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Evaluation of Seed Rates and Sowing Methods on Growth, Yield, and Yield Attributes of Tef [*Eragrostis Tef* (Zucc.) Trotter] in Ada District, East Shewa, Ethiopia

Abraham Reda (M.Sc) (Author)
Major Advisor: Nigussie Dechassa (PhD) (co-author)
Co-Advisor: Kebebew Assefa (PhD) (co-author)

ABSTRACT
Tef is a major staple cereal crop in Ethiopia. However, its productivity is limited, amongst others, by the use of improper sowing methods and inappropriate seed rates. A field experiment was conducted at Debre Zeit Agricultural Research Centre, East Shewa Zone during the 2012 main cropping season under rain-fed condition, to assess the effect of seed rates and sowing methods on growth, yield, and yield attributes of tef. Factorial combinations of two sowing methods (row and broadcast) and six seeding rates (2.5, 5, 10, 15, 20, and 25 kg ha^{-1}) were laid out in a randomized complete block design (RCBD) with three replications. Seed rate significantly affected days to panicle emergence, days to physiological maturity, main panicle weight, main panicle seed weight, and thousand seed weight. Accordingly, the maximum values of these parameters were obtained at the seed rate of 2.5 kg ha^{-1}. Moreover, significant main effects of both seed rate and sowing method were observed on the number of total tillers, productive tillers, plant height and grain yield. Row planting method and seed rate of 2.5 kg ha^{-1} had produced the maximum number of total and productive tillers with concurrent decrease in plant height and grain yield as compared to the other treatments. Higher grain yield of 2702 kg ha^{-1} was obtained at seeding rate of 25 kg ha^{-1} followed by 15 and 20 kg ha^{-1} which had produced grain yield of 2453 and 2371 kg ha^{-1}, respectively. There were significant interaction effects of sowing methods and seed rates on shoot biomass yield, straw yield, lodging percentage, culm length and harvest index. The highest seed rate of (25 kg ha^{-1}) with both sowing methods produced higher shoot biomass yield, straw yield, and lodging percentage. However, combining the highest seeding rate with the broadcasting method resulted in lower harvest index. Lodging index was consistently increased with increasing seed rate under row planting. Hence, considering the growth and yield obtained from the current study by using 25 kg ha^{-1} seed rate together with row planting can be suggested for higher tef production in the study area.
Key words: Tef, row sowing, broadcasting, seed rate, yield, and yield attributes

1. INTRODUCTION

Tef [*Eragrostis tef* (Zucc.) Trotter] is an indigenous C_4, self-pollinated, chasmogamous annual warm season grass that is used throughout Ethiopia as grain crop for human consumption and as forage for livestock (Tareke and Nigusse, 2008). Tef is an endemic cereal crop of Ethiopia and its major diversity is found only in Ethiopia. According to Vavilov (1951), Ethiopia is the geographical centre of origin and diversity. According to CSA (2012), tef is one of the most important cereals being grown in Ethiopia and accounts for about 22.6% of the total area and 16% of the gross grain production of the major cereals cultivated in Ethiopia. The area devoted to tef cultivation is on increase owing to the versatile merits of tef to Ethiopian farmers. Firstly, both the grain and straw fetch relatively higher prices in the market in comparison to other major cereal crops (Delelegn and Fassil, 2011). Secondly, tef is an excellently adapted crop to diverse environments in the country (Dejene and Lemlem, 2010).

The national average yield is 1.28 t ha^{-1} for tef which is 57% below the national average maize yield and 37% below the national average wheat yields (CSA, 2012). This low yield and productivity is mainly due to the traditional farming system which is not supported by improved technologies such as proper sowing method and optimum seed rate (Tareke, 2010). There has been an interest in defining the relationships between seed rate and sowing method on crop yield in order to establish optimum populations to reach the attainable yields. As a result, the effects of seed rate and sowing method on tef plant characters and crop productivity has received greater attention in this study.

Aiming at increasing the growers' productivity through strategic manipulations of sowing method and seed rate in Ada District of East Shewa is of paramount importance. Therefore, the study was initiated with the following specific objectives:

- To assess the effect of seed rates and sowing methods on growth, yield, and yield attributes of tef
- To determine the optimum sowing method and seed rate for tef production on black clay soils (Vertisols) of Debre Zeit area

Table 9. Mean Days to seedling emergence, panicle emergence, and physiological maturity of tef as affected by sowing method and variable seed rates

Treatment	Days to		
	Emergence	Panicle emergence	Maturity
Seed rates (kg ha^{-1}) (Means over both sowing methods)			
2.5	4.67	43.50a	109.30a
5	4.50	43.00ab	108.00ab
10	4.67	42.67abc	104.20bc
15	4.33	42.00bcd	101.80cd
20	4.17	41.67cd	98.20d
25	4.33	41.00d	98.20d
Mean	4.44	42.31	103.28
LSD (0.05)	NS	1.19	4.48
Sowing methods (Means over all seed rates)			
Row sowing	4.28	42.50	104.44
Broadcasting	4.61	42.11	102.11
LSD (0.05)	NS	NS	NS
CV (%)	11.50	2.30	3.60

2. MATERIALS AND METHODS

The field experiment was carried out on a vertisol at Debre Ziet Agricultural Research Centre (DZARC) in Ada district of East Shewa, Ethiopia under rain-fed condition during the 2012 main cropping season from June to November. Tef variety Quncho (DZ-Cr-387 RIL355), which was developed and released by Debre zeit Agricultural Research Centre in 2006 (MoARD, 2008) was used as a test crop. The treatments consisted of factorial combinations of two sowing methods (broadcasting and row sowing) and six seed rates (2.5, 5, 10, 15, 20 and 25 kg ha^{-1}). The 12 factorial treatment combinations were laid out in RCBD) and replicated 3 times. The gross plot size was 2 m x 2 m (4 m^2) and the distance between plots and replications were 1 m and 1.5 m, respectively. For row sowing, the distance between rows was 20 cm, and the seed rate for each plot was divided into equal proportions of 10 rows per plot based on weight and broadcast on the surfaces of each row. Fine seedbed suited for tef cultivation was prepared before planting. Sowing of the seed was done on 30 July 2012. Fertilizers were applied at the rate of 60/60 kg ha^{-1} N/P_2O_5 in the form of Urea and DAP, respectively.

2.1. Data collection and measurement

Days to seedling emergence, Days to panicle emergence, Days to maturity, Plant height, Culm length, Panicle length, Main panicle weight, Number of total tillers and productive tillers, Main panicle seed weight, 1000-seeds mass, Grain yield, Total biomass, Straw yield, Harvest index and Logging index

2.4. Data Analysis

All the data were subjected to analysis of variance (ANOVA) using SAS, version 9.1.3, general linear model (GLM) procedures (SAS Institute, 2002). Means were separated using the least significant difference test (LSD) at $p < 0.05$ significant level.

3. RESULTS AND DISCUSSION

3.1. Effect of Sowing Methods and Seed Rates on Tef Crop Phenology

The main as well as the interaction effects of sowing method and seed rate did not influence the number of days required for seedling emergence.

3.1.1. Days to panicle emergence

The analysis of variance indicated that the number of days taken from seedling emergence to panicle emergence was significantly ($P \leq 0.05$) affected by seeding rate. In contrast, neither the main effects of sowing method nor the interaction effects of sowing method and seed rate had significant influence on days to panicle emergence. Generally, the number of days required for panicle emergence increased with decrease in the seed rate. Thus, the number of days required for panicle emergence was increased by 6% in response to decreasing the seeding rate from 25 kg ha^{-1} to 2.5 kg ha^{-1} (Table 1). Compared to the higher seeding rates (15, 20, and 25 kg ha^{-1}), the crop

took significantly higher number of days for panicle emergence when it was planted at seeding rate of 2.5 kg ha^{-1}, which was in statistical parity with the number of days required for panicle emergence by plants sown at the low seeding rates of 5 and 10 kg ha^{-1}.
Means followed by the same letter within a column within the same treatment category are not significantly different at 5% level of significance; CV = Coefficient of variation; LSD = Least significant difference

3.1.2. Days to Maturity

Days to physiological maturity were significantly (P≤ 0.01) affected by main effect of seed rates. However, this parameter was affected neither by the main effect of sowing methods nor the interaction effect of sowing methods and seed rates. Similar to its effect on days to panicle emergence, decreasing the seeding rate significantly prolonged days to maturity of the crop. Thus, plants grown at the seeding rate of 2.5 kg ha^{-1} matured significantly later than plants grown at the other seeding rates except at the seeding rate of 5 kg ha^{-1}, which statistically matured at the same time (Table 1). Thus, the maturity time of plants grown at the seeding rate of 2.5 kg ha^{-1} was prolonged by about 11% compared to maturity time of plants grown at the seeding rate of 25 kg ha^{-1}. However, the maturity time required by plants grown at the seeding rate of 10 kg ha^{-1} was in the intermediate range (Table 1).

3.2. Effects of Sowing Method and Seed Rate on Plant Height, Its Components, and Tillering

3.2.1. Plant Height

The analysis of variance revealed significant difference (P≤ 0.05) on main effects of sowing methods and highly significant (P≤ 0.01) on main effects of seed rates on plant height. However, the interaction effect of sowing methods and seed rates did not influence this parameter. The shortest plants were obtained from the seeding rate of 2.5 kg ha^{-1} whereas the tallest plants were obtained from the seeding rate of 25 kg ha^{-1}. Thus, on average, tef plants raised from the seeding rate of 25 kg ha^{-1} were taller than those raised at the seeding rate of 2.5 kg ha^{-1} by about 14%. On the other hand, plants grown using row sowing method showed significantly greater plant height than plants grown using the broadcasting method (Table 2).

Table 10. Main plant height, panicle length, number of total and fertile tillers of tef as affected by sowing method and seed rates

Treatment	Plant height (cm)	Panicle length (cm)	No. of total tillers plant^{-1}	No. of fertile tillers plant^{-1}
Seed rate (kg ha^{-1}) (Means over both sowing methods)				
2.5	113.20c	50.23	26.33a	23.83a
5	124.90ab	51.17	15.00b	12.83b
10	124.20b	51.00	12.00c	10.33c
15	126.20ab	51.98	9.83cd	8.17cd
20	126.90ab	52.68	8.00d	6.67d
25	128.55a	52.72	7.50d	5.83d
Mean	123.99	51.63	13.11	11.28
LSD (0.05)	3.95	NS	2.65	2.42
Sowing Methods (Means over all seed rates)				
Row sowing	125.44a	52.11	14.61a	12.83a
Broadcasting	122.55b	51.15	11.61b	9.72b
LSD (0.05)	2.28	Ns	1.53	1.40
CV (%)	2.70	5.40	16.90	17.90

Means followed by the same letter with in a column within the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference

3.2.2. Panicle Length
Panicle length measured at physiological maturity did not show significant difference due to the main effects of sowing methods, seeding rates, and their interaction.

3.2.2. Number of Total and Productive Tillers

The analyses of variance showed significant (P≤0.01) main effects of both sowing methods and seeding rates on the number of both total and productive tillers per plant at dough stage. However, there interaction effects did not significantly shows. The result of this study indicated significantly higher mean numbers of both total and fertile tillers were obtained at the seed rate of 2.5 kg ha^{-1} as compared to other seed rates (Table 2). Similarly, the number of total tillers increased by 100% in response to increasing seed rate from 5 kg ha^{-1} to 25 kg ha^{-1}. The row sowing method had significantly more numerous total tillers than plants under broadcasting. The total number of tillers-of row-sown tef plants exceeded the total tiller number of broadcast tef plants by 26%. Similarly, row-sown tef plants produced 32% higher number of productive tillers per plant than broadcast tef plants (Table 2).

4.2.3. Culm Length

Culm length was affected significantly (P ≤ 0.05) by the main effects of both sowing method and the interaction effects of sowing methods and seed rates. This parameter was also highly significantly (P ≤ 0.01) influenced by the main effects of seed rates. The maximum culm length was recorded with row-sowing at the seed rate of 20 kg ha^{-1} as compared to the interaction effect of the rest of treatments. On the other hand, the shortest culm length was recorded with row-sowing at the seeding rate of 2.5 kg ha^{-1} as well as broadcasting at the same seeding rate (Table 3). The culm length recorded from plants established with row-sowing at 20 kg seed rate exceeded the culm length raised at the seeding rate of 2.5 kg ha^{-1} using row-sowing method by about 28%. The culm length of plants established by row-sowing exceeded the culm length of plants established by broadcasting by 2.70% (Table 3).

Table 11. Interaction effects of sowing method and seed rate on culm length of tef

Treatment		Culm length (cm(
Sowing method	Seed rate (kg ha^{-1})	
Row	2.5	62.32e
	5	74.48bc
	10	74.46bc
	15	73.86bc
	20	79.86a
	25	75.02bc
Broadcast	2.5	63.63e
	5	73.01bc
	10	72.00cd
	15	74.62bc
	20	68.57d
	25	76.58 ab
	Means	72.37
	LSD (0.05)	4.23
Sowing Methods (Means over all seed rates)		
Row		73.33a
Broadcast		71.40b
LSD (0.05)		1.73
CV (%)		3.5

Means followed by the same letter within a column within the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference

3.3. Yield Parameters

3.3.1. Main Panicle Weight and Main Panicle Seed Weight

The statistical analysis revealed that both the main panicle weight and seed weight were significantly (P ≤ 0.01) affected by the main effect of seed rates but neither by the main effects of sowing method nor by the interaction effects. Decreasing the seeding rate significantly increased both the main panicle weight and seed weight. The maximum of both main panicle weights and panicle seed weights were recorded at the lowest seed rate of 2.5 kg ha^{-1}; this was closely followed by the main panicle weight obtained from the seeding rate of 5 kg ha^{-1}. The minimum panicle weights were recorded at the seed rates of 25, 20, and 15 kg ha^{-1} where as the lowest main panicle seed weights were recorded for plants established at the seed rates of 25 and 20 kg ha^{-1}. The main panicle weight of tef plants established at the seeding rate of 2.5 kg ha^{-1} exceeded that established at the seeding rate of 25 kg ha^{-1} by about 56% (Table 4).

Table 12. Main panicle weight, main panicle seed weight, grain yield and thousand seed weight of tef as affected by sowing methods and seed rates

treatment	Main panicle weight (g)	Main panicle seed weight (g)	1000-seed weight (g)	Grain Yield (kg ha^{-1})
Seed rate (kg ha^{-1}) (Means over both sowing methods)				
2.5	3.13a	1.81a	0.42a	1547d
5	2.57b	1.37b	0.39ab	1679cd
10	2.16c	1.22bc	0.36bc	1783c
15	2.08cd	1.09cd	0.36bc	2453b
20	1.73d	0.86e	0.35c	2371b
25	2.01cd	0.99de	0.34c	2702a
Mean	2.28	1.23	0.37	2089.14
LSD (0.05)	0.36	0.19	0.04	212.3
Sowing Methods (Means over all seed rates)				
Row	2.32	1.26	0.373	2167a
Broadcast	2.24	1.19	0.368	2011b
LSD (0.05)	ns	ns	ns	122.6
CV (%)	13.1	12.9	8.6	8.5

Means followed by the same letter within a column in the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference

4.3.3. Thousand Seed Weight

The analysis of variance of the data showed significant ($p \leq 0.05$) variation in 1000-seed weight for the main effect of seed rates but not for the main effect of sowing methods and the interaction effects. Similar to the main panicle seed weight, decreasing the seed rate significantly increased 1000-seed weight of tef. Thus, the heaviest 1000-seed weight was obtained at the seed rate of 2.5 kg ha^{-1}, closely followed by the 1000 seed weights obtained at the seed rate of 5 kg ha^{-1}. The lightest 1000-seed weights were obtained in response to establishing at the highest seed rates of 25 and 20 kg ha^{-1}. The 1000-seed weight obtained at the seed rates of 10 and 15 kg ha^{-1} lay in the intermediate range. The 1000-seeed weight obtained in response to establishing the crop at the seed rate of 2.5 exceeded that obtained at the seed rate of 25 kg ha^{-1} by 24% (Table 4).

3.3.4. Grain Yield

The ANOVA of the grain yield data revealed significant ($P \leq 0.05$) on main effect of sowing methods and highly significant ($P \leq 0.01$) on main effect of seed rates. However, the two factors did not interact to influence this parameter. In contrast to the above yield components, decreasing the seed rate generally led to decreased grain yields. Therefore, the highest grain yield was obtained in response to establishing at the highest seed rate of 25 kg ha^{-1}. This was closely followed by the grain yield obtained at the seed rates of 20 and 15 kg ha^{-1}. On the other hand, the lowest grain yields were recorded for tef plants established at the lowest seed rates of 2.5 and 5.0 kg ha^{-1}. The grain yields obtained from plants raised at the seed rate of 10 kg ha^{-1} was in the intermediate range (Table 4). Row sowing led to significantly higher yields than broadcasting. Thus, tef plants established through row-sowing produced grain yields that exceeded the grain yield of plants established with broadcasting method by 8% (Table 4).

3.3.5. Shoot Biomass

The analysis of variance showed that total shoot biomass of tef was affected highly significantly ($P \leq 0.01$) by the main effects of seed rates and significantly ($P \leq 0.05$) by the interaction effect ($P \leq 0.05$) of sowing methods and seed rates. However, the main effects of sowing method did not affect this parameter. Increasing the seed rate significantly increased shoot biomass yield. Plots sown by broadcast sowing at the seed rates of 15 and 25 kg ha^{-}

^{1}, and row sown at seed rate of 25 kg ha^{-1} resulted in significantly higher above ground shoot biomass yield than the other treatments except with row sowing of 20 kg ha^{-1}, which showed comparable (Table 5). The minimum above ground shoot biomass yield was found with broadcast sowing at 2.5 kg ha^{-1}. On the other hand, row sowing at 15 kg ha^{-1} and broadcasting at 20 kg ha^{-1} showed the second highest shoot biomass yield than 2.5, 5 and 10 kg ha^{-1} by both sowing methods but there was no significant variation among them (Table 5). This might be due to the fact that biomass yield was directly related to plant height, panicle length, grain yield and tiller numbers which were directly influenced by seed rate, sowing method and their interaction as revealed in the result.

4.3.6. Straw Yield

Straw yield was highly significant affected ($P \leq 0.01$) by the main effects of seed rate and by the interaction effect of seed rate and sowing methods ($P \leq 0.05$) while the main effects of sowing methods were not significant on this parameter. The highest but statistically comparable straw yield were obtained from broadcast sowing of 15 and 25 kg ha^{-1} and row sowing at the seed rates of 20 and 25 kg ha^{-1} than the rest of the treatments but the lowest straw yield was recorded under broadcast planting method of 2.5 kg ha^{-1}. Plots treated with broadcast sowing of 20 kg ha^{-1} resulted in the second highest shoot biomass yield compared to 2.5, 5 and 10 kg ha^{-1} for both sowing methods except row sowing of 15 kg ha^{-1} which showed statistically equivalent mean straw yield (Table 5). This might be due to the fact that biomass yield was directly related to plant height, panicle length, grain yield and tiller numbers which were directly influenced by seed rate, sowing method and their interaction as revealed in the result.

Table 13. Interaction effects of sowing method and seed rate on shoot biomass, straw yield, lodging percentage, and harvest index of tef grown

Treatment		Shoot biomass (kg ha^{-1})	Straw Yield (kg ha^{-1})	Harvest Index (%)	Lodging (%)
Sowing method	Seed rate (kg ha^{-1})				
Row	2.5	6563de	4913ef	25.21abc	40.98e
	5	7389cd	5658de	23.47de	42.70de
	10	8056c	6134cd	23.89cde	45.19cd
	15	9528b	7095bc	25.48ab	48.26c
	20	10750ab	8323a	22.54ef	55.79b
	25	11633a	8794a	24.44bcd	61.64a
Broadcast	2.5	5667e	4222f	25.55ab	42.90de
	5	6250de	4623ef	26.01a	44.04de
	10	6694de	5049ef	24.57abcd	48.07c
	15	11472a	9000a	21.55f	52.93b
	20	9570b	7255b	24.17bcd	61.64a
	25	11083a	8519a	23.27de	59.79a
	Means	8721	6632	24.18	50.33
	LSD (0.05)	1311.7	1049.8	1.48	3.44
Sowing Methods (Means over all seed rates)					
Row		8986.4	6820	24.17b	49.0944b
Broadcast		8456.1	6445	24.19a	51.5611a
LSD (0.05)		Ns	ns	0.61	1.40
CV (%)		8.9	9.35	3.6	4.0

Means in the same column within the same treatment category followed by different letters are significantly different as judged by LSD at $P \leq 0.05$. NS= non-significant

3.3.7. Harvest Index

The ANOVA of harvest index revealed highly significant ($P \leq 0.01$) effect due to the interaction effect of seed rate and sowing methods and significantly ($P \leq 0.05$) effect due to the main effect of seed rates. However, the main effect of sowing method was not significant on this parameter. The maximum harvest index was found with broadcast sowing of 5 kg ha^{-1} as compared to the interaction effect of the rest of treatments, with an exception to this was row sowing of 2.5 and 15 kg ha^{-1}, and broadcast sowing at the seed rate of 2.5 and 10 kg ha^{-1} which showed statistically comparable mean harvest index while minimum harvest index was found with broadcast sowing of 15 kg ha^{-1} (Table 5).

4.4. Lodging Index

Analysis of variance (Table 5) was performed using the transformed data. Lodging index was affected highly significantly ($P \leq 0.01$) by the main effects of both seed rates and sowing methods, and significantly ($P \leq 0.05$) by the interaction effects of sowing methods and seed rates.

The higher Lodging index was found under the maximum seed rate and both sowing methods. Accordingly the maximum lodging index, although not sever, was recorded with row sowing under the larger seed rate of 25 kg ha^{-1}, and broadcast sowing at the seed rate of 20 and 25 kg ha^{-1} compared to possible combination of treatments but it showed lower with row sowing at lowest seed rate of 2.5 kg ha^{-1} (Table 5). Crops grown with broadcast sowing under the seed rate of 15 kg ha^{-1} gave similar lodging index with crops grown under 20 kg ha^{-1} with row planting method (Table 5). The higher lodging at higher seed rates under both planting methods might be due to the fact that the highest seed rate at both broadcast and row sowing method enhanced fast vegetative growth and succulent stem elongation of tef.

4. SUMMARY AND CONCLUSION

Tef is the most important staple food crop in Ethiopia. Tef has existed in Ethiopia since the record history of the country, and hence Ethiopia is the centre of origin and diversity of tef. The principal limitation of tef cultivation in the country is its low productivity and the national average grain yield is estimated 1.28 t ha^{-1}. One of the reasons for this low yield among other reasons is lack of appropriate sowing methods and utilization of improper seed rate. Hence, a field experiment was conducted during the main cropping season (June-November) of 2012 on Vertisols on-station at DZARC with the objective of to assess the effect of seed rate and sowing methods on growth, yield and yield attributes of tef.

Tef variety Quncho (DZ-Cr-387) was planted using combinations of two levels of sowing methods (broadcast and row planting) and six levels of seeding rates (2.5, 5. 10. 15, 20 and 25 kg ha^{-1}). The experiment was laid out in RCBD design with factorial arrangements using three replications. All necessary agronomic and cultural practices were exercised during the growth period and necessary observations were recorded at various stages of crop growth and analyzed by SAS, soft ware program. The results are summarized as under.

Seeding rate significantly influenced days to panicle emergence and physiological maturity. At seeding rates of 25 kg ha^{-1}, tef crop showed earlier panicle emergence than the rest of the treatments with exception of 20 and 15 kg ha^{-1} which were statistically comparable. On the other hand, days to physiological maturity was significantly earlier at the highest seeding rate of 25 and 20 kg ha^{-1} than the rest of the treatments except the seeding rates of 15 kg ha^{-1}. Days to seedling emergence did not reveal statistical significant variation due to both seed rates and sowing method.

Significant differences were observed due to both seed rates and sowing method in the number of total and productive tillers, and plant height. But the interaction of seed rates and sowing methods was not significant on these traits. Seed rate of 2.5 kg ha^{-1} had produced significantly greater number of total and productive tillers, but it showed lower plant height than the rest of the treatments. The crop planted in rows manifested substantial number of tillers and higher plant height as compared to broadcast sowing method. But statistically significant variation was not observed between sowing methods and among seed rates with regard to influencing of panicle length across the treatments.

On the other hand, seeding rate had highly significant effects on main panicle weight, main panicle seed weight and significant effects on thousand seed weight. In this result, the trend of main panicle weight, main panicle seed weight and thousand seed weight were decreased proportionally with seed rate. Likewise, statistically highly significant effects were also noted in grain yield due to both seed rates and sowing methods. There was also yield increment slightly with seed rate under the row planting method.

The interaction effect of sowing methods and seed rates were significant on above-ground shoot biomass, straw yield, lodging percentage, culm length, and harvest index. Significantly higher values were found for shoot biomass, culm length, straw yield, and lodging index at higher seed rates under both sowing methods but increased seed rates showed low harvest index.

In general, significant differences in grain yield and in most yields related parameters of tef were observed due to sowing methods and seeding rates; especially in case of 25 kg ha^{-1} which gave high and comparable yield at high seeding rate of 15 and 20 kg ha^{-1}. On the other hand, row sowing method had significant effects on growth parameters, yield and yield components of tef crop in terms of plant height, total tiller, fertile tiller and grain yield. Hence, it is difficult to make any definite conclusion based on the experiment of only one season and one location. However, as a tentative conclusion, seed rate at 25 kg ha^{-1} using row planting method can be suggested for the production of high grain and straw yield of tef on vertisols of Ada plains in Debre Zeit area.

Overall, the present experiment has to be repeated over years and locations with similar agro-ecologies and soil types in order to reach at more conclusive recommendations for use by the tef growing farmers.