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# Economic Analysis of Tef Yield Response to different Sowing Methods: Experience from Illuababora Zone, Ethiopia

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**Abstract**
Tef (Eragrostis tef) is a major staple food crop in Ethiopia and used to prepare a spongy flat bread called enjera which is consumed by about 70% of the Ethiopian population. Promotion of different tef sowing method had been one of the areas of intervention to improve the productivity of tef by AGP (Agricultural Growth Program) since 2011. Substantial improvement in tef grain yield was observed though some of the sowing methods were perceived as a labor intensive by smallholder farmers. In the study area the economic feasibility of the introduced sowing technologies under the farmers' condition was not yet evaluated. Hence experiments on tef sowing methods were conducted with the objective to economically evaluate and select appropriate sowing technologies under smallholder farmers` condition. The data was collected from Bedelle and Dhidhessa districts of Illuababora zone and subjected to the economic analysis method of CIMMYT (1988). The economic return from four methods namely, hand broadcasting method, ATA machine broadcasting method, row planting and transplanting method were evaluated. The yield obtained from the row planting was 42 % higher than hand broadcasting method. The transplanting method improved the yield of tef crop by 44% than the yield obtained through row planting method. Nevertheless, the net benefit obtained from transplanting (12,670 birr/ha) was found to be 45% less than the broadcasting (18476 birr/ha) method. The transplanting method was failed to be economically feasible option demanding further refinement with regards to its labor intensiveness. In contrast, the ATA machine broadcaster gave a MRR of 740% as compared to hand broadcasting method while the farmers obtained 94% MRR from the row planting. On a tentative basis farmers could thus choose ATA manual broadcasting machine as compared to hand broadcasting for highest economic return. In order to gain optimum economic advantage from row planting and transplanting methods, improving their labour intensive nature through participatory approach would be a key area of future research.
**Keywords** : Quncho tef , broadcasting, row planting , transplanting MRR,ATA.

## Introduction

Tef (Eragrostis tef) is a major staple food crop in Ethiopia, mostly used to prepare enjera, a spongy flat bread that is consumed by about 70% of the Ethiopian population (Arnold et al., 2008). In 2011/12, it was estimated that tef made up 20 percent of Ethiopia's cultivated area and second most important cash crop (after coffee) covering about 2.7 million hectares. In the same year tef was grown by 6.3 million farmers and the total national production was evaluated at 3.5 million tons and was valued at 1.6 billion USD. On the consumption side, it is found that tef is more readily eaten by urban household (61kg/ person/year) than by rural house-holds (20kg/person/year) (Minten and etal,2013).

It is grown at middle elevations between 1,800 and 2,200 meters above sea level and in regions that have adequate rainfall. Compared to other cereals, tef is considered a lower risk crop as it can withstand adverse weather conditions .While research on improved tef varieties has been done since the mid-1950s, investments have been limited and only a small number of improved varieties have been released, i.e. about 20 in total (Fufa et al. 2011). On the other hand using the commercial surplus data for the period 2011/12, tef value was estimated to be 464 million USD or one quarter lower than coffee (599 million USD). The value of commercial surplus of tef is equal to the commercial surplus of the three other main cereals combined in the country (sorghum, maize, and wheat) which makes it important crop for farm income as well as food security ( Minten and etal,2013).

Tef productivity remained very low mainly due to poor access to high yielding tef varieties and poor

 

agronomic practices used by farmers. Traditionally the farmers broadcast the tef seed using a high seed rate between 25 and 50 kg /ha( ATA 2013b). It was also argued that traditional broadcasting reduce yield because the uneven distribution of seed increase competition between tef plant for nutrient, water and light (Fufa etal.2011). As a solution it is recommended to reduce the seed rates and to plant in rows or alternatively to transplant from a nursery plot (Vandercasteelen etal 2014). Given these facts, high yielding tef variety called "Quncho" has been released by Ethiopian research centres and it had been promoted by Ministry of Agriculture as one of the promising crops for food security. The promotion utilizes different machineries which assist the sowing and row planting methods. Nevertheless, it is not only the biological yield that matters for the smallholder farmers but also the amount of labor consumed during the implementation of each technological options (CASCAPE PRA, 2011).

Cognizant with the above facts, the experiment was conducted to generating evidences on economic advantage of different tef sowing methods in order to support AGP (Agricultural growth program) through generating substantial evidence.

## Materials and Method

### Description of the Study areas

The experiment was conducted in Bedelle and Dhidhessa districts of Illuababora zone. The overall agro-ecological description of the Districts were summarized as follows in table 1 below.

Table 2. Description of the Districts areas where Quncho tef Experiment was conducted

| District | Name of Kebeles (Villages) | altitude | Annual temperature (Co ) | Mean annual Rainfall |
|---|---|---|---|---|
| Dhidhessa | Saso, Yembero , Goro | 1500-2200 | 21.7ºC-23 ºC | 1200-1700mm |
| Bedelle | Yabala | 1300 -2000 m.a.s.l | 11 ºC -17 ºC | 1250-1750mm |

### Data Analysis Method

The economic evaluation comprising a partial budget with dominance, marginal and sensitivity analysis were carried out as described by CIMMYT (1988). The minimum acceptable rate of return was set at 100%. Economic analysis was done using the prevailing farm gate prices for inputs at planting/sowing season and for outputs at the time the crop was harvested. All costs and benefits were calculated on hectare basis in Ethiopian birr (Birr/ ha). During the study period one US dollar was equivalent to 18 Ethiopian Birr.

The Dominance analysis procedure was used to select potentially profitable treatments. The method comprised ranking of treatments in order of ascending TVC from the lowest (farmers practice) to the highest cost (Onuk etal 2010). This helps to eliminate those treatments costing more but producing a lower NB than the next lowest cost treatment. The selected and rejected treatments by using this technique were referred to as undominated and dominated treatments respectively. For each pair of ranked undominated treatments, a percentage marginal rate of return (% MRR) was to be calculated. The percent MRR between any pair of undominated treatments denotes the return per unit of investment in crop management practices expressed as percentage. To obtain an estimate of these returns we calculate the MRR, which was given by the following formula

$$MRR\ (\%) = (\Delta NB / \Delta TVC) * 100;$$

Thus, a MRR of 100% implies a return of one birr on every birr of expenditure in the given variable inputs. A quadratic response on returns to shift in method of planting is assumed and therefore the undominated treatments that fail to satisfy this criterion were discarded from the MRR analysis. Given the diversity of the agro-ecology and availability of the Quncho tef technological options, different sowing technologies of tef were introduced and tested. Accordingly the approach and experimental designed applied during the experiment in selected districts were mentioned in table 2 below.

Table 3. Summary of the treatments used for the evaluation of sowing methods

| Districts | Treatment No | Sowing method | Fertilizer rate (kg/ha) | Sowing (kg/ha) |
|---|---|---|---|---|
| Bedelle and Dhidhessa | 1 | Hand Broadcasting | 100kg DAP and 100 Urea | 5kg |
| | 2 | ATA Machine broadcasting | 100kg DAP and 100 Urea | 5kg |
| | 3 | Row planting | 100kg DAP and 100 Urea | 5kg |
| | 4 | Transplanting | 100kg DAP and 100 Urea | 15 cm by 20cm |

 

**RESULTS**

During the experiment with sowing method, the agronomic performance of tef across the treatments were found to be varied considerably. The yield of tef was highest for the transplanting and the lowest for the hand broadcasting. The yield gained from the transplanting was 30% higher than the hand broadcasting methods. Similarly the labor utilization consistently increases from hand broadcasting to transplanting method. The labor cost for transplanting of tef from the seed bed to the main farm field was observed to be the highest while the hand broadcasting consumed the least labor.

Table 4. Result of Partial budget analysis for Quncho tef experiment Dhidhessa and Bedelle District

| Parameters | Hand Broadcasting | ATA Machine broadcasting | Manual Row planting | Transplanting |
|---|---|---|---|---|
| Average yield (Qtl/ha) | 14.8 | 15.7 | 20.1 | 21.3 |
| Adjusted yield (Qtl/ha) | 14.1 | 14.9 | 19.1 | 20.2 |
| Average of tef straw yield (kg/ha) | 1380 | 1,240 | 1,293 | 1,323 |
| Adjusted tef straw yield (Kg/ha) | 1,311 | 1,178 | 1,228 | 1,257 |
| Gross field benefit of tef grain per ha | 20,290 | 21,514 | 27,537 | 29,173 |
| Gross field benefit of tef straw per ha | 1,390 | 1,249 | 1,302 | 1,333 |
| Total GFB (Birr/ha) | 21,679 | 22,763 | 28,839 | 30,506 |
| Field cost of DAP (Birr/ha) | 1,587 | 1,587 | 1,587 | 1,587 |
| Field cost of UREA (Birr/ha) | 1,250 | 1,250 | 1,250 | 1,250 |
| Field cost of seeds (Birr/ha) | 89 | 89 | 89 | 89 |
| Labor cost of fertilizer application (Birr/ha) | 214 | 256 | 1,344 | 4,200 |
| Labor cost of row making/ha | - | - | 1,680 | 5,040 |
| Labor cost of sowing per ha | 63 | 150 | 517 | 5,670 |
| Total labor cost | 277 | 406 | 3,541 | 14,910 |
| TVC (birr/ha) | 3,203 | 3,332 | 6,466 | 17,836 |
| Net benefits per ha | 18,476 | 19,431 | 22,373 | 12,670 |

*1USA Dollar =18 Ethiopian Birr during the study; 1Quital (Qtl)=100kg ; Field price of tef grain=1439birr/Qt1;Field price of 1kg tef straw=1birr; Field price of 1Qtl DAP=1587birr; 1Qtl of Urea=1250 birr

As indicated on the table 3, the net benefit from transplanting was 45% lower than the net benefit obtained from hand broadcasting. Similarly, the net benefit obtained from the row planting method was higher than the net benefit obtained through transplanting methods by more than 75%.

Table 5.Result of labor utilization across treatments of Quncho tef technology

| Treatment type | Labor required per plot in hour | Row making per ha | Fertilizer application per ha | Sowing or planting /transplanting per ha(MD) | Total labor per ha(MD) |
|---|---|---|---|---|---|
| Hand Broadcasting | 0.53 | 0.00 | 5.10 | 1.50 | 6.60 |
| ATA Machine broadcast | 0.58 | 0.00 | 6.10 | 1.19 | 7.29 |
| Row planting | 6.74 | 40.00 | 32.00 | 12.30 | 84.30 |
| Transplanting | 28.40 | 120.00 | 100.00 | 135.00 | 355.00 |

*MD=Man Days=8 hours

Human labor was the major source of input for production and management of tef starting from sowing to harvesting. The human labor utilization by the transplanting method was five times greater than the row planting method. As indicated in the table 5 it was apparent that changing from treatment 1 (hand broadcasting ) to treatment 2 (ATA Machine broadcasting) to treatment T3 ( row planting) would give positive MRRs of 740 % and 94% respectively. Hence row planting was certainly a worthwhile alternative to hand broadcasting . Nevertheless the marginal rate of return in shifting from ATA machine broadcasting to row planting gave a MRR less than 100%.

Table 6. Result of Marginal analysis Quncho tef treatments in Dhidhessa and Beddelle Districts

| Treatments | TVC | Marginal cost | Net benefits | Marginal benefit | Marginal rate of return |
|---|---|---|---|---|---|
| Hand Broadcasting | 367 | - | 21,313 | | |
| ATA Machine broadcast | 495 | 129 | 22,268 | 955 | 7.40 |
| Row planting | 3,630 | 3,134 | 25,209 | 2,942 | 0.94 |

The transplanting method was even not considered and eliminated for the marginal analysis since it was

 

not passed the test of dominance analysis. This was due to the fact that shifting from the row planting to transplanting does not result in proportional increase in the net benefit obtained from the practices. Unless the labor utilization for transplanting method is improved by more than 65% it is difficult to get the transplanting method in the option list for the farmers as indicated on the table 6 below.

Table 7.Dominance analysis after assumed 65% improvement in labor consumption during transplanting

| Treatments | TVC | Net benefit |
|---|---|---|
| Hand Broadcasting | 366.5 | 21,312.84 |
| ATA Machine broadcast | 495.5 | 22,267.57 |
| Row planting | 3,629.9 | 25,209.12 |
| Transplanting | 5,307.8 | 25,198.07 D |

D*=Dominated

**DISCUSSION**

Introduction of different sowing method considerably improved the productivity of Quncho tef. Statistical analysis of yield data showed the existence of significant difference at $p<0.05$ between hand broadcasting (14.8 Qt/ha) and row planting (20.1Qtl/ha). From the three sowing method evaluated, the transplanting gave the highest yield advantage over the row planting and hand broadcasting. As indicated in the result part, the mean grain yield obtained from transplanting method was 43% greater than hand broadcasting method. On the other hand as compared to hand broadcasting method the ATA(Agricultural transformation agency) machine broadcasting method slightly improved tef productivity. This was attributed to the fact that the machine broadcasting helped the farmers to maintain even distribution of tef seed during sowing. The grain yield obtained from row planting and transplanting were more close to each other as compared to the grain yield obtained from hand broadcasting methods. Though different planting technology improved tef productivity more than the local practice both the transplanting and row planting methods were perceived by the farmers as a labor intensive during implementation.

The farmers will switch from traditional broadcasting to row planting of tef only if the benefit of doing so outweighs the costs. According to Vandercasteelen, 2014, implementing row planting tends to have a positive yet moderate yield effect though it requires substantially more human labor. The net benefit analysis result indicated in the result part of table 3 emphasizes the fact that the net benefit obtained from row planting was the highest followed by ATA machine broadcasting. The grain yield obtained from the traditional hand broadcasting method was the least while the yield obtained from the transplanting was the highest. In contrast to the yield performance, the net benefit obtained from transplanting (12670 birr/ha) was found to be 45% less than the net benefit obtained from the hand broadcasting (18476 birr/ha). Similarly the net benefit obtained from the transplanting method was 76% and 53% less than the net benefit obtained from row planting and ATA machine broadcaster.

The method of transplanting was found to be economically inferior when the opportunity cost of labor involved was considered. In most cases as long as the alternatives existed the farmers tend to compare and contrast physical labor and other investment involved in adopting the new technology. Both transplanting and row planting technologies demand intensive human labour utilization as compared to the hand broadcasting. The main exclusive labor components in transplanting methods include raising the seedling on separate nursery bed, making the hole for each tef seedling at 20 cm distance between rows and 15cm between tef seedling. Moreover, it demanded application of Urea and DAP fertilizers under each transplanted seedlings which requires much more labor. All of the aforementioned procedures made the transplanting method the most labor intensive and expensive one as compared to the transplanting and row planting method. On the other hand, the row planting method involves row making, drilling the tef seed and fertilizer along the row with a distance of 15 to 20 cm between rows .

Though both methods transplanting and row planting method were new for the farmer`s in Illubabor zone of Ethiopia, the transplanting method was perceived as more difficulty technology option by farmers to be adopted due to its labor intensiveness'. This confirmed the finding of Vandercasteelen and etal, 2014,who have assessed the farmers perception in Oromia region. The aforementioned authors stated the fact that farmers plan to plant the largest part (80 %) of their tef lands using broadcasting and only 19 % of the tef area of these farmers will be allocated to row planting and 1 % to transplanting.

Particularly, the transplanting period overlaps with the high rainfall season in the Western part of Ethiopia which threatens the adoption of the transplanting method. Consequently it was exacerbated by muddy situation of the tef plot during the sowing resulted from frequent trampling by both oxen and human labor. The finding was in agreement with Vandercasteelen and etal, 2014, who had observed the reluctance of the farmers to implement row planting or transplanting method. He also assesses the farmers perception and find the fact that 25 % of the farmers perceived implementing the technology was too difficult after rainfall (Vandercasteelen and

 

etal, 2014). Similarly, the row planting method which ranks the second with regard to the agronomic yield gave the farmers better net benefit which was 21% and 15% more than ATA broadcasting machine and hand broadcasting method respectively as indicated in the table 3 of the result part.

To conduct the detail analysis on economically acceptable treatments, different tools were employed to exactly pinpoint the better performing treatments under farmers' conditions. In principle the MRR (Marginal rate of return) less than 100% were considered low and unacceptable to farmers. This was due the fact that in most cases a return with less than 100% would not offset the cost of capital (interest) and other related transaction costs while still giving an attractive profit margin to serve as an incentive (CIMMYT, 1988). As indicated in result part of table 5, the marginal rate of return indicates considerable proxy for the future incentives and means for replacing the old practice with the new practices. During the analysis the dominance analysis was conducted to separate the dominated and dominant treatment. As illustrated in table 6, the transplanting method was dominated given the lack of proportional increase in net benefit as compared to the costs that varies. Hence it becomes the only treatment which was excluded from the marginal analysis. The remaining treatments were compared against the benchmark of the manual hand broadcasting. Hence the marginal rate of return for the machine hand broadcasting was 740% while shifting from this treatment to the row planting resulted in MRR of 94%. The row planting showed moderate performance as compared to the transplanting method treatments though it was slightly less than 100% by itself.

The MRR for row planting was depressed to 94% mainly because of row making activity before drilling in order to keep the distance between rows equal throughout the tef plot. With regard to the row making farmers were seen frequently avoiding extra time investment for the row making when the large plot was considered . Similarly, when large plot areas were considered the farmers tend to overlook the row making before drilling as a separate activity due to its tediousness' and human labor shortage. Nevertheless, it needs curious and repeated economic and farmers perception evaluation over a period of time before scaling up the row planting method.

Moreover, the sensitivity analysis was applied to pinpoint treatments which are likely to remain stable and sustain acceptable returns for farmers despite price or cost fluctuations. Hence, transplanting technology demands reduction in labor by more than half as compared to the current labor utilization in order to remain in the option list for the smallholder farmers. This underlines the need to find more technological means to get use of the yield improvement potential or advantage of transplanting method by further working on improvement of its labor efficiency followed by row planting .

**Conclusion and Recommendation**

Quncho tef transplanting method gave highest grain yield than the hand broadcasting and row planting methods in all the study areas. The yield obtained from the row planting was 42 % higher than the hand broadcasting method. Similarly, the transplanting method improved tef yield by 44 % and 5% higher than the yield obtained through hand broadcasting and row planting methods respectively. The transplanting method gave more yield than the row planting method though the difference was statistically not significant. Labor intensiveness was clearly observed in transplanting and row planting methods as compared to the hand broadcasting methods. Transplanting of the tef seedling involved five times greater labor than row planting. The tef seedling reaches at the stage of the transplanting at the end of the August where the highest rainfall occurred in the Western part of Ethiopia which makes implementing the technology difficult for the farmers.

Moreover, the farmers would switch from hand broadcasting to row planting of tef only if the net benefit of doing so outweighs the costs. The transplanting method gave the highest tef grain yield though the net benefit obtained from transplanting (12,670 birr/ha) was found to be 45% less than the net benefit obtained from the hand broadcasting (18476 birr/ha). Similarly the net benefit obtained from the transplanting method was 76% and 53% less than the net benefit obtained from row planting and ATA machine broadcaster respectively. Hence the transplanting technology demanded further improvement to be in the option list of farmers. Moreover, the row planting method gave a net benefit of 21% and 15% more than ATA broadcasting machine and hand broadcasting method respectively. The MRR was found to be 94% for row planting and 740% for ATA manual broadcaster and row planting method respectively.

In general, given the entire above mentioned scenarios, increasing technological options in tef production and improving the existing row planting technology would substantially improve the income of tef producing smallholder farmers. Hence under the aforementioned conditions on tentative bases, the ATA broadcasting machine could be economically a better technological option for the farmers which can be refined through multi-location testing over a wider area.

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