**21043.8**
Yield kg	1,083.33	993.33	1,550.00	1580
Grain value	23,833.33	21,853.33	34100	34760
Straw value	32,500.00	29,825.00	43083.33333	42100
Total Revenue	**56,333.33**	**51,678.33**	**77,183.33**	**76,860**
Net revenue	**22,773.53**	**16,998.53**	**52,217.53**	**55,816.2**

Source: own data computed 2017
Note: *Tef* grain price 2200 birr/ql; straw price= 500 birr/ql, and plot area = 500 m^2

Rule of thumb, when the farmer output is relatively small, the average cost decreases, whereas when the output starts increasing, the average cost increases too. Farmers producing *tef* that seek to maximize their profits, use the average cost to determine the point that they should shut down production in the short term. Therefore, if the price of a *tef* is higher than the AVC of the good, it means that the firm is covering all the variable costs. In this case, farmers will continue in *tef* production. On the contrary, if the price they receive for *tef* yield is lower than the AVC, firms cease production to avoid additional variable costs. Benefit-maximizing farmer will use the AVC to determine at what point they should shut down production in the short run. If the price they are receiving for the good is more than the AVC given the output they are producing. As long as price is above the AVC and covering some of the total variable costs, you are better off continuing production. If the price falls below the AVC, then the farmer may decide to shut down production in the short run because the price is no longer covering any portion of the all of the variable costs (Table 6).

Marginal cost the increase or decrease in the total cost of a production run for the production of additional unit of *tef*. The purpose of analyzing marginal cost is to determine at what point of a farmer can achieve economies of scale in *tef* production. The calculation is most often used among farmers as a means of isolating an optimum production level. Change of *tef* production from ATA package to extension package the total production cot for unit *tef* per hectare decreases by 12.45 birr while change of production from treatment of research with row planting can decrease cost for unit *tef* per hectare by 17.45 birr (Table 6). Marginal costs are variable costs consisting of all input costs in the production at the short run. In companies where average costs are fairly constant, marginal cost is usually equal to average cost. However, in small scale *tef* production at household level require minimum capital investment as compare to commercial investment in *tef* producers as a rule of thumb and have low average costs, it is comparatively very low (Table 6).

The productions of *tef* with a benefit-cost ratio greater than 1 have greater benefits than costs; hence they have positive net benefits. The higher the ratio, the greater the benefits relative to the costs; note that simple benefit-cost ratio is insensitive to the magnitude of net benefits and therefore may favor production with small costs and benefits over those with higher net benefits. (This problem can be eliminated by the use of the incremental benefit-cost ratio or the net present value.)

The higher the BCR the better the treatment to apply; general rule of thumb is that if the benefit is higher than the cost the production process in *tef* is a good investment. If a project has a BCR that is greater than 1, it indicates that benefits outweigh of the costs. Therefore, the treatment should be considered if the value is significantly greater than 1. If the BCR is equal to 1, the ratio indicates that expected benefits equal the costs. If the production BCR is less than 1, the costs outweigh the benefits and it should not be considered. Considering Table 6 treatments of extension package and ATA package had a BCR of (0.32) and (0.51), which indicates that the two treatments cost has outweighed the benefit that show every birr of 1 cost added will result a loss of 0.32 and 0.51 birr; while applying treatment of research row planting and research broadcast planting in *tef* production at small scale level had a benefit of 1.09 and 1.65 birr for each 1 birr of its cost invested (Table 6). Recommendation and findings of Hailu, G. *et.al* (2017) states that reducing the costs of remoteness through the construction of rural roads and increasing distribution outlets of modern inputs is likely to have a positive impact on *tef* productivity; this study also justifies that producers of *tef* in the nation are widely dispersed so input costs mark-up can vary accordingly and will have impact on the change of TVC and BCR.

Table 6: Partial budget analysis on farm trial per hectare (birr)

Treatments	Yield $_{kg}$	TVC	AVC	MC	NB	BCR
Extension package	1,083.33	33,559.8	30.97	-	22,773.53	-0.32
ATA package	993.33	34,679.8	34.91	-12.44	16,998.53	-0.51
Research row planting Package	1,550	24,965.8	16.09	-17.45	52,217.53	1.09
Research broadcast planting	1,580	21,043.8	13.32	-130.73	55,816.2	1.65

Source: own data computed 2017

Note: TVC= total variable cost (variable cost) = total cost
AVC= average variable cost
MC= marginal cost
NB= net benefit
BCR = benefit cost ratio

4. CONCLUSIONS AND RECOMMENDATIONS

The objective of this on farm experiment was to validate and recommend on farm economically superior technology packages to small scale farmers who are engaged in the *tef* production. keeping constant all other factors that can create a variation among smallholder producers and soil type variability the result indicates that research package on broadcast planting and raw planting systems were found to be superior in the potential producer of sample selected districts research both broadcasting and row sowing recommendations gave better grain yield 1580kgha^{-1} and 1550 kgha^{-1}, respectively. Whereas ATA package and extension package recommendations gave grain yield 993kgha^{-1} and 1083 kgha^{-1}, respectively. Similarly research row sowing and broadcasting recommendations were gave higher above ground biomass 10167kgha^{-1} and 10000kgha^{-1}, respectively as compared to the ATA and Extension package practice. The result indicates that seed rate of 10-15 kgha^{-1} both for broad cast and row sowing gives better grain yield and shoot biomass providing the highest return with marginal rate of return of, whereas ATA package was found to be the least economically viable treatment having minimum MRR. However, the profitability of the four treatment packages varied across the three farm trials. The variation could be both due to the treatments and location specific condition with soil type variability or other different heterogeneous factors; yet the research packages with two different planting methods were found high yielding with low total variable cost incurred and high benefit cost ratio as compared to other treatments. So; it was found that the research package with broadcast planting method of *tef* was more profitable and followed by the raw planting methods when compared to the extension and ATA packages. Intervention and scaling up of the two methods of planting in research package can benefits farmers to gain good returns as compared to others for profitability and to increase the market supply or sustaining consumption of the household. This study recommends a research package that reduces the TVC can increase profitability; which Hailu, G. *et.al* (2017) also stated innovations that reduce labor requirements for growing *tef* might satisfy the increasing demands for *tef* at an affordable price.

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