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Participatory Seeding Rates Evaluation on Teff (Eragrostis teff (Zucc.) Trotter) Using Seed Spreader in Wolaita, South Ethiopia: Farmers Evaluation and Economic Analysis

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Abstract
Farmers' participatory evaluation of seeding rates on teff using seed spreaders in Wolaita Zone, South Ethiopia was conducted during the main rainy seasons of 2010 and 2011. Six treatments viz. 5, 10, 15, 20, 30 (recommended rate) and 35 kgha^{-1} (farmers practice) were used in the experiment. Treatments lower than recommended and farmers seeding rate were mixed with seed spreader (i.e. dry sand). The experiment was laid out in Randomized Complete Block Design with four replications. Teff variety (DZ-Cr-37) was used. Before commencing the experiment, awareness creation and on job trainings were given to Farmers Research Group (FRG) farmers. The farmers' evaluation result during 2010 and 2011 in the field, based on visual observation (i.e. lodging intensity, expected grain and straw yield) indicated that they preferred lower seeding rates such as 5kg/ha, 10kg/ha, 15kg/ha and 20kg/ha mixed with sand as 1st, 2nd, 3rd and 4th rank, respectively. In addition, the average economic analysis value during 2010-2011 using benefit: cost ratio, depicted an increasing trend up to 15kg/ha and then a decreasing trend in subsequent to 15kg/ha. Furthermore, the grain yield, farmers preference and economic analysis justified that the lower seeding rates particularly 15 kgha^{-1} mixed with sand could be economically and technically feasible for farmers since it save seeds (100 % over 30 kgha^{-1}), efficient utilization of improved seed; and to address seed demand of resource poor farmers. Hence, lower seed rates (10 and 15 kg ha^{-1} mixed with sand) are technically and economically feasible for farmers in the study area.
Key words: FRG, Seeding rate, Seed spreaders, Teff

1. Introduction

Teff (Eragrostis tef (Zucc.) Trotter) is the most important and traditional staple cereal crop in Ethiopia and is grown extensively under various climatic and soil conditions. It is a dominant cereal accounting about 32% of the total cereal production (MoARD, 2007) and provides over two-thirds of the human nutrition in Ethiopia (Lacey and Llewellyn, 2005; Stallknecht et al., 1993). Teff is major grain crop next to maize in Wolaita Zone, Southern Region of Ethiopia which occupies 23% of the land covered by grain crops (SNNPRS, 2007).

Mean while, seed is considered as a basic input for agricultural development due to the fact that it ensures grain production and adds new genetic resource to the total crop gene pool (Raj et al., 2007).The deficiency of good quality seeds available to farmers is one of the biggest issues in agricultural development in Ethiopia and it is believed this makes farmers difficult to obtain enough harvest from their farming. Hence wise utilization of seed through appropriate seeding rate is crucial.

In Ethiopia, the recommended seed rate for teff is 25 to 30 kg/ha (ESE, 2001), but farmers often use 40–50 kg/ha, because it is difficult to distribute the seed evenly, the viability of farmers' own seed is reduced (i.e. uncertainty of the germination percentage), and to suppress weeds at early stages (Tefera & Belay, 2006). Since few years, in countries abroad Ethiopia such as USA, South Africa and Australia, teff has been cultivated for grain and fodder purposes. They accomplish sowing using planters at optimum rate of 5 to 8 kg seed/ha (Stallknecht et al., 1993), which implies that an Ethiopian farmers (i.e. at 30kg/ha) are being utilizing extremely higher seed rate by 275% to 500% as compared (30Kg ha-1) with (8kg/ha) and (5kg/ha), respectively. The figure is becoming higher when compared with farmers using the above recommended rate.

The small seed size of teff is taken as agronomic limitation during teff production that poses a problem during sowing and after germination (Seyfu, 1997). At sowing, the very small seed size makes it difficult to control population density and its distribution. After germination, the uneven plant stand has an impact on growth, nutrient use efficiency of the crop and crop yield (Seyfu, 1997). Furthermore, the dense population in teff could have an effect on seed quality since it favors competition, lodging, disease and insect prevalence. Seed spreaders (seed mixers) are materials (sand, dry soil, sieved compost, etc) which are used to further improve the performance of tiny seeds during planting. Reports indicated the paramount importance of seed spreaders on small seeds (Rathore, 2001; Naturland 2002, Owuor et al., 2001). Accordingly, seed spreaders make seed bulk and aids to broadcast tiny seeds uniformly by hand, saves poor farmers from extra seed cost, contribute in seed saving and help to realize better growth yield. Furthermore, it is easily applicable for teff and other tiny seeded

crop and might also easily adoptable by farmers. Therefore research was initiated with the dual objectives. First one was to introduce a farmer participatory research method called "Farmer Research Group based Research" (hereinafter called as FRG approach) to find out the reason of shortage of seeds together with FRG farmers on their location. Second one was to share the outcomes of farmers' preference with the economic analysis. Furthermore, information on the issue on teff growing areas of Ethiopia, including the study area is very scanty.

2. Research Methodology

2.1. Description of the Study Area

This experiment was conducted in Wolaita Zone, Duguna Fango Woreda (Edo Kebele), South Ethiopia in the main rainy season of 2010-11. The research site is found in the altitude 1591 m.a.s.l, latitude $07^0$02'14.9" N and $038^0$00'44.5"E with the minimum and maximum average annual temperature is 16^0C and 26^0C, respectively; and the average annual rainfall of 950 mm. The site was selected for the experiment because teff is highly cultivated in the area and also due to the presence of established Farmers Research Group (FRG).

2.2. Treatments and Experimental Design

Six treatments viz, 5, 10, 15, 20, 30 (recommended rate), and 35 kgha-1 (average farmers practice) were used in the experiment. Among the treatments 5, 10, 15 and 20 kgha-1 were mixed with dry sand. Dry sand that passed 2mm diameter sieve was used for the experiment. Since farmers hand have accustomed with higher seeding rate (i.e. 35 kg/ha), its volume was 1st determined. Lower seeding rate treatments such as 5, 10, 15 and 20 kgha-1 were placed in labelled container with 35kg/ha. Then, the difference in space from the labelled volume by 35kg/ha and applied rates (i.e. 5, 10, 15 and 20 kgha-1) were filled with dry sand; and both were mixed before sowing. Finally, keeping the difference in the seed amount, each treatment was kept at constant volume in which farmers' hand has been familiar for broadcasting. The experiment was conducted in Randomized Complete Block Design (RCBD) with four replications. Treatments in the 1st replication were arranged in an easy to grasp way for the farmers i.e. according to the increasing order of the seeding rate amount. The remaining replications were assigned using randomization technique. Size of each plot was 9m2 (3m x 3m). The spacing between plots and blocks were 0.75m, respectively; and one meter free area was left around the experimental field.

2.3. Farmers Participation during Experiment

This approach emphasizes composition of multidisciplinary research team, researchers from the university, development agents (extension officers) and group of farmers organized for research and extension (FRG), who conduct research based on farmers' needs. The FRG members were 10 during 2010; and 16 during 2011. For FRG members, an awareness creation was given on the necessity of participatory evaluation, site selection, field and lay out preparation, sowing, fertilizer application, field management and participatory crop performance evaluation. In addition on job training on how seed is mixed with sand, purpose of mixing and crop management practices were given to participant farmers. This was done to ensure their full participation and to let them feel responsible on each and every step from the beginning to the end, except scientifically technical matters. Furthermore, when researchers did technical things, farmers were briefed the purpose of the activity (e.g. agronomic data measurements, soil sample collections, etc).

2.4. Crop Management

For the experiment early maturing teff variety (DZ-Cr-37) was selected since it is preferred by many farmers. Prior to sowing, the experimental land was well prepared; and sowing was done through hand broadcasting. Fertilizer in the form of urea at a rate of 50kg/ha and DAP at 125kg/ha were applied. DAP was applied at sowing time while urea was applied by split application (half at planting and the remaining half at mid tillering stage). Important agronomic practices were uniformly applied to all experimental plots as often as required. Disease and insect prevalence was checked regularly and there was no incidence of disease and insect pest in the experimental field.

2.5. Data Collected and Analysis

2.5.1. Farmers stand evaluation preferences

The data were collected before harvest (i.e. at crop physiological maturity stage). Farmers were grouped into four and each group was assigned to one replication. Farmers' used their own criteria viz. lodging intensity, expected grain and straw yield. Each group had a secretary and after a number of round way trips on assigned replication coupled with a hot discussion, they came up with common ranking preferences. Finally each group presented its preference to other participants. The preference of each group, total summary and average preference rank of FRG

farmers is indicated on table 1 and 2. To summarize all rankings, tally method was used in which the first, second, third, fourth, fifth and sixth ranking had weighted value of six, five, four, three, two and one points, respectively.

2.5.2. Partial economic analysis

The following methods were used for partial economical analysis

a. Total income (birr) = income from grain yield + straw
b. Total variable costs (birr) was taken from input costs (seed and fertilizers) keeping labor, land constant
c. Marginal cost (birr) was calculated by deducting the total variable cost of each seeding rate with respect to the cost of previous seeding rate
d. Net benefit (birr) = Gross Return - Total Variable Cost
e. Marginal net benefit (birr) was calculated by deducting the net benefit of each seeding rate with respect to the net benefit of previous seeding rate
f. Benefit: cost ratio = Net benefit of each seeding rate / Total variable cost of its seeding rate

3. Results and Discussions

3.1. Farmers Evaluation during Experiment

Farmers evaluation result revealed that farmers grouped for the evaluation during 2010 and 2011 were came up with different preferences. However, most of the participating farmers preferred lower seeding rates when mixed with sand than higher seeding rates (Table 1a and 1b). The farmers' evaluation in 2010 indicated that 5kg/ha, 10kg/ha, 15kg/ha and 20kg/ha mixed with sand were preferred as 1st, 2nd, 3rd and 4th rank, respectively (Table 1a). Similar trend of preference ranking were noticed during 2011 (Table 1b). Lodging intensity, expected grain and straw yield were the most frequently indicated justifications for selecting treatments in the field. This suggests that FRG approach has some positive effects on extension process due to farmers' better understanding of scientific data. Furthermore participation of farmers is helpful in order to bring more precise information during research output applicability to wider context. Similarly, variable selection and use of farmers' own criteria during participatory variety evaluation was reported by Nishikawa, 2011. In addition, the importance of farmers' participatory research at all stages was reported by (Abule Ebro et al., 2011 and Nishikawa, 2011).

3.2. Economic Analysis

The average grain yield of teff did not statistically influenced by seeding rate during 2010 and 2011(data was not presented). However, partial economic analysis (Table 2a and b) was carried out to evaluate the economic performance of different seeding rates. Economic analysis indicated that seeding rates showed differences the gross returns, net returns and benefit: cost ratio (Table 2a and b). During 2010, the highest gross returns (10,008 birr /ha), net returns (8313birr/ha) and benefit: cost ratio (5.25) was recorded from treatment receiving 30kg/ha, 30kg/ha and 10kg/ha mixed with sand, respectively (Table 2a). Total variable cost in treatment receiving 35kg/ha was higher (1766.5 birr/ha) followed by 30kg/ha (1694.5 birr/ha) compared to other treatment combinations. Least cost of cultivation (1334.5 birr /ha) was recorded from 5kg/ha plus sand with benefit: cost ratio of 4.52 (Table 2a). During 2011, the highest gross returns (11,160 birr /ha), net returns (9609.5 birr/ha) and benefit: cost ratio (6.35) was recorded from treatment receiving 20kg/ha sand, 20kg/ha and 15 kg/ha mixed with sand, respectively (Table 2b). Highest total variable cost was recorded in treatment receiving 35kg/ha (1766.5 birr/ha) followed by 30kg/ha (1694.5 birr/ha) compared to other treatment combinations. Least cost of cultivation (1334.5 birr /ha) was recorded from 5kg/ha plus sand with benefit: cost ratio of 6.05 (Table 2b). Furthermore, the average benefit: cost ratio for 2010 and 2011 showed an increasing trend up to 15kg/ha and then a decreasing trend in subsequent to 15kg/ha (Fig. 1). Partial economic analysis result during 2010 and 2011 in general revealed that 15 kg/ha mixed with sand were economically feasible for teff production in the study site.

4. Summary and Conclusion

It is true that few years ago, an increasing trend for the grain cost of teff was observed and particularly the average unit seed price was high for the improved seed. In the mean while, farmers in the study area are not readily accessible to the improved seed due to scarcity. Hence, it is worthwhile to use lower seeding rates by mixing with sand than higher seeding rates. This is evidenced by the fact that raising the seed rate did not bring corresponding significant increment in grain yield of teff. Farmers' evaluation and the economic analysis indicated the better performance of lower seeding rates mixed with sand. Among seeding rates, 15kg/ha mixed with sand seems technically and economically feasible in the study site since it save seeds by 100% over 30kgha^{-1}, adequate area coverage with relative uniform distribution, promotes efficient utilization of improved and quality seed; prevent

farmers from extra seed cost and also highly suitable for addressing resource poor farmers. Moreover, the absence of weed which is a common problem in other teff growing areas during lower seeding rates is not a concern for FRG members in the study area. This is because of the common practice of multiple and continuous cropping on the small land holding size. In general, FRG approach has some positive effects on extension process due to farmers' better understanding of scientific data and should be considered as important tool for the applicability of research outputs to wider context.

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Table 1a. Summary of farmers' preference during stand evaluation, 2010

Seeding rate	Farmers Preference					
	Group 1	Group 2	Group 3	Group 4	Total Point	Average ranking
5kg/ha + Sand	6	4	5	6	21	1st
10kg/ha + Sand	5	5	6	4	20	2nd
15kg/ha + Sand	3	6	3	5	17	3rd
20kg/ha + Sand	4	3	4	3	14	4th
30kg/ha	3	3	3	3	12	5th
35kg/ha	3	3	3	3	12	5th

Note: Nos. viz. 6,5,4,3,2&1 indicates 1st , 2nd , 3rd , 4th , 5th and 6th rank, respectively.

Table 1b. Summary of farmers' preference during stand evaluation, 2011

Seeding rate	Farmers Preference					
	Group 1	Group 2	Group 3	Group 4	Total Point	Ranking
5kg/ha + Sand	2	6	6	6	20	1st
10kg/ha + Sand	5	5	5	3	18	2nd
15kg/ha + Sand	6	3	4	4	17	3rd
20kg/ha + Sand	3	4	3	5	15	4th
30kg/ha	4	2	1	2	9	5th
35kg/ha	1	1	2	1	5	6th

Note: Nos. viz. 6, 5, 4, 3, 2&1 indicates 1st , 2nd , 3rd , 4th , 5th and 6th rank, respectively.

Table 2a. Partial Economic analysis in consideration of Grain and Straw yield, 2010.

Parameters	**5kg/ha**	**10kg/ha**	**15kg/ha**	**20kg/ha**	**30kg/ha**	**35Kg/ha**
Grain Yield (Kg/ha)	850	1020	1050	1050	1160	1140
Grain income (@ 8 birr/kg)	6800	8160	8400	8400	9280	9120
Straw Yield(t/ha)	2.86	3.16	3.24	3.34	3.64	3.69
Straw income (@200 birr/ton)	572	632	648	668	728	738
Total income (birr)	**7372**	**8792**	**9048**	**9068**	**10008**	**9858**
Costs						
• Seed @14.40 birr/kg)	72	144	216	288	432	504
• Urea @ 6 birr/kg) 50kg/ha	300	300	300	300	300	300
• DAP @ 7.70birr/kg) 125kg/ha	962.5	962.5	962.5	962.5	962.5	962.5
Total Variable Cost	**1334.5**	**1406.5**	**1478.5**	**1550.5**	**1694.5**	**1766.5**
Marginal Cost (Birr)		72	72	72	144	72
Net Benefit (Birr)	**6037.5**	**7385.5**	**7569.5**	**7517.5**	**8313.5**	**8091.5**
Benefit :Cost	4.52	5.25	5.12	4.85	4.91	4.58

Table 2b. Partial Economic analysis in consideration of Grain and Straw yield, 2011.

Parameters (2011)	**5kg/ha**	**10kg/ha**	**15kg/ha**	**20kg/ha**	**30kg/ha**	**35Kg/ha**
Grain Yield (Kg/ha)	880	900	1010	1040	920	990
Grain income (@ 10 birr/kg)	8800	9000	10100	10400	9200	9900
Straw Yield(t/ha)	2.43	2.6	3.05	3.04	3	3.23
Straw income (@250 birr/ton)	607.5	650	762.5	760	750	807.5
Total income (birr)	**9407.5**	**9650**	**10862.5**	**11160**	**9950**	**10707.5**
Costs						
• Seed @14.40 birr/kg)	72	144	216	288	432	504
• Urea @ 6 birr/kg) 50kg/ha	300	300	300	300	300	300
• DAP @ 7.70birr/kg) 125kg/ha	962.5	962.5	962.5	962.5	962.5	962.5
Total Variable Cost	**1334.5**	**1406.5**	**1478.5**	**1550.5**	**1694.5**	**1766.5**
Marginal Cost (Birr)		72	72	72	144	72
Net Benefit (Birr)	**8073**	**8243.5**	**9384**	**9609.5**	**8255.5**	**8941**
Benefit :Cost	6.05	5.86	6.35	6.20	4.87	5.06

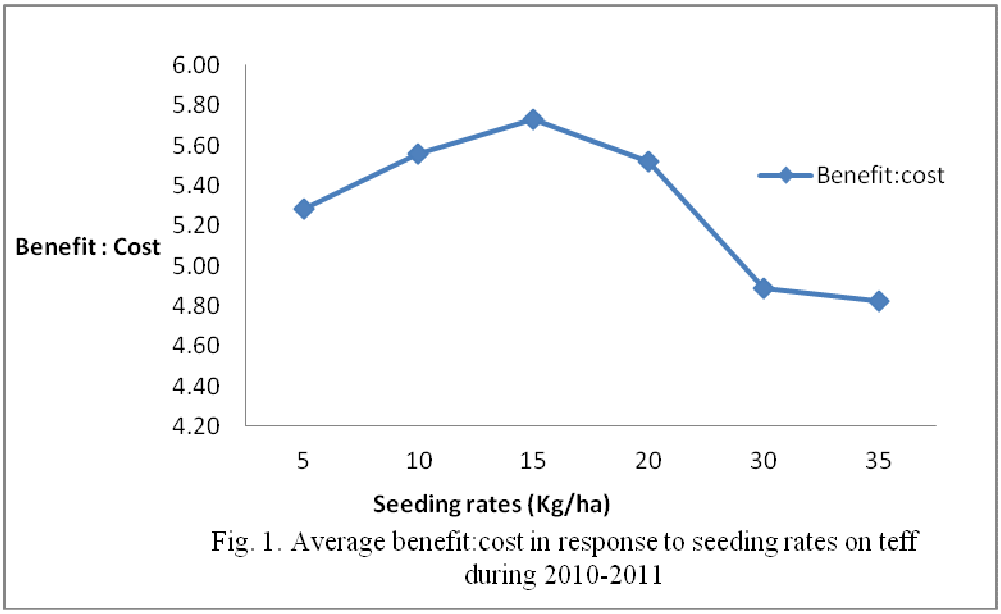

Fig. 1. Average benefit:cost in response to seeding rates on teff during 2010-2011