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Evaluation of Released Tef (*Eragrostis tef* (Zucc.) Trotter) Varieties in Selected Districts in Gurage Zone, Southern Ethiopia

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Abstract: Tef (*Eragrostis tef* (Zucc.) Trotter) is one of the most important staple food crops cultivated throughout the country. Evaluating and selecting high yielding tef varieties for the study area. Ten tef varieties including one standard check was planted using randomized complete block design at Endegagn, Cheha and Enamorina-Ener districts for two consecutive years; 2017-2018. The mean squares of varieties were highly significant (P≤ 0.01) for plant height and panicle length and significant for grain yield. The mean squares of locations were highly significant (P≤ 0.01) for all traits. The mean square of combined analysis for environment effect on variety (environment × variety/genotypes) were exhibited significant (P≤ 0.05) for plant height and highly significant (P≤ 0.01) for panicle length. Whereas non-significant for grain yield. So it was not necessary to perform analysis of variances for characters to each location. The highest mean grain yield was recorded for Nigus (1.44 t/ha) followed by Filagot (1.363 t/ha) and the least was Dukem (1.096 ton/ha). The tallest in plant height was variety Quncho (95.99 cm) with longer panicle length (33.84 cm) and the shortest was Simada (76.53 cm) but shortest panicle length was from Tsedey (25.79 cm). Whereas, in grain yield Nigus was the highest and stable across locations and Magna, Quncho and Tesfa were the 3rd, the 4th and the 6th stable across locations respectively. When we compare these locations, Endegagn is the potential area than Enemorina–Ener and Cheha districts. Grain yield had positive and highly significant (P≤0.01) association with plant height and panicle length at phenotypic level but non significance at genotypic level. Nigus, Magna and Quncho varieties performed best and high yielders in low rainfall spreading season at grain filling period. The result of the study revealed that Nigus, Magna and Quncho varieties should be used for low rainfall distribution season for tef production in the study area.

Keywords: Correlation, *Eragrostis tef*, Stability Analysis, Yield Performance

1. Introduction

Tef [*Eragrostis tef* (Zucc.) Trotter] is one of the major food crops in Ethiopia where it is annually cultivated on more than three million hectares of land [1]. The production area of tef is increasing in extraordinary scale due to increased market demand, higher nutritional value, and low incidence of damage by insects, better adaptation to drought and high value of straw. The performance of one genotype differs significantly from environment to environment. Genetically, tef is adaptable to a wide range of environmental conditions and even under unfavorable environmental condition. It can be grown at altitudes ranging from near sea level to 3000 masl (meter above sea level), but it performs well between 1100 and 2950 masl [2]. Accessions of tef collected from diverse regions in Ethiopia also exhibited huge diversity for important agronomical and morphological traits [3].

Tef has recently been receiving global attention particularly as a 'health food' due to the absence of gluten and gluten-like proteins in tef grains [4]. Gluten is a protein found in wheat, barley and rye. Despite its merits, tef's yield remained to be very low, 1.5 t/ha [1]. This low yield is attributed to lodging, moisture stress and low inherent-yield capacity of the cultivars. However, a number of varieties have been developed with yielding capacity of 1.7 to 2.2 t/ha [5]. There are 44 tef varieties released in Ethiopia so far since 1970s [6]. These improved varieties have been developed pushing the national average tef yield from 0.7 ton/ha in

1994 to 1.75 ton/ha in 2018 cropping season [7]. As the assessment need of the community indicates the gap was for shortage of variety choice, shoot fly, lodging and high yielder varieties. Therefore, this experiment was carried out with the objective to select high yielding tef varieties for the study areas.

2. Materials and Methods

2.1. Description of Test Varieties with Experimental Sites

The field experiment was conducted at Enamorina-Ener district is located between 7°35′-8°13′ latitude North and 37°58′-37°93′ longitude East, Cheha district is located between 7.99°58′-8°25′ latitude north and 37°59′-38°06′ longitude east; 185 kilo meters south west of Addis Ababa. And from Endegagn district the experiment was conducted specifically at 7°40′ north and 37°48′ east. These three districts were used from Guraghe zone, Southern Ethiopia for two consecutive years 2017 to 2018 cropping seasons.

The test materials were collected from Debre Zeit Agricultural Research Center. For this experiment only 10 tef varieties used namely Kora, Tesfa, Tsedey (Cr-37), Magna, Dukem, Filagot, Nigus, Simada, Bosset and including Quncho as a standard check.

2.2. Experimental Design

The experiment was planted using randomized completely block design with three replications. Each variety was planted in plot area of 2 m x 2m= 4 m^2, the space between rows, blocks and plots was 20 cm, 100 cm and 50 cm, respectively and sown using hand drilling. All agronomic practices were equally performed for all treatments as per recommendations. Seed rate: 15 kg/ha. Fertilizer rate 60 kg/ha N from urea (46%N) used in split application at planting and tillering, respectively, and 60 kg P_2O_5 per hectare from blended of NPS (19% N-38% P_2O_5 +7% S) applied at planting time.

2.3. Data Collected and Analysis of Variance (ANOVA)

Data were collected on plant height, panicle length and grain yield. The collected data were subjected to analysis of variance (ANOVA) using SAS Software (Version 9.0) [8] and [9]. Mean separation was carried out using least significant difference (LSD) at 5% level of significance. The correlation coefficients among traits computed as PROC CANDISC [8]. Both genotypic and phenotypic correlations, which are the associations between two variables, were estimated by the formula as suggested by Weber and Moorthy, [10].

$$\text{Genotypic correlation: rg (xy)} = \frac{\text{Gcovg(xy)}}{\sqrt{\sigma^2\text{px}\sigma^2\text{py}}} \text{ and phenotypic correlation: rp (xy)} = \frac{\text{Pcov(xy)}}{\sqrt{\sigma^2\text{px}\ \sigma^2\text{py}}}$$

3. Results

Analysis of variance form agronomic characters on tef (*Eragrostis tef (Zucc.) Trotter*) varieties were tested in two cropping seasons (2017 – 2018) and at three districts in Guraghe zone, Southern Ethiopia Table 1. Combined analysis of variance was carried out for grain yield and other agronomic characters as outlined by Gomez and Gomez [9] using SAS [8]. The mean squares of varieties were highly significant (P≤0.01) for plant height and panicle length and significant for grain yield. The mean squares of locations were highly significant (P≤0.01) for the three traits (height, panicle length and grain yield). The mean square of combined analysis for effect of environment on variety (environment × genotypes/variety) were exhibited significant (P≤0.05) for plant height and highly significant (P≤ 0.01) for panicle length, although non-significant for grain yield. So it was not necessary to perform analysis of variances for characters to each location. The significant differences indicated that existence of large variability among variety and locations in traits measured. The coefficient of determination (R^2) is used to measure the proportion of variability in a data set that is accounted by the statistical model. All the traits scored more than 85% estimate of R^2, except grain yield (56.70%) The R^2 and goodness-of-fit for the same data set, higher R^2 value represents smaller difference between the observed data and the fitted value.

Table 1. *Combined analysis of variances for some agronomic characters on tef varieties tested by two cropping seasons (2017 – 2018) and three locations.*

Source of variation	DF	Mean squares		
		PH	PL	GY
Variety	9	407.05**	76.32**	0.089*
Location	2	5906.68**	1067.44**	1.31**
Replication	2	7.65	5.62 Ns	0.019 Ns
Location*Variety	18	60.18*	22.15**	0.112 Ns
Error	58	30.20	8.44	0.072
Mean		87.82	29.80	1.23
CV (%)		6.26	9.75	21.74
R-square (%)		90.44	86.84	56.70

*, ** and Ns = significant, highly significant and non-significant respectively. DF degree of freedom, PH= plant height in centimetre, PL= panicle length in centimetre and GY= grain yield in ton ha^{-1}.

4. Discussion

4.1. Grain Yield Performance of Tef Varieties

Significant difference was observed for the traits used under study. The highest mean grain yield was recorded for Nigus (1.44 t/ha) followed by Filagot (1.4 t/ha). The least in grain yield was recorded from Dukem (1.096 t/ha) across all locations during 2017 and 2018. Similarly Yasin and Agdew, [11] reported significant differences among different tef varieties for grain yield.

Table 2. *Mean separation of three traits for combined mean analysis two cropping seasons.*

Varieties	PH	PL	GY	Rank by GY
Nigus	92.82^{ab}	31.76^{ab}	1.444^{a}	1
Filagot	81.76^{de}	26.13^{d}	1.363^{ab}	2
Magna	91.58^{ab}	31.68^{ab}	1.234^{a-c}	3
Kora	92.94^{ab}	30.89^{bc}	1.223^{a-c}	4
Quncho	95.99^{a}	33.84^{a}	1.223^{a-c}	4
Tesfa	88.70^{bc}	28.42^{cd}	1.199^{a-c}	6
Boset	85.30^{cd}	28.52^{cd}	1.193^{a-c}	7
Simada	76.53^{f}	27.51^{d}	1.180^{bc}	8
Tsedey	79.26^{ef}	25.79^{d}	1.178^{bc}	9
Dukem	93.33^{ab}	33.42^{ab}	1.096^{c}	10
GMean	87.82	29.80	1.23	-
LSD (5%)	5.19	2.74	0.25	-

Means with the same letter in the same column are not significantly different ($p < 0.05$) using LSD probability level. PH= plant height in centimetre, PL= panicle length in centimetre and GY= grain yield in ton ha^{-1}.

From these cropping seasons, there was relatively lower rainfall distribution in the study area at grain filling period. Due to these there were lower yields recorded from all locations across the cropping seasons Tables 1, 2 and 3. Among the study areas Endegagn was higher in grain yield production and the least was Cheha district Table 3. This finding was similar with the result of Bakala et al., [2] who reported 0.57 – 2.03 t/ha of grain yield on tef genotypes in southern Oromia. Magna (DZ-01-196) is an old improved variety developed by pure line selection and released in 1970 [12]. It has been popular for its very white seed colour, but its productivity has been relatively low (1.6–1.8 ton/ ha) [13]. The variation in grain yield was due to the differences in genetic variability found among varieties [14].

From the study materials the tallest in plant height was variety Quncho (95.99 cm) with longest panicle length (33.84 cm) and the shortest in plant height was Simada (76.53 cm) but shortest panicle length was from Tsedey (25.79 cm). Panicle length was one of yield determining traits Table 2.

Table 3. *Overall mean of the traits across locations.*

Locations	PL	PH	GY
Endegagn	35.01^{a}	100.47^{a}	1.394^{a}
Enamorina-Ener	31.08^{b}	90.26^{b}	1.308^{a}
Cheha	23.29^{c}	72.73^{c}	0.998^{b}

4.2. Stability Analysis of Tef Varieties

Statistically there were not significant differences between varieties x location (GXE) interactions and no changes in the rank of genotypes across locations. It suggests that there were not specifically adapted varieties for each location. Comparatively Nigus was the highest and stable in grain yield across locations. Filagot (2^{nd}) in grain yield but not stable, the highest at Endegagn district and the lowest at Enemoina-Ener district. Magna (3^{rd}) and Quncho (4^{th}) were stable across locations Figure 1. Also Kora was the (4^{th}) in grain yield but not stable; it was the highest at Enemorina- Ener and 9^{th} at Endegagn district. When we compare three locations, Endegagn district is better area in yield whereas Cheha district is the least Table 2 and Figure 1.

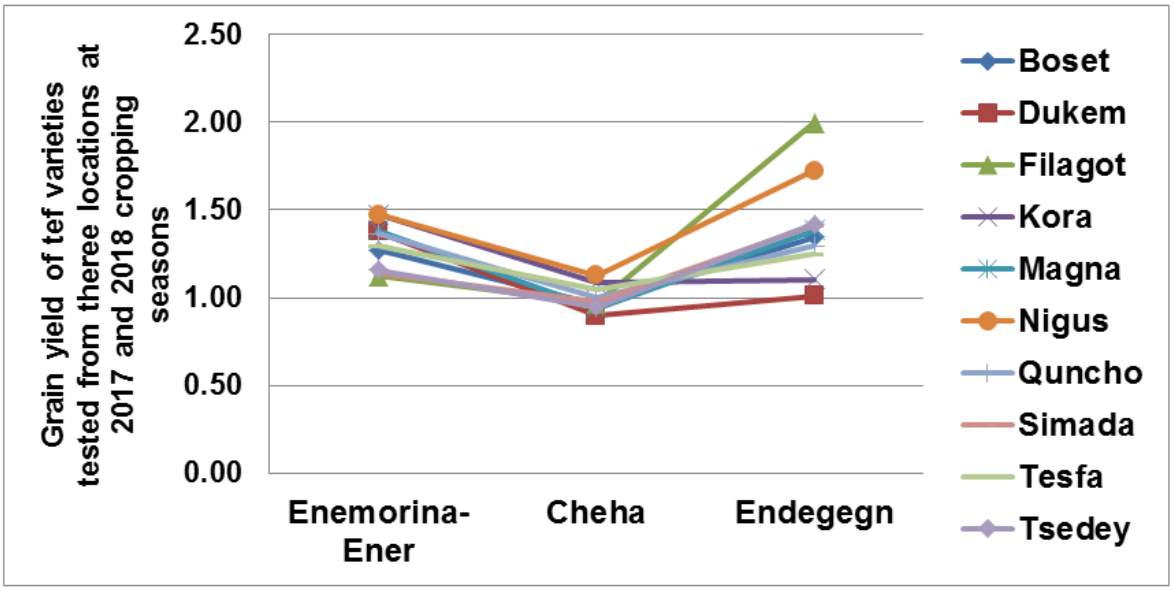

Figure 1. *Mean grain yield of three locations of 10 tef varieties tested two cropping years (2017-2018).*

Table 4. *Coefficient of correlation estimates at genotypic and phenotypic levels for three traits.*

Variables	Attribute	PH	PL	GY
PH	G	1	0.907**	0.088
	P		0.896**	0.453**
PL	G		1	-0.065
	P			0.364**
GY	G			1
	P			

*, ** = significant, highly significant at the level of P<0.01 and P<0.05 respectively. P= phenotypic correlation, G= genotypic correlation.

4.3. Correlation of Yield and Yield Related Characters

The correlation coefficients among traits computed as PROC CANDISC analysis using SAS [8] Table 4. The coefficients of variations at phenotypic and genotypic levels were estimated using the formula adopted by Weber and Moorthy [10]. Significance of variability for each trait was tested against tabulated F-values at 5% and 1% probability level.

Grain yield had positive and highly significant ($P \leq 0.01$) association with plant height and panicle length at phenotypic level whereas non significance at genotypic level. This indicates that genotypes with higher plant height and with high panicle length produced high grain yield. Therefore, these traits are important to be used as selection criteria for grain yield in tef production. Similarly Asaye [15] reported that plant height was positively correlated with grain yield. Panicle length had positive and highly significance correlated with plant height at both phenotypic and genotypic levels from the study materials Table 4.

5. Conclusion

Tef is one of the most important staple food crop cultivated throughout the country. The mean squares of varieties were highly significant ($P \leq 0.01$) for plant height and panicle length and significant for grain yield. The mean squares of locations were highly significant ($P \leq 0.01$) for all traits. The mean square of combined analysis for environment effect on variety (environment × variety/genotypes) were exhibited significant ($P \leq 0.05$) for plant height and highly significant ($P \leq 0.01$) for panicle length. Whereas non-significant for grain yield. So it was not necessary to perform analysis of variances for characters to each location. The highest mean grain yield was recorded for Nigus (1.44 t/ha) followed by Filagot (1.363 t/ha). Whereas, Nigus (1^{st}) was the highest and stable in grain yield across locations and Magna (3^{rd}), Quncho (4^{th}) and Tesfa (6^{th}) stable across locations. When we compare the three locations, Endegagn district is the potential area than Enemorina –Ener and Cheha districts in order. Grain yield had positive and highly significant ($P \leq 0.01$) association with plant height and panicle length at phenotypic level but non significance at genotypic level. Nigus, Magna and Quncho performed best and high yielders in low rainfall spreading season at grain filling period.

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