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Full Length Research

Evaluation of Some Improved Tef Genotypes in Guraghe Zone, Southern Nations Nationalities and Peoples Regional State, Ethiopia

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An experiment was conducted at Guraghe zone central Ethiopia during 2016 main cropping season in order to identify and promote well adapted and promising genotypes of teff. The experiment was laid out in a randomized complete block design with three replications. The data recorded were plant height, panicle length, lodging index, stand percentage, days to maturity, leaf rust disease, grain yield, biomass yield and harvest index. The data was analyzed using SAS software and means were separated using least significant difference. The analysis showed that varieties indicates significance difference (P<0.05) for all agronomic traits, but it indicates none significant difference by their stand percentage. Dz-cr-387 (Quncho) was shown to be high yielder variety followed by the varieties Dz-01-354and Dz-Cr-385 with the values of 3283.3, 3133.3 and 3025.0 kg ha-1, respectively. The varieties Dz-01-196, Dz-cr-387 and Dz-cr-974 were found to be having high biomass with the values of 15458, 15175 and 14392 kg ha-1, respectively. Dz-cr-387 (Quncho) was superior in almost all the agronomic traits evaluated while varieties Dz-01-1281 and Dz-01-787 were out performed by most of the improved varieties of teff tested. The varieties evaluated had a wide genetic background for the studied traits, thus showing grain yield ranges from 2000 to 3283.30 kg ha-1. Therefore, based on objectively measured traits, the variety Dz-cr-387 was found most promising having the potential to increase the average yield of tef in Guraghe zone and is therefore recommended for general cultivation. The correlation coefficients among all possible pairs of traits in this study was indicates that Grain yield exhibited strong positive and significant correlation with biological yield (0.618$^{**)}$, harvest index (0.387$^{**)}$, Plant height (0.160), Panicle length (0 .096), Lodging index (0.097), and Spike length (0 .051). Generally, the present study revealed the identification of genotypes with superior grain yield and other desirable traits for further evaluation and eventual release to the farming community.

Keywords: Teff, Variety, Grain yield, Guraghe zone and Genotypes.

1. INTRODUCTION

Tef [*Eragrostis tef* (Zucc.) Trotter] is among the major cereals of Ethiopia, occupying about2.6 million hectares (23% of the grain crop area) of land which is more than any other major cereals such as maize (16%), sorghum (14%) and wheat (13%) [1]. Of the 85% gross grain production (about 14 million tons) contributed by cereals, tef constituted 19%, following maize (23%) during the main season of 2007/08. Ethiopian farmers grow tef for a number of merits, which is mainly attributed to the socioeconomic, cultural and agronomic benefits [2]. Tef withstands low moisture conditions and often considered a rescue crop that survives and grows with remaining low moisture in the season when early planted crops (*e.g.* maize) fail due to low moisture. Moreover, the ability of tef to tolerate and grow on Vertisols with drainage problems makes it a preferred cereal by farmers.

Tef belongs to the family *Poaceae,* sub family *Eragrostoideae*, tribe *Eragrosteae* and genus *Eragrostis.* It is the only cultivated cereals among 350 species under the genus. Tef is a c4 and self-pollinated, chasmogamous annual cereal with 0.2-1% out crossing. Besides, *tef* is known to be an alloteraploid (2n=4x=40), with basic chromosome number of x=10 (Tavassoli, 1986). Several wild species of *Eragrostis* were identified to be close progenitors of the present day tef [4]. However, Mulu *et al*. [5] using AFLP analysis confirmed that *Eragrastis pilosa* is immediate progenitor of tef.

In Ethiopia, tef is a highly valued crop and is primarily grown for its grain that is used for preparing injera, which is a staple and very popular food in the national diet of Ethiopians. It can also be used in many other food products such as kitta (unleavened bread), anebaberro (double layered injera), porridge and alcoholic beverage such as tella and katikala [6;7]. Seyfu [2] suggested that tef is not suitable for bread making as it lacks the necessary amount and quality of protein complex called “gluten” that can be formed into dough with the rheological properties required for the production of leavened bread. As it is protein nutritionally very useful but for some people who are allergic to this protein results in cancer. Further, according to the National Academy Press [8] tef contains no gluten thus American’s with severe allergies to wheat gluten are among those buying tef these days.

Nutritionally, tef has as much, or even more food value than the major grains: wheat, barley and maize. This is probably because tef is eaten in the whole grain. Tef grains contain 14-15 % proteins, 11-33 mg iron, 100-150 mg calcium and rich with potassium and phosphorous [8]. The absence of anemia in Ethiopia seems to be associated with the level of tef consumption as the grains contain high iron as reported by National Academy [8]. Furthermore, Asrat and Frew [6] reported that the carbohydrate content of tef ranges from 72.1-75.2%, protein 8.1-11.1% and ash 2.5-3.2%; the major components of ash being iron. They reported also that tef has got high lysine content compared to all cereals except rice and oats.

Ecologically, tef is adapted to diverse agro-ecological regions of Ethiopia and grows well under stress environments better than other cereals known worldwide [9]. Because of this, it is said to be a “low-risk” crop for farmers. According to Seyfu [10] it can be grown from sea level up to 2800 m.a.s.l, under various rainfalls, temperature and soil regimes. However, He emphasized that for better performance, it requires an altitude of 1800- 2100 m.a.s.l., annual rain fall of 750-850 mm, and a temperature range of 100C-270C. It is predominantly cultivated on sandy loam to black clay soils. In addition, its high price in the market, reduction of post harvest management cost, fewer disease and pest problems, sustained demand from consumer, are some of the specific merits that makes tef important and preferred by farmers [10].

In Ethiopia, tef is cultivated on an area of about 1.8 million hectares [11]. This makes it the first among cereals in the country in area coverage. Further [12] reported that 15% of the total cereal crops production in the country is contributed by tef.

Despite the aforementioned importance and coverage of large area, its productivity is very low. The average national yield of tef is less than 1ton per hectare, i.e, 8 qt/ha [12]. Some of the factors contributing to low yield of tef are; lack of high yielding cultivars, lodging, weed, water lodging, low moisture and low fertility conditions [13].

The most common way of planting tef is by broadcasting the small seed at the rate of 25-30 kg ha-1 [14]. This sowing method results in lodging; which is the main cause for low yield of tef due to high plant density [15]. To minimize the problem of lodging on tef, low seed rate, row planting, late sowing, application of plant growth regulators, appropriate rate and timing of fertilizer application [16; 17].

Since the beginning of the tef improvement research, many varieties have been developed for different agro-ecologies by the research institutes of the country. However, most of these varieties have not been promoted and utilized by farmers, particularly in moisture stressed and inaccessible areas. Some of the reasons for this low adoption of improved varieties, as mentioned by Chilot, *et al*.,[18] is the traditional top-down research and development processes without the participation of the ultimate users, the farmers as well as the inaccessibility of improved varieties to the farmer community. Therefore, evaluation of tef released varieties with farmers in our conditions is a short cut way to identify and promote well adapted and promising genotypes.

In Guraghe zone, the tef production has been practiced for some decades, however, the area covered by tef production was 28,675.89 hectares and the average yield 9.07 Q/ha. This figure implies that tef production coverage and its productivity is low [1].Because, there is no enough information about the determinant of the adaptation and intensity of use of improved varieties along with the recommended agronomic practices. But, there is some attempts to adapt different crop varieties by Gurage Zone Department of Agriculture in collaboration with different Agricultural Research Centers to introduce different improved varieties aiming at increasing the production and productivity of crops grown in the area [19].So, this study was proposed with the objectives of

General Objective:

- To evaluate the genotypic and phenotypiccharacteristics of improved tef genotypes for their grain yield and other agronomic traits.

Specific Objectives:

- Tocreate awareness so as to improve food security and income generation through enhancing crops production and productivity.

2. MATERIALS AND METHODS

2.1 Site Description

The experiment was conducted at wolkite university research field for two consecutive years, 2015 and 2016. The university is located around 172km to the south-west direction from capital city of Addis Ababa gurage zone. The university was launched in 2012 in gurage zone, southern nations and nationalities of Ethiopia. Gurage zone occupies an area of 5,932 km^2, having an altitudes ranging from 1,001 to 3,500 m.a.s.l and a rainfall ranging from 801 to 1400mm per annum. About 93% of the total area is characterized as dry woyenadega to moist woyenadega and moist dega climatic condition and different soil of black, red and brown types found predominantly that makes the zone suitable for production of wide range of agricultural crops. The mean annual temperature ranges from 14 to 24^0C with an average of 20.5^0C. The rainfall pattern in the Gurage Zone is bimodal in which 80% of rain falls in the Kremt period of June to August whereas 20% in the Belg period of February to May [19].

2.2 Experimental materials and Design

The plant materials composed of 18 tefvarieties (Dz-01-196, Dz-cr-255, Dz-cr-37, Dz-01-354, Dz-01-1681, Dz-01-285, Dz-01-99, Dz-cr-974, Dz-01-787, Dz-cr-44, Dz-cr-385, Dz-01-1281, Dz-cr-409, Dz-01-2675, R/L # 1336, Ho-cr-136, Dz-cr-358 and Dz-cr-387)which were obtained from Debre zeit Agricultural research center. The treatments were designed by using randomized complete block design (RCBD) with three replications. The length of each plot was 2m by 1m with 20cm spacing between rows. A distance of 50 cm between plots was maintained and the distance between blocks and replications was 1m. The recommended seed rate of 30kg/ha and fertilizer rate of 60 kg ha-1 N/ P2O5 were used. Weeds were controlled manually and at early tille ring all the stands were thinned to 10 cm-intra-row spacing.

2.3 Data collection

Plant height - height of the plant in centimeter from the base of the main stem to the tip of the panicle and recorded as the average of five randomly selected plants.
Days to 50% maturity: the number of days elapsed from the date of sowing to the date when 50% of the crop stand - stems, leaves, and floral bracts - in a plot changed to light yellow color were recorded.
Panicle length - 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 ten randomly selected plants;
Lodging index: It was recorded using the method of Caldicott and Nuttall [20], who defined lodging index as the sum of the product of each degree of lodging (0-5scale) and their respective percentage divided by five. Lodging index =Sum (Lodging Scores X their respective percentage area lodged)/5. The calculated values for lodging index is between 0 (no lodging or erect) and 100 (complete lodging).
Biological yield: Above ground total biomass in gram of all the plants in all the rows of each plot was recorded at harvest.
Grain yield - the weight of the air-dried seeds harvested from each plot; and
Harvest index - the ratio of grain yield to above ground (shoot) biomass;

2.4 Data Analysis

Analysis of variance (ANOVA) was carried out following the procedures outlined by Steel and Torrie [21] to determine the presence of significant differences among the genotypes using SAS computer program. Significant differences were further subjected to least significance difference (LSD) for mean separation. The interrelationship between grain yield and other agronomic parameters were determined by correlation coefficients that indicates the relative importance of direct and indirect influences of each of the component characters towards grain yield trait.

3. RESULTS AND DISCUSSION

The analysis of variance (Table 1) indicated that the genotypic mean square values were significant for six of the eight agronomic traits recorded, implying that the varieties were highly variable. Most of the characters except standing percentage showed significant differences due to the genetic variability of tef genotypes. The coefficient of variation ranged from

Table 1. Mean square values and coefficient of variation for agronomic characters of Teff genotypes.

Source of Variation	d.f	Mean Squares							
		PH	PnL	LI	STP	LR	BY	GY	HI
Rep	2	30.33*	3.45NS	0.39*	158.79NS	7.40NS	5971666.7NS	307743.05NS	1.25NS
Genotypes	17	409.18**	52.95*	1.18**	70.72NS	203.48**	13005447.3**	364166.67**	38.76**
Error	34	24.40	7.77	0.35	83.30	46.62	2203958.3	196934.23	7.13
CV (%)		4.51	7.04	25.96	12.06	28.80	12.38	16.52	11.71

Note: ****, *** denote effects significant at 1% and 5% respectively while NS showed non significant variation

Table 2. Mean performance of genotypes for different agronomic traits.

Genotypes	PH	PenkL	LI	STP	LR	BY	GY	HI
DZ-01-196	115.76bc	38.80edc	2.33bdc	78.33a	30.00bac	15458a	2708.3bdac	17.54f
DZ-cr-255	113.45bc	40.46bdc	2.33bdc	80.00a	21.67edc	13308bdac	2958.3ba	21.88cfed
DZ-Cr-37	99.28e	35.67feg	3.00ba	70.00ba	16.67fed	8817f	2491.7bdc	28.15b
DZ-01-354	123.24ba	45.40a	2.0000edc	81.67a	26.67bdc	13733ba	3133.3ba	22.78ced
DZ-01-1681	101.30e	36.32fed	3.00ba	70.00ba	23.33bedc	10408fe	2600.0bdac	24.97cb
DZ-01-285	106.56de	41.77bac	2.00edc	75.00ba	38.33a	13300bdac	2858.3bac	21.52cfed
DZ-01-99	99.960e	39.42edc	2.67bac	78.33a	10.00f	11183fdec	2675.0bdac	24.03cbd
DZ-Cr-974	121.94ba	42.24bac	1.33ef	76.67ba	33.33ba	14392ba	2700.0bdac	18.69fe
DZ-01-787	110.56dc	41.93bac	1.00f	73.33ba	26.67bdc	10392fe	2125.0dc	20.38fed
DZ-Cr-44	113.60dc	44.25ba	2.00edc	78.33a	28.33bac	11958bdec	2666.7bdac	22.32ced
Dz-Cr-385	79.36f	33.10fg	3.33a	78.33a	13.33fe	9183f	3025.0ba	33.07a
DZ-01-1281	106.67de	43.13bac	1.67edf	76.67ba	33.33ba	10300fe	2000.0d	19.53fe
DZ-Cr-409	101.79e	31.49g	1.67edf	80.00a	10.00f	11000fde	2808.3bac	25.20cb
DZ-01-2675	116.67bc	41.96bac	2.67bac	78.33a	26.67bdc	10175fe	2133.3dc	20.93cfed
R/L # 1336	123.33ba	39.73bedc	2.00edc	71.67ba	26.67bdc	13392bdac	2858.3bac	21.83cfed
Ho-Cr-136	98.52e	32.00fg	3.00ba	78.33a	13.33fe	9983fe	2433.3bdc	24.26cbd
DZ-Cr-358	110.40dc	41.40bac	2.33bdc	61.67b	26.67bdc	13567bac	2891.7ba	21.35cfed
DZ-Cr-387	126.56a	43.20bac	2.67bac	75.00ba	21.67edc	15175a	3283.3a	21.78cfed
LSD(5%)	8.196	4.63	0.98	15.14	11.33	2463.4	736.36	4.43

Source: Own study

4.51% for plant height to 28.80% for leaf rust diseases.

All varieties showed highly significant deference (P<0.01) for plant height (Table 1). Variety Dz-cr-387 (Quncho) had the highest plant height (126.56cm) while a short statured plant of 79.36cm was recorded in variety Dz-cr-385 (Table 2). Tef varieties used in the present study had diverse genetic composition and as a consequence produced varying plant height ranged from 69.33 to 112.33cm. The variation in panicle length were found to be significant (P<0.01) (Table 1). The variety Dz-01-354 had maximum panicle length (45.40cm), while the shortest panicle length was recorded in the variety Dz-cr-409 (31.49cm) (Table 2). In this study the panicle length ranged from 45.40cm to 31.49cm among varieties. The studied genotypes showed variation significantly in lodging index (table 1). The highest lodging index was recorded for variety Dz-Cr-385 (3.33).

From the studied genotypes the lowest lodging index was recorded to variety Dz-01-787 with the value of 1.0. The genotypes showed variation none significantly in standing percentage (Table 1). The highest standing percentage was recorded for variety Dz-01-354 (81.67%). From the studied genotypes the lowest standing percentage was recorded for variety Dz-cr-358 with the value 61.67%. The highest leaf rust (38.33%) disease was recorded from variety Dz-01-285, while the lowest (10%) was recorded from variety Dz-01-99. The analysis result of genotypes revealed that highly significant difference (P<0.01) in biomass yield (table 1). Genotypes mean value of biomass yield ranged from 8817 kgha^{-1} to 15458 kgha^{-1}.The highest and poorest biomass yield was recorded for variety Dz-01-196 and variety Dz-cr-37 with the values of 15458 kgha^{-1} and 8817 kgha^{-1},respectively (Table 2). In present investigation yield in kgha^{-1} was found to be significant difference (P<0.01). The variety Dz-cr-387 (Quncho) superseded all the genotypes with the highest yield of 3283.3 kgha^{-1}. It was followed by the variety Dz-01-354 with grain yield of 3133.3kgha^{-1}. The genotype Dz-cr-1281 showed poor performance in this experiment producing only 2000kgha^{-1}(table 2). The grain yield in the tested tef genotypes ranged between 2000 kgha^{-1} to 3283.3kgha^{-1}. Variation in yield shows a diverse genetic background of genotypes studied under this condition. The possible reasons for the observed difference could be variation in their genetic makeup. Harvest index is important yield parameters in various grain crops including tef. The variation in harvest index was significantly different (P<0.05) (Table 2). The ranged harvest index was recorded from 17.54 to 33.07. The highest harvest index was noticed at genotype Dz-cr-385 (33.07) followed by genotype Dz-cr-37 (28.15). The lowest harvest index was recorded from genotype Dz-01-196 (177.54) followed by genotype Dz-cr-994 (18.09).

Further,it was observed that the genotype Dz-cr-387(Quncho) remained superior in terms of both grain and biomass yield as well as in other important yield components (Table 2). It is therefore suggested that this variety must be brought forward for testing across the various ecological areas of the studied district in a couple of years. The possible reason for the observed differences for all the traits recorded could be because of variation in the genetic makeup of the studied varieties. In support of this finding, different researchers have reported significant amount of variability in different tef populations studied.

The correlation coefficients among all possible pairs of traits in this study were presented in Table 3

Table 3: Correlation coefficient between grain yield and other traits in tef line.

Traits	PH	PNL	LI	SPL	LR	BY	GY	HI
PH	1	.649**	-.322*	-.010	.469**	.669**	.160	-.630**
PNL	.649**	1	-.333*	.049	.571**	.452**	.096	-.458**
LI	-.322*	-.333*	1	-.132	-.394**	-.180	.097	.375**
SPL	-.010	.049	-.132	1	.031	.024	.051	.026
LR	.469**	.571**	-.394**	.031	1	.450**	.079	-.433**
BY	.669**	.452**	-.180	.024	.450**	1	.618**	-.468**
GY	.160	.096	.097	.051	.079	.618**	1	.387**
HI	-.630**	-.458**	.375**	.026	-.433**	-.468**	.387**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Grain yield exhibited strong positive and significant correlation with biological yield (0.618**) and harvest index (0.387**). It also indicates positive correlations with Plant height (0.160), Panicle length (0 .096), Lodging index (0.097), Spike length (0 .051). Similar results of positive correlation of these traits with yield were reported by Hailu [22], Fufa *et al*.,[23] and Kebebew *et al*.,[24]. This indicated that selection for higher plant height, Panicle length, lodging index, and Spike length is computed to bring about improvement in grain yield. Moreover, in contrast to the present result, Kebebew *et al.,*[24] observed negative association of grain yield with harvest index.

Plant height had the highest positive correlation with biological yield (0.669) followed by panicle length (0.649). Biological yield indicates positive and highly significant correlation with panicle length (0.452), spike length (0.024) and grain yield (0.618). It also, revealed negative and highly significant correlation with lodging index (-0.180) and harvesting index (-0.468). In contrast positive correlation of plant height and lodging index was reported by Fufa *et al*.,[23] and Kebebew *et al*.,[24]. Harvesting index had shown negative and highly significant correlations with plant height (-0.630), panicle length (-0.458) and leaf rust (-0.433).

4. SUMMARY AND CONCLUSIONS

The present investigation was conducted at Wolkite University, ferezie research site on eighteen (18) teff genotypes. Each genotype was planted on 2mx2m plot size with 20cm between rows by using RCBD Design. The spacing between plots and between blocks was 0.5m and 1m, respectively. The genotypes exhibited significant variation ($p<0.05$) for most traits studied except, standing percentage and grain yield, which shows non-significant variation. Leaf rust, lodging index and Grain yield showed high coefficient of variation. The genotypes Dz-cr-387 and Dz-01-354 were revealed highest grain yield.

After evaluating the performance of 18 different tef genotypes, it is concluded that the genotype Dz-cr-387 remained superior in terms of yield production as well as in other important yield components. It is, therefore suggested that Dz-cr-387 should be brought forward for testing across the various ecology of Guraghe zone in particular and similar agro ecologies at large. The present study revealed considerable amount of diversity among the tested populations which could be manipulated for further improvement in tef breeding.

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