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Effects of Sowing Methods and Seed Rates on Yield Components and Yield of Tef in Soro Woreda, Hadya Zone, Southern Ethiopia

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Abstract
Tef [Eragrostis tef (Zucc.) Trotter] is among the major cereals of Ethiopia and occupies the largest cultivated land more than any other cereals. The need for its production as a staple food is increasing from year to year; however, its productivity is almost stagnant. Tef variety, Kuncho (Dz-Cr-387) was sown during the main cropping season of 2014/15 at First Oda Kebele, Soro District, Hadya Zone, Southern Ethiopia to study the effect of two types of sowing methods (broadcast and row) and three levels of seed rates (25, 20 and 10 kg/ha) and to investigate the interaction effect of sowing methods and seed rates on yield components and yield of tef. A factorial experiment was laid out in RCBD in three replications. All plant parameters were significantly affected by main effects of sowing methods and seed rates. Only two plant parameters (Days to 90 % PM and grain yield) were significantly affected by the interaction effect of sowing methods and seed rates. Sowing plants in rows increased plant height by 4.67cm over the broadcast sowing method. Similarly, there was significant increase in plant height by decreasing the seed rate from 25 kg/ha to 10 kg/ha. There was 2.55 cm increase of panicle length observed on plants sown in rows as compared to plants sown in broadcast. In the same way, there was significant increase of panicle length by decreasing the seed rate from 25 kg/ha to 10 kg/ha. The highest days to 90 % physiological maturity was recorded by combining row sowing method with 20 kg/ha seed rate. There was 7 days delay of days to 90 % physiological maturity due to this combination as compared to the control treatment. Lodging was more in broadcast sowing than in row sowing. There was 7.78 percent more lodging observed in the treatments under broadcast sowing method as compared to treatments under row sowing method. It was not statistically different by using 25 kg/ha and 20 kg/ha seed rates but it was lower and significant at 10 kg/ha seed rate as compared to the first two seed rates. There was 15.7 % increase of grain yield of tef by combining the row sowing method with 10 kg/ha seed rate as compared to the control treatment. There was more straw yield (327.8 kg/ha) obtained from treatments under row sowing method as compared to treatments under broadcast sowing method. Similarly, there was significant increase of straw yield by decreasing the seed rate from 25 kg/ha to 10 kg/ha. The higher biomass yield (6 %) was obtained from plants grown under row sowing as compared to plants grown under broadcast sowing. Correspondingly, there was biomass yield increment observed by decreasing the seed rate. In general, the combination of row sowing method with 10 kg/ha seed rate was the best treatment for high grain yield of tef at the study site. Yet, repeated experiment over different seasons and locations necessitates for conclusive recommendation.
Keywords: Row sowing, Kuncho tef

Introduction

Tef [*Eragrostis tef* (Zucc.) Trotter] is among the major cereals of Ethiopia. It occupies about 3.8million hectares of land which is more than any other major cereals such as maize, sorghum and wheat (CSA, 2013). It is an indigenous cereal crop to Ethiopia. Ethiopian farmers grow tef for a number of merits, which mainly attributed to the socio-economic, cultural and agronomic benefits (Seyfu, 1993). Tef has much or even more food value than the major grains such as wheat, barley and maize. Tef grain contains 14-15% proteins, 11-33 mg iron, 100-150 mg calcium, and rich with potassium and phosphorus nutrients (National Academy, 1996). Tef has got many prospects outside of Ethiopia due to its gluten freeness, tolerance to biotic and abiotic stress, animal feed and erosion control quality.

Tef is predominantly cultivated on sandy-loam to black clay soils. Its ability to tolerate drainage problems makes it a preferred cereal by farmers and becomes a highly valued crop primarily grown for its grain that is used for making *injera* (Abel, 2005). It is typically hand-broadcasted on the field and, in most cases, seeds are left uncovered. Tef can produce a crop in a relative short growing season and will produce both grain for human food and fodder for cattle (Seyfu, 1997).

Tef is relatively free of plant diseases when compared to other cereal crops. In Ethiopia, in locations where humidity is high, rusts and head smuts are important diseases. About 22 fungi and 3 pathogenic nematodes have been identified on tef (Bekele, 1985). Regardless of its high area coverage, adaptation to different environmental conditions and requirement as a staple food in Ethiopia, the yield of tef grain is not increasing above the national average yield of 1.2 t/ha (CSA, 2013) which is very low as compared to other major cereals.

Therefore, the objectives of this study were to study the effect of broadcast and row sowing, and to investigate the interaction effects between seed sowing methods and seed rates on the yield and yield

components of tef.

Methodology

Description of the study area

Soro District is one of 10 Districts in Hadiya Zone. It is 32km far away from Hosanna city. It has an area of 706 sq. km. The District has mean annual temperature of 17.6 - 27.5 ºC , mean annual rainfall of 1001-1200 mm and an elevation of 501- 2500 m.a.s.l. It has the following soil physico-chemical properties; organic carbon= 2.42%, soil pH=5.5, available phosphorus=2.5ppm, soil texture =sandy clay loam and cation exchange capacity (CEC) =27.6meq/100g soil. Cereals crops such as barley, wheat, maize and sorghum are commonly produced in the area.

Treatments and Experimental Materials

The following six treatments were used for this experiment:
1/ Broadcast sowing at seed rate of 25 kg/ha (control) = T_1
2/ Broadcast sowing at seed rate of 20 kg/ha = T_2
3/ Broadcast sowing at seed rate of 10 kg/ha = T_3
4/ Row sowing at a seed rate of 25 kg/ha = T_4
5/ Row sowing at a seed rate of 20 kg/ha = T_5
6/ Row sowing at a seed rate of 10 kg/ha = T_6
NB: For all cases 100 kg DAP and Urea were applied and 20 cm spacing between rows was used for row sowing method.

The tef variety kunco (Dz-CR-387) was used for this study which grows to the height of 72-104 cm and has got very white seed color. It was released by Debre Zeit Research Center in 2006 and matures within 86-151 days.

The treatments were arranged in 2*3 factor factorial by using Randomized Complete Block Design (RCBD) in three blocks. Each plot had an area of 8 m by 5m with 0.5m spacing between plots and 1m between blocks. The treatments were assigned to plots by lottery method. The net plot size will be 7 m by 4 m (28 m^2).

Field Management

Land preparation was done according to farmers practice in the area (oxen-plough) and leveling was carried out by human power to ensure better seedbed for small seeds of tef. Total DAP was applied before two days of sowing and Urea fertilizer was applied 20 days after sowing. Applying the fertilizer in split was done to reduce leaching loss of nutrients and to synchronize the supply with the crop demand. Weeding was done similar to farmers practice.

Data Collection

Phenological Data Collection

Days to 90% physiological maturity was taken as the number of days elapsed from sowing to the date when 90% of the crop stand stems, leaves and floral bracts in a plot changed to light yellow color.

Lodging percentage was measured as the degree of lodging of plants usually assessed at the time of harvest based on the scale of 1-5 where 1 stands for 0-10% plants lodged, 2 for 10-25% plants lodged, 3 for 25-50% plants lodged, 4 for 50-75% plants lodged and 5 for 75-100% plants lodged .

Growth and Morphological Data

Panicle length, plant height, grain yield, straw yield and shoot biomass were collected to determine the yield and yield components of the crop. **Panicle length** was measured by a ruler as the length of the panicle in centimeter from the node where the first panicle branch starts to the tip of the panicle as the average of 10 randomly selected plants at physiological maturity. **Plant height** was measured by a ruler as the height of plant in centimeter from the base of the main stem to the tip of the panicle and recorded as the average of 10 randomly selected plants.

The following parameters were determined at and after harvesting of the crop. **Grain yield** was recorded as the weight of the air-dried seeds harvested from 28m^2 of each plot. **Straw yield** was determined by subtracting grain yield from above ground dry biomass yield. **Shoot biomass** was taken as the weight of the straw and the grain from 28m^2 of each net plot at harvest in kg.

Soil Data Collection

A composite soil sample of 0.5 kg from the depth of 0-30 cm was taken before planting. The zigzag field technique was followed and the soil sample was air-dried before laboratory analysis. The air-dried soil sample was sieved through 2 mm mesh and the relevant soil physico- chemical parameters for this study were analyzed at Wolayita Sodo soil laboratory.

Soil organic matter, soil pH, total nitrogen, available phosphorus, soil texture and cation exchange capacity (CEC) were the important parameters analyzed for this study only. Soil organic matter was determined by following Walkley and Black method (1934). Soil pH was determined in 1:2.5 soil: water ratio using a glass electrode attached to a digital pH meter. Total N was determined by Kjeldahl method (Frietal and Dewis, 1970).

Available P was determined by Olsen and Bray II method (1954).

Statistical Data Analysis

The plant data collected were subjected to Analysis of Variance (ANOVA) by using SAS 9.0 Software and mean separation was carried out using least significant difference (LSD) test.

Result and Discussion

Crop Growth Parameters

Plant Height

Plant height was significantly affected by the main effects of sowing methods (P<.0001) and seed rates (P < 0.01) (Appendix Table 1). It was found to be more due to row sowing over broadcast sowing method (Table 1). Similarly, there was increase in plant height from highest to the lowest seed rate (Table 1). The increase in plant height due to row sowing and decreasing seed rate from 25 kg/ha to 10 kg/ha might be due less intra-specific competition of plants for light and other growth resources such as nutrients and soil moisture. Similar to this finding, Refissa (2012) reported increased plant height due to row sowing method and lower seed rate.

Table 1: Mean plant height of tef as affected by sowing methods and seed rates at Soro District, 2015

Sowing method	**PH(cm)**
Broadcast sowing	94.44[b]
Row sowing	99.11[a]
LSD(0.05)	1.36
Seed rates	
25 kg/ha	94.83[c]
20 kg/ha	96.83[b]
10 kg/ha	98.66[a]
LSD (0.05)	1.67
CV (%)	11.34

PH = plant height

Panicle Length

Panicle length was significantly affected by sowing methods (P < 0.001) and seed rates (P = 0.001) but it was not significantly affected by their interaction (Table 6). It was higher in row sowing than in broadcast sowing. Similarly, Shiferaw (2012) reported increment of panicle length by row sowing method as compared to broadcast sowing method. There was also significant increment in panicle length by decreasing the seed rate from 25 kg/ha to 10 kg/ha. In the same way, Mitiku (2008) found higher panicle length of tef by decreasing the seed rate from 25 to 20 kg/ha. The increment of panicle length in the case of row sowing as well as decreasing seed rate might be resulted due to more space provided for the crop to utilize more growth resources by decreasing competition among plants.

Table 2: Mean panicle length of tef as affected by sowing method and seed rate at Soro District, 2015

Sowing method	**PL(cm)**
Broadcast sowing	39.33[b]
Row sowing	41.88[a]
LSD(0.05)	0.65
Seed Rates	
25 kg/ha	39.33[c]
20 kg/ha	40.60[b]
10 kg/ha	41.83[a]
LSD (0.05)	0.80
CV (%)	15.3

PL= Panicle length

Days to Physiological Maturity

Days to physiological maturity was significantly (P < 0.001) affected by sowing method and seed rate (P < 0.0001), and by their interaction (P < 0.001) (Appendix Table 1). Row sowing at 20 kg/ha seed rate delayed the crop significantly longer time to physiological maturity over other treatments. Unlikely, plants under 25 kg/ha seed rate for both sowing methods took shorter time to reach at their physiological maturity as compared to others (Table 4). Similar finding was reported by Refissa (2012) in which treatments under lower seed rate sown in rows took longer time to reach at their physiological maturity. This might be due to less intra-specific competition of plants resulted from reduced seed rate and better management of plants in the rows that contributed to fair utilization of growth resources in the soil.

Table 3: Mean days to physiological maturity of tef as affected by sowing methods and seed rates at First Oda in 2015

Sowing Method (SM)		
Seed rate (SR)	**Broadcast sowing**	**Row Sowing**
25 kg/ha	96.00[d]	95.00[d]
20 kg/ha	98.00[c]	103.00[a]
10 kg/ha	99.00[b]	101.66[ab]
LSD (0.05)		1.02
CV (%)		8.71

BS= Broadcast sowing, RS= Row sowing. Means followed by the same letter are not significantly different at 5% probability level.

Lodging percent

Lodging percentage was significantly ($P < 0.01$) affected by sowing method and seed rates but not affected by their interaction (Appendix Table 1). The lower result was obtained from treatments sown in rows as compared to broadcast sowing method (Table 3). In the same way, the lowest value was obtained under 10 kg/ha seed rate and statistically non-significant differences were found by using 25 kg/ha and 20 kg/ha seed (Table 3). Similar to this result, Refissa (2012) reported decreasing of lodging in tef crop by decreasing the seed rate and sowing in rows. The higher result of lodging percentage in the case of broadcast sowing method as well as at 25 kg/ha seed rate in this research might be due higher intra-specific competition among plants that led them to bear weak stems prone to strong wind and rainfall. Lodging of a crop usually occurs due to strong wind, high rainfall and management problems causing in the displacement of the crop from its normal position.

Table 4: Mean lodging percent of tef as affected by sowing methods and seed rates at First Oda in 2015

Sowing method (SM)	**LP**
Broadcast sowing	56.11[a]
Row sowing	48.33[b]
LSD(0.05)	3.67
Seed rate(SR)	
25 kg/ha	56.66[a]
20 kg/ha	54.16[a]
10 kg/ha	45.83[b]
LSD(0.05)	4.49
CV (%)	6.69

LP= Lodging percent; Means followed by the same letter are not significantly different.

Yield and Yield Components

Grain yield

Grain yield was significantly affected ($P < 0.001$) by sowing methods, seed rates and by their interaction (Appendix Table 1). The highest grain yield was obtained by combining row sowing method with 10 kg/ha seed rate which is 15.71 % greater as compared to the control treatment (Table 8). Similar result was reported by Shiferaw (2012) in which the combination of row sowing method and lower seed rate gave the highest grain yield of tef. This might be due to the combined effects of row sowing method that facilitated better field management and lower seed rate that contributed to lesser plant population by minimizing intra-specific competition for growth resources among plants.

Table 5: Mean grain yield (kg/ha) of tef as affected by sowing method and seed rate at First Oda in 2015

Seed rate(SR)	**Sowing Method (SM)**	
	Broadcast Sowing	Row Sowing
25/kg/ha	1813.00[e]	1906.33[c]
20 kg/ha	1824.00[e]	2007.00[b]
10 kg/ha	1848.33[d]	2098.00[a]
LSD (0.05)		23.33
CV (%)		8.7

Straw Yield

Straw yield was significantly ($P < 0.05$) affected by the main effect of sowing method and seed rate ($P < .0001$) but their interaction was not significant (Appendix Table 1). Mitiku (2008) also reported significant effect of seed and N rates but their interaction was not significant. More straw yield was obtained from treatments sown in rows than treatments sown in broadcast in which better field management of crops might have favored the stem to accumulate more dry matter.

Table 6: Mean straw yield of tef as affected by sowing methods and seed rates at First Oda in 2015.

Sowing Method (SM)	SY (kg/ha)
Broadcast sowing	6543.30[b]
Row sowing	6871.10[a]
LSD (0.05)	235.83
Seed rate (SR)	
25 kg/ha	5861.00[c]
20 kg/ha	6703.30[b]
10 kg/ha	7557.30[a]
LSD (0.05)	288.83
CV (%)	13.34

Biomass Yield

Biomass yield was significantly ($P < 0.01$) affected by the main effects of sowing method and seed rate ($P < 0.0001$) but not significantly affected by their interaction (Appendix Table 1). The higher biomass yield was obtained from row sowing as compared to broadcast sowing (Table 9). In addition, there was significant increase of above ground biomass yield by decreasing the seed rate from 25 kg/ha to 10 kg/ha. Contradictory to this result, Mitiku (2008) found total above ground biomass increment with an increase in seed rate of tef. The increase in biomass due to row sowing method and decreased seed rate in this research might be contributed from increased grain yield and the straw of the crop for aforementioned factors.

Table 7: Mean above ground biomass yield (kg/ha) as affected by sowing methods and seed rates of tef grown at First Oda, 2015

Sowing Method (SM)	BY
Broadcast sowing	8371.80[b]
Row sowing	8874.90[a]
LSD (0.05)	235.04
Seed rate (SR)	
25 kg/ha	7720.70[c]
20 kg/ha	8618.80[b]
10 kg/ha	9530.50[a]
LSD (0.05)	287.87
CV (%)	5.9

Conclusion

A field experiment was conducted at Soro District, Hadiya Zone, Southern Ethiopia, during the 2014/15 cropping season with the objectives of studying the effect of broadcast and row sowing and investigating their interaction effect on the yield and yield components of tef at farmers' training center (FTC). A factorial experiment with two methods of sowing and three levels of seed rates was laid out in RCBD in three replications. All important soil and plant parameters were collected during the study. The tef variety, Kuncho (DZ-CR-387 RIL 355) was used for this experiment. DAP and Urea fertilizers were used as the source of nutrients. DAP was applied during sowing but the urea fertilizer was applied 20 days after sowing.

All plant parameters except straw yield were strongly affected by sowing methods and seed rates. Only two plant parameters; days to 90 % physiological maturity and grain yield were significantly affected by the interaction of sowing methods and seed rates at the study area.

In general, the combination of row sowing method with 10 kg/ha seed rate was the best treatment for high grain yield of tef at the study site. Yet, repeated experiment over different seasons and locations necessitates for conclusive recommendation.

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