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Adaptability Study and Performance Evaluation of Tef (*Eragrostis tef L.)* Varieties at Shone, Southern Ethiopia

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ABSTRACT

Tef is highly nutritious and is an important part of Ethiopia's cultural heritage and national identity. It is an excellent source of essential amino acids especially lysine, the amino acid that is most often deficient in grain foods. The experiment was conducted to identify, select and recommend adaptable, high yielding, Insect pest and disease resistant variety. Twelve tef varieties were evaluated in RCBD with three replications on station of shone 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 shone site. Based on the obtained result, the improved tef varieties namely; DZ-Cr-974 (Dukem), Ho-Cr-136 (Amarach), DZ-01-255 (Gibie) DZ-CR-358(Ziquala) and DZ-Cr-438 (Kora) performing well in study area. 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 Southern Ethiopia. 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.

Keywords: *Adaptability, Varieties, improved*

INTRODUCTION

Tef (Eragrostis tef (Zucc.) Trotter) (2n =4x =40) classified under poaceae family and Eragrostis genus. Tef is an annual cereal crop most poaceae family and Eragrostis genus. Tef is an annual cereal crop most widely grown over broad environmental conditions. Its owes its center of origin and diversity in Ethiopia and is widely cultivated throughout the country as a staple food crop [1].

Tef can grow under wide and diverse agro-ecologies. Even though there are areas where the crop is grown during *Belg* season, tef is mainly cultivated during the *Meher*season. It can be grown from sea level up to 2800 m.a.s.l, under various rainfalls, temperature and soil regimes. However, tef performs excellently at an altitude of 1800-2100 m, annual rainfall of 750-850 mm, growing season rainfall of 450-550 mm and a temperature range of 10°C-27°C [2]. According to the survey data of Central Statistical Agency, tef production has expanded by 124.5 percent in between 2003/2004 and 2012/2013 cropping years. Growth was achieved mainly due to 37 percent expansion in area under cultivation and 64 percent increase in yield levels per hectare. Annual tef production has been increasing year after year on average by about 10%. Annual increase in productivity is supposed to contribute about 6% of the 10% growth with 4% attributed to increase in net cropped area allotted to tef [3].

Tef is highly nutritious and is an important part of Ethiopia's cultural heritage and national identity. It is an excellent source of essential amino acids especially lysine, the amino acid that is most often deficient in grain foods. It contains more lysine than barley, millet, and wheat and slightly less than rice or oats (Jansen et al., 1962). It is an excellent source of fiber and high in mineral contents like Fe, Ca, Cu, Zn and Mg [5]. Moreover, it is gluten-free and preferred food for persons with celiac disease, diabetics (slow release carbohydrates) and anemia [6]. In Ethiopia tef is traditionally used to make injera, which is a soft, porous, thin

pancake, with slightly sour taste. It is commonly consumed with various meat and/or pulse sauces called wot. The flour is also used for the preparation of tef porridge, and un- raised bread called Kitta or anebabero (two over-laid injeras). Sometimes, the grain is also brewed into a native beer called Tella or Fersso and a more alcoholic traditional liquor, locally known as arakie, or katikalla. Tef straw is used as animal feed, binder of mud used for plastering local houses or huts, and to make local grain storage silos called goteras[7].

Despite the aforementioned importance and coverage of large area, its productivity is very low when it is compared with cereal crops like maize and wheat. The national average yield is 1.38 tha^{-1} for tef which is 77.97% below the national average maize yield and 39.86% below the national average wheat yields [8] which is attributed to nutrient limitations, drought and water logging [9]. So far, the national research center is releasing several varieties of teff for the country in general. It is critical to observe those varieties their adaptation and performance in southern areas. Therefore, this study was conducted primarily for the purpose of evaluating and selecting adapted, high-yielding improved teff varieties with the participation of farmers at Shone, Southern Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

The field experiment was carried out at Shone Agricultural Research site (7.69-7.91 N, 37.97-38.10 E, and 1501-2500 m.a.s.l.) of the Institute of Agricultural Research (ARS) during the 2019/2020 GC main cropping season. The soil of the experimental site is Nitosol and with a pH of 5.2.

Experimental Material

The experimental material of the study comprised of 12 tef varieties kindly provided from the Debre Zeit Agricultural Research Center and was cultivated at the Shone and Hosanna research field of Wachemo University in 2019/20 main cropping season.

Table1. *List of tef (Eragrostis tef) genotypes 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 offarmers 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 m^2) 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.

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

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 thetime 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 [10]. 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.

Table2. 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 SST-SSB	SSE(r-1)(t-1)	
Total	tr-1	TSS		

Where: r = Number of replications; t = Number of treatments / genotypes; SS =Sum ofSquare; MS = Mean of square; S.Em $= \pm \frac{E.M.SS}{r}$ Coefficient of variation (CV %) $= \frac{\sqrt{ErrorMS\ X\ 10}}{Grand\ \ mean}$

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 [11] 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, [12] 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 Shone 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 .*

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 (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. [13] also reported wide range of variation among Tef genotypes. But, this result is in contrast to [14] finding.

Table5. *Mean and Range values for different agronomic traits for 12 Tef varieties at shone Site 2019/2020.*

		DH	DM	DE	PL	PH	CL	PBP	GFP	GYkgh	BM	HI
	Mean	71.11	112.2	4.3	31.3	80.47	58	19.53	41.15	13.4	2.99	19.2
Range	**Max**	74.56	117.5	7	36.4	94.1	67.1	25.22	45.2	19.5	5.1	33.2
	Min	67	108.2	3.56	24.7	81.2	49.7	14.7	35.2	4.96	2	6.44
DZ-01-196		72.0ab	113abc	4.0cd	30.1bcd	87.6abc	56.4bcd	22.3ab	40bcde	1424abc	3.4.0b	16.4bc
DZ-01-899		71.2abc	112.6bc	4.2bcd	31.8cd	86.5abc	55.6bcde	23.2ab	41.2bcde	1230bc	3.3bc	14.8cd
DZ-01-1285		72.0ab	108.2c	4.5bc	31.3abc	93.2a	60.7b	15.8cd	35.2e	490d	3.1bcd	6.4d
DZ-Cr-354		71.2abc	117.5a	4.5bc	30.1bcd	81.0c	49.7e	18.7bcd	45.2a	1252bc	2.1cd	23.5b
DZ-Cr-974		72.0ab	109c	4.0cd	24.7d	93.0a	67.1a	25.2a	38de	1955a	5.1a	16bc
DZ-01-2675		68.0cd	112.2bc	6.0ab	31.5abc	92.05a	61.3b	14.7d	43.2ab	960cd	2.0d	20 b
DZ-Cr-438		72.2ab	110.5c	3.2cd	36.4ab	94.0a	57.05bcd	24.4a	37.2cde	1620ab	2.8bcd	23bc
Ho-Cr-136		67.0d	110.5c	3.5cd	32.6abc	90.8ab	57.0bcd	21.5ab	42.5ab	1827a	2.23cd	33.2a
DZ-Cr-387		74.5a	116.2ab	7.0a	30.7abc	83.2bc	52.5de	15.3cd	41.6abcd	1220bc	2.8bcd	18.4bc

DZ-Cr-409		71.0bcd	113abc	3.5d	36.3a	90.1ab	52.7cde	20.5bc	42abc	1040c	2.24cd	18.6bc
DZ-01-255		71.5ab	113.2bc	4.0cd	32abc	91.7a	58.7bc	25.1a	41.5bcde	1751ab	3.6b	20.4bc
DZ-CR-358		74.4ab	111.4c	5.4cd	38.0ab	96.2a	59.07bcd	27.6a	3923cde	1720ab	3.9bcd	24bc
CV (%)		4.61	3.48	10.82	8.27	5.11	5.44	11.36	12.05	5.55	12.6	16.46
LSD		4.56	4.17	2.67	4.8	5.36	5.02	3.06	4.167	377.38	5.47	6.58

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

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 days to maturity, plant height, days to heading, Culm length, palm length, Number of primary branches per plant, Grain filling period, Days to emergency, Grain yield, biomass yield and harvest index. High grain yield of tested varieties recorded by variety DZ-Cr-974-(1955kg/h) followed by DZ-01-1285 (490 kg/h). On the other hand, lowest grain yield was recorded by DZ-01 196 (490kg/h). Grain yield was an important character to be considered for variety selection to address the objective of the present activity. For this reason, five improved varieties i.e. DZ-Cr-974 (Dukem), Ho-Cr-136 (Amarach), DZ-01-255 (Gibie) DZ-CR-358 (Ziquala) and DZ-Cr-438 (Kora). 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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