Performance Evaluation and Selection of Improved *Tef* (*Eragrostis tef* L) varieties at Main Campus Site Hadiya Zone, Southern Ethiopia.

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ABSTRACT

Tef [*Eragrostis tef* (Zucc.) Trotter] is a cereal crop resilient to adverse climatic and soil conditions, and possessing desirable storage properties. It is, a tetraploid with 40 chromosomes ($2n = 4x = 40$), belongs to the family Poaceae and, together with finger millet (*Eleusine coracana* Gareth.), to the subfamily Chloridoideae. It was originated and domesticated in Ethiopia. The experiment was conducted to identify, select and recommend adaptable, high yielding, Insect pest and disease resistant twelve released and one local variety at Main Campus Site Hadiya zone of SNNPR. Twelve tef varieties were evaluated in RCBD with three replications on station of Main Campus Site during main cropping season of 2019/2020. Analysis of variance revealed that there were significant differences among tef varieties, Culm length, panicle length, plant height, days to heading, days to maturity, grain filling period, primary panicle brunch, grain yield, biomass yield and harvest index at Main Campus site. Based on the obtained result, the improved tef varieties namely; DZ-Cr-438 DZ-Cr-974 (Dukem), DZ-01-899 (Gimbechu) and DZ-01-196 (Magna) at Main Campus site. Therefore, these varieties showed better performance for most of the studied characters including grain yield. Therefore, these varieties were selected and recommended for the study area and similar ecologies of Hadiya Zone. This finding, being the result of one year with single location, it is recommended that the experiment should be repeated at multi locations for several years to confirm the obtained results.

Key words: *Adaptability. Grain. Yield. Tef. Varieties*

INTRODUCTION

Tef [*Eragrostis tef* (Zucc) Trotter] is an allotetraploid with 40 chromosomes ($2n = 4x = 40$), belongs to the family Poaceae, subfamily Eragrostoideae, tribe Eragrosteae and genus *Eragrostis*. It is an ancient and the most important cereal crop in Ethiopia and the country is considered to be both the center of origin and center of diversity for this cereal (Vavilov, 1951). There are about 350 *Eragrostis* species of which E.tef is the only species cultivated for human consumption. At the present time, the gene bank in Ethiopia holds over five thousand tef accessions collected from geographical regions diverse in terms of climate and elevation. Tef is adaptable to a wide range of ecological conditions in altitudes ranging from near sea level to 3000 masl and even it can be grown in an environment unfavorable for most cereal, while the best performance occurs between 1100 and 2950 masl in Ethiopia (Hailu and Seyfu, 2000). It is the major food crop in Ethiopia where it is annually cultivated on more than three million hectares of land by 6.3 million small-scale farmers on more than 30 % of the total area allocated to cereal crops (CSA, 2014). The importance of tef in Ethiopia is mainly due to its preference by both farmers and consumers. Farmers, above all, grow tef due to its tolerance to several biotic and a biotic stress especially to the poorly drained Vertisols, a dominant soil type in the central highlands where other cereals can hardly survive without the use of proper drainage system. Over 50 million people in Ethiopia

consume tef as staple food due to the better quality bread called “injera” made from it compared to that from other cereals. The absence of gluten in its grain (Assefa, 2014) makes tef a healthy food such that people allergic to gluten can safely consume tef products. Compared to the straw from other cereals, the straw from tef is more nutritious and palatable for livestock feed (Kebebew et al., 2015). The nutritional value of Tef grain is similar to the traditional cereals. Tef is considered to have an excellent amino acid composition, lysine levels higher than wheat or barley, and slightly less than rice or oats. Tef is also higher in several minerals, particularly iron. Tef grain is also a rich source of protein and nutrients and has additional health benefits including that the seeds are free from gluten. According to a recent study, the bio-available iron content was significantly higher in tef bread than in wheat bread. In general, tef provides quality food and grows under marginal conditions, many of which are poorly suited to other cereals. However, tef is considered to be an orphan crop since it is only of regional importance and has until recently not been the focus of crop improvement (Assefa, 2014).

The yields of Tef are low in Ethiopia as well as in southern region due to different production problems including: lack of improved varieties, non-adoption of improved technologies, disease and pests are some of the most serious production constraints in Tef production in Ethiopia. Some varieties of Tef were released by the different regional and federal research centers in Ethiopia; however, most of them were not evaluated around areas of southern Ethiopia and farmers were not participated in varietal improvement and testing process. Participation of farmers’ in varietal choice has considerable value in technology evaluation and dissemination. Participatory varietal evaluation and selection is being conducted in some crops like common bean and barley (Fufa et al., 2010). According to Courtois et al. (2001) evaluated the effect of participation of farmers by comparing only the rankings of varieties by farmers and researchers at the same locations and reported a strong concordance between farmers and breeders in environments that have been producing contrasting plant phenotypic performance in rice. Two way feedbacks between farmers and researchers is indeed vital component of highly client-oriented breeding programs in locally important and traditionally cultivated crop (Getachew et al., 2008). Daniel et al. (2007) stated that farmers’ selection criteria vary with environmental conditions, traits of interest, ease of cultural practice, processing, use and marketability of the product, ceremonial and religious values. Therefore, this study was mainly conducted with the objectives to evaluate and select improved tef varieties which are adaptable, high yielding and to assess farmers’ criteria for variety selection with the participation of farmers in southern Ethiopia

MATERIALS AND METHODS

Description of the Study Area

The varieties were tested at Main Campus Agricultural Research Site (MCARS) during 2019/2020 cropping season. Main Campus Agricultural Research Site is located (7.30-7.35N, 37.48-37.52 E. It has an altitude of 2000-2500 m.a.s.l. with annual average rainfall of 850mm. The annual average temperature of the study area is 16.65°C with maximum and minimum temperature of 22.8°C and 10.5°C respectively. With the soil type classified as Nitosol soil with a pH of 5.2.

Experimental Materials

The experimental material of the study comprised of 12 tef varieties kindly provided from the Debre Zeit Agricultural Research Center and was cultivated at Main Campus Agricultural Research Site (MCARS) during 2019/2020 cropping season.

Table 1. List of tef (*Eragrostis tef*) varieties used for experiments

No	Code	Locale name	Released By	Year of release
1	DZ-01-196	Magna	DZARC	1970
2	DZ-01-899	Gimbechu	DZARC	2007
3	DZ-01-1285	Koye	DZARC	2002
4	DZ-Cr-354	Enatit	DZARC	1970
5	DZ-Cr-974	Dukem	DZARC	1995
6	DZ-01-2675	Degatef	DZARC	2005
7	DZ-Cr-438	Kora	DZARC	2014
8	Ho-Cr-136	Amarach	DZARC	2006
9	DZ-Cr-387	Quncho	DZARC	2006
10	DZ-Cr-409	Boset	DZARC	2012
11	DZ-01-255	Gibie	DZARC	1993
12	DZ-CR-358	Ziquala	DZARC	1995
13	Local check			

Experimental Design and Trial Management

Twelve (12) improved varieties of tef were tested for their adaptability, evaluation and selection with full participation of farmers in the study areas. The trial was carried out in Randomized Complete Block Design (RCBD) in three replications. The varieties were grown under uniform rain fed conditions. The plot size was 3 m length and 3 m width (9 m²) with 0.2 m of row spacing. The spaces between plots and replications were 1 m and 1.5 m, respectively. Sowing was done by manual drilling along the rows at seed rate of 5 kg/ha. Sowing was done within the last week of July to 1st week of August 2019. The sources of P₂O₅ and nitrogen fertilizer were NPS and UREA respectively. Both applied at the rate of 100 kg ha⁻¹. All of the NPS was applied at planting and UREA was applied in two splits, half at the time of planting and the remaining half at tillering stage. All other pre and post-planting management practices were done in accordance with the research recommendations for tef production in the area. Twice hand weeding and plowing and other management practices were done as required. All other recommended agronomic practices were kept normal and uniform to ensure normal plant growth and development. Seed yield of each plot was recorded and then converted into kg/ha.

Agronomic data collected

Data were collected either on plant or plot bases on yield and yield related traits.

On plot basis:

Days to 50% heading (DH): The numbers of days from sowing to when 50% of the plants were started heading. It was counted as the number of days from sowing to 50 % heading stage i.e., 50% of the heads fully emerged from the flag leaf sheath.

Days to emergency: Number of days taken from date of sowing to 50% of plants to emerge

Days to 75% maturity (DM): The numbers of days from date of sowing to a stage at which 75% of the plants were reached physiological maturity or 75% of the panicles on the plots turned golden yellow color.

Grain yield per plot (GYP): The grain yield per plot was measured in grams using sensitive balance after moisture of the seed is adjusted to 12.5%. Total dry weight of grains harvested

from the middle four rows out of six rows were taken as grain yield per plot and expressed as grams per plot.

Shoot Biomass yield per plot (BMYP): It was recorded by weighing the total above ground yield harvested from the four central rows of each experimental plot at the time of harvest when moisture content adjusted to 8%.

Harvest index (%): It was estimated by dividing grain yield per plot to biological yield per plot. It is ratio of grain yield to the above ground biomass yield.

$$HI \% = \frac{\text{Grain yield per plot} \times 100}{\text{Biomass yield per plot}}$$

On plant basis:

Plant height (cm): The distance between the ground level to the tip of the terminal spikelet in cm of the mother ten plants.

Culm length (cm): The heights of the ten plants selected at random were measured at harvesting time in centimeter. The height was taken as the distance between the soil surfaces to the beginning of panicle.

Number of primary branches per plant (PPB): Counting the total number of primary branches on main stem of each selected plant at the time of harvest

Panicle length (cm): Panicle lengths as the average length from the base of the panicle to the tip of ten pre-tagged plants were recorded in centimeter from central rows of each plot.

Days to grain fill period: Number of days from 50% heading of the plants to maturity

Statistical analysis and variance components

The data was subjected to analysis of variance using SAS software v 9.1.3 (SAS, 2004). The Significant difference among genotypes was tested by 'F' test at 1% and 5% levels of Probability. The structure of analysis of variance (ANOVA) table is presented below.

Table 2. The structure of analysis of variance (ANOVA) (Gomez and Gomez, 1998)

Source	Df	(SS)	(MS)	F
Block	r-1	SSB	SSB/(r-1)	MSR/MSE
Treatment	t-1	SST	SST/(t-1)	MST/MSE
Error	(r-1)(t-1)	TSS	SSE(r-1)(t-1)	
		SST-SSB		
Total	tr-1	TSS		

Where: *r* = Number of replications; *t* = Number of treatments / genotypes; *SS* = Sum of Square; *MS* = Mean of square; *S.E.m* = $\pm E.M.SS/r$

$$\text{Coefficient of variation (CV \%)} = \sqrt{\frac{\text{ErrorMs}}{\text{Grand mean}}} \times 100$$

RESULTS AND DISCUSSION

Analysis of Variance

The analysis of variance showed that there were highly significant ($p \leq 0.01$) difference among varieties for days to heading, plant height, grain yield, biomass yield and harvest index while significant ($P \leq 0.05$) difference in panicle length, primary panicle brunch, Culm length, days to maturity, *days to emergency* and grain filling period at Shone site. Generally, the analysis of variance revealed that the presence of considerable variations among the 12-tef varieties for all the traits. This indicating the presence of variability, which can be exploited through selection for further breeding programs. These results were supported by Chondie, Bekele (2017) who reported considerable variation in the days to maturity, plant height and panicle length, days to heading and grain yield of different tef varieties when planted over years. Similarly, AliyiKedir *et al.* (2016) reported that highly significance differences between varieties for the characters like days to maturity, panicle length, plant height, days to heading, days to maturity and grain yield.

Table3. Analysis of variance for different characters of tef varieties studied at Main campus site.

Sources of variation	df	DH	DM	DE	PL	PH	CL	PBP	GFP	GY	BM	HI
MSR	2	0.83	10.16	2.00	5.61	28.15	20.02	13.46	11.11	0.013	0.889	40.57
MST	16	12.31**	23.52*	3.27*	18.2*	33.1**	57.3*	45.5*	27.8*	0.08**	2.45**	130. **
MSE	32	3.28	9.64	1.10	10.01	20.16	12.16	7.04	8.23	0.015	0.5	24.41
F-value		2.06	2.44	3.00	1.22	2.6	4.18	4.69	2.12	5.67	4.87	5.33
CV (%)		1.78	2.74	18.30	8.44	4.09	5.14	12.1	8.37	23.26	23.73	25.73

* = Significant at 5% level of probability, ** = highly Significant at 1% level of probability, ns= Not significant, CL=Culm length, PL=panicle length, PH=plant height, DE days to emergency, DH=days to heading, DM days to maturity, GFP=grain filling period, PPB=primary panicle brunch, GY=grain yield, BMY=biomass yield, HI=harvest index, MSR=mean square of replication, MST= mean square of treatment, CV= coefficient of variation and .

At Main Campus site, the analysis of variance indicated that there were highly significant ($P < 0.01$) difference among varieties in plant height, days to emergency, grain yield, biomass and harvest index while significant difference ($P < 0.05$) in Culm length, panicle length, days to heading, days to maturity and primary panicle brunch. Generally, the analysis of variance results revealed that the presence of adequate variations among the tef *varieties* for most of the traits suggesting that the higher opportunity of selecting *varieties* for trait of interest. The result of analysis of variance allows carrying out further genetic analyses for all traits. Similarly, Asaye 2017 reported that days to heading, days to maturity, grain yield per plot and shoot biomass. Grain filling period is only character that show non significance. Likewise, Hailu *et al.* (2003a) reported significant differences in days to heading, days to maturity, plant height, panicle length, panicle weight, yield per panicle, lodging index, shoot biomass and grain yield.

Range and Mean Values

The mean performances of the Twelve Tef varieties and one Local checks for 11 characters are presented in Table 5. The mean values for days to 75% maturity ranged from 117.5 (DZ-Cr-354) to 108.2.75 (DZ-01-1285), Plant height was varies from 94.0 (DZ-Cr-438) to 81.2 (DZ-Cr-354), The mean values for days to 50% heading ranged from 74.5 (DZ-Cr-387) to 67.0 (Ho-Cr-136), Culm length was ranged from 67.1 (DZ-Cr-974) to 49.7 (DZ-Cr-354), palm length was ranged from 36.4 (DZ-Cr-438) to 24.7 (DZ-Cr-974), Number of primary branches per plant was ranged from 25.2 (DZ-Cr-974) to 14.7 (DZ-01-2675), Grain filling is an important trait that ultimately affects the overall grain yield by increasing grain weight. Therefore, it was ranged from 45.2 (DZ-Cr-354) to 35.2 (DZ-01-1285), Days to emergency was ranged from 7.0 (DZ-Cr-387) to 3.56 (Ho-Cr-136). Grain yield was ranged from 1955 (DZ-Cr-974) to 490 (DZ-01-1285), biomass yield per plot and harvest index was ranged from 5.1 (DZ-Cr-974) to 2 (DZ-01-2675), 33.2 (Ho-Cr-136) and 6.4 (DZ-01-1285) respectively. From the result it was observed that those characters with the higher range of values were also had higher mean values and vice versa. Such considerable range of variations provided a good opportunity for yield improvement. Thus, high variability for 11 traits in twelve and one local check studies implied that there was reasonably sufficient variability. This provides ample scope for selecting superior and desired Tef varieties by the plant breeders for further improvement. Generally, the range of variation was wide for all the characters studied at Main Campus site. Abebe (2013) also reported wide range of variation among Tef genotypes. But this result is in contrast to Fentie *et al.*, (2012) finding.

The mean performances of the Twelve Tef varieties and one Local checks for 11 characters are presented in Table 6. The mean values for Grain yield was ranged from 1723 (DZ-Cr-438) to 950 (DZ-Cr-354), days to 75% maturity ranged from 105 (Local check) to 98.2 (DZ-01-1285), Plant height was varies from 103.2 (DZ-Cr-438) to 78.2 (DZ-01-196), The mean values for days to 50% heading ranged from 72.3 (Local check) to 62.4 (DZ-Cr-409), Culm length was ranged from 67.6 (DZ-Cr-438) to 45.5 (DZ-01-196), Grain filling is an important trait that ultimately affects the overall grain yield by increasing grain weight. Therefore, it was ranged from 36.5 (DZ-Cr-354) to 25.5 (DZ-Cr-438), palm length was ranged from 37.2 (DZ-CR-358) to 25.9 (DZ-Cr-974), Number of primary branches per plant was ranged from 26.8 (DZ-CR-358) to 16.0 (DZ-01-899), Days to emergency was ranged from 8.0 (DZ-Cr-387) to 3.5 (DZ-01-196). Biomass yield per plot and harvest index was ranged from 3.8 (DZ-Cr-438) to 1.73 (DZ-Cr-387), 26.4 (DZ-Cr-387) and 15.3 (DZ-Cr-409) respectively. From the result it was observed that those characters with the higher range of values were also had higher mean values and vice versa. Such considerable range of variations provided a good opportunity for yield improvement. Thus, high variability for 11 traits in twelve and one local check studies implied that there was reasonably sufficient variability. This provides ample scope for selecting superior and desired Tef varieties by the plant breeders for further improvement. Generally, the range of variation was wide for all the characters studied at Main Campus site. Similar results were previously reported by Abebe, 2013.

Table 6. Mean and Range values for different agronomic traits for 12 Tef varieties at Main Campus site main cropping season 2019/2020.

Mean		DH	DM	DE	PL	PH	CL	PBP	GFP	GYkgh	BM	HI
		67.72	102.64	5.2	30.7	88.1	56.3	21.18	31.82	1279	2.76	19.23
Range	Max	72.2	105	8	37.2	103.2	67.6	26.8	36.5	1723	3.8	26.4
	Min	62.4	98.2	3.5	25.9	78.2	45.5	15.8	25.5	950	1.73	15.3
Local check		72.2a	105.0a	4.5b	31.4bcde	81def	52.4def	16.4bcd	31.5abc	1220cd	2.2cd	22.1ab
DZ-01-196		66.4bc	102.4abc	3.5e	31.5abcd	78.2f	45.5f	21.1abc	34ab	1630ab	3.3ab	19.7bc
DZ-01-899		67.5cb	101.2cd	4.5cd	27.5de	82.1def	53.4def	16.0cd	31.5abc	1650a	3.2ab	20.3bc
DZ-01-1285		67.2bc	98.2d	4.6b	31.8bcde	89.4bcd	58.6bcd	18.2bcd	28bc	1120cd	2.9bc	15.4c
DZ-Cr-354		66.3bcd	104ab	5.0b	28.8cde	78.8ef	49ef	16.8d	36.5a	950d	1.94d	19.5bc
DZ-Cr-974		68.6abc	102.2bcd	4.2de	25.9e	81.6def	54.8cde	26.0a	30.6abc	1330bc	3.4ab	15.5c
DZ-01-2675		68.3ab	102.3abc	6.2a	31.8bcd	88.8cde	54.8cde	18.2bcd	34ab	1150cd	2.08d	22.1ab
DZ-Cr-438		72.3ab	98cd	4.3bc	34.4ab	103.2a	67.6a	21.8abc	25.5c	1723a	3.8a	18.2bc
Ho-Cr-136		64.6cd	96.6d	4.52cd	34.8ab	91.8bc	56.1bcd	18.8bcd	31abc	1180cd	2.9b	16.03bc
DZ-Cr-387		72ab	102abc	8.0a	31.6bcd	95.8abc	64.2ab	16.2d	32abc	1050cd	1.73d	26.4a
DZ-Cr-409		62.4d	101.2cd	3.6e	36.1a	96.2ab	62.1bc	22.6abc	37.6a	1220cd	3.1ab	15.3d
DZ-01-255		69bc	103abc	4.6cd	33abcd	91.8bc	58.8bcd	21.8ab	35ab	1110cd	2.2cd	19.7bc
DZ-CR-358		72abc	116.3a	3.5d	37.2a	103.9ab	66.2bc	26.8a	44.3b	1112cd	4.3a	15.4bc
CV (%)		2.22	2.36	20.14	10.38	6.22	5	12.82	10.86	23.13	3.24	24.07
LSD		3.64	5.45	1.4	4.65	9.8	5.35	4.66	8.45	0.17	1.23	6.89

CL=Culm length, PL=panicle length, PH=plant height, DH=days to heading, DM =days to maturity, GFP=grain filling period, PPB=primary panicle brunch, GY=grain yield, BMY= biomass yield, HI=harvest index. Mean within a column followed by the same letter(s) within a column are not significantly different from each other at 5%.by DMRT

CONCLUSION AND RECOMMENDATION

The objective of present investigation was to evaluate and select improved tef varieties which are adaptable, high yielding and to assess farmers' criteria for variety selection with the participation of farmers. Analysis of variance means performance of quantitative traits in this study showed that there were significant differences among tef varieties for Grain yield, days to maturity, plant height, days to heading, Culm length, Grain filling period, palm length, Number of primary branches per plant, Days to emergency, biomass yield and harvest index at Main Campus site. High grain yield of tested varieties at Main Campus site recorded by variety DZ-Cr-438- (1723kg/h) followed by DZ-Cr-354 (950 kg/h). On the other hand, lowest grain yield was recorded by DZ-Cr-354 (950 kg/h). Grain yield was an important character to be considered for variety selection to address the objective of the present activity. For this reason, three improved varieties i.e. DZ-Cr-438 DZ-Cr-974 (Dukem), DZ-01-899 (Gimbechu) and DZ-01-196 (Magna) at Main Campus site. Therefore, these varieties were selected and recommended for the study area and similar ecologies of Hadiya Zone and being the result of one year with single location; it is recommended that the experiment should be repeated at multi locations for several years to confirm the obtained results.

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