Journal of Scientific Agriculture 2020, 4: 77-82
doi: 10.25081/jsa.2020.v4.6263
http://updatepublishing.com/journal/index.php/jsa

Research Article

ISSN: 2184-0261

Selection for yield and its component traits in interspecific recombinant inbred lines of tef

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ABSTRACT

Forty recombinant inbred lines (RILs) of interspecific cross of *Eragrostis tef* x *E. pilosa* were evaluated to study variability and interrelationships among agronomic traits using randomized complete block design. The RILs were evaluated for 17 traits. The result showed panicle length, rind penetrometer resistance of the first and the second basal internodes, 100-kernel weight, kernel weight per panicle, plant height and grain yield per plant had high estimates of genetic coefficient of variation, broad sense heritability and genetic advance. Thus, improvement of these traits could be attained through direct selection without the masking effect of the environment. The correlation study showed positive and significant ($p<0.01$) phenotypic and genotypic associations of grain yield per plant with days to heading and maturity, panicle length, 100-kernel weight, kernel weight per panicle, biomass yield per plant and harvest index. Genotypic path coefficient analysis revealed that panicle length, biomass yield per plant, crushing strength of the second basal internode, harvest index, days to heading and kernel weight per panicle exerted appreciable positive direct effect on grain yield per plant. These traits could, therefore, be considered as indirect selection criteria while selecting lines in order to improve grain yield of the interspecific population.

Received: May 29, 2020
Accepted: June 26, 2020
Published: August 08, 2020

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KEYWORDS: *Eragrostis tef*, genetic variability, interspecific cross, path analysis

INTRODUCTION

The small-seeded cereal, Tef [*Eragrostis tef* (Zucc.) Trotter], has originated and diversified in Ethiopia [1], and it is very important as a source of food for the people, and feed for livestock. Although some attention has been given to small-scale production of tef in some countries, the cultivation of tef as a cereal is largely confined to Ethiopia [2,3]. In Ethiopia, large area is allocated for its cultivation because of its multifold importance. Tef does not need chemicals for controlling storage pests, and can easily be stored under any local storage conditions [4]. Tef can be grown in intercropping with *gomenzer* (*Brassica carinata* Braun), sesame, safflower, sunflower, sorghum, maize and faba bean [5-8]. Because of its suitability to be grown on moisture stress and waterlogged areas where other crops can not successfully grow, tef has a complementary role in Ethiopian agriculture [4]. Besides, the straw is also valuable for farmers as it is used for construction of traditional granaries and houses.

Understanding the nature and magnitude of traits interrelationships, genetic variability, heritability and genetic advance is of the foremost importance in order to set selection criteria and practice effective selection. Although there are some reports in germplasm lines of tef [9-17], the information on the interspecific inbred lines of tef is inadequate. Therefore, the present work was proposed with the objective to study inter-trait relationships, the nature and extent of genetic variability, heritability and genetic advance of agronomic traits in RILs of *Eragrostis tef* and *E. pilosa* so as to practice direct and indirect selection.

MATERIALS AND METHODS

Experimental Locations

Field experiment was carried out at Alemtena and Debre Zeit Agricultural Research Center, Ethiopia. Debre Zeit is located at 8° 44' North, 38° 58' East and has an altitude of 1900 m.a.s.l. It receives a total annual rainfall of 652.8 mm and the mean annual temperature is 19.9°C. Alemtena is located at 8° 20' North, 39° East at an altitude of 1650 m.a.s.l. It receives a total annual rainfall of 638.0 mm and the mean annual temperature is 21.1 °C.

Experimental Materials and Management

Forty RILs developed by single seed descent method from the interspecific cross of a cultivar of *E. tef* (Kaye Murri) and an accession of *E. pilosa* (30-5) were used for this study (Table 1). The RILs, random selection from F_{10} generation, were grown on a plot of 2 m^2 consisting of 5 rows each 2 m long. The space between rows was 20 cm. At early tillering each row was thinned by allowing 10 cm distance between plants. The trial was laid out in randomized complete block design with four replications. Fertilization was done at the rate of 60 kg ha^{-1} N and 26 kg ha^{-1} P for *Vertisol* of Debre Zeit, and 40 kg ha^{-1} N and 26 kg ha^{-1} P for the light soil of Alemtena.

Data Collection and Analyses

Morpho-agronomic data were recorded as averages of ten randomly selected plants, except in the case of rind penetrometer resistance and crushing strength for which averages of five plants were used. The RILs were evaluated for days to heading and maturity, plant height (cm), panicle length (cm), number of productive tillers, spikelets per panicle, kernels per panicle, kernel weight per panicle (g), 100-kernel weight (mg), biomass yield per plant (g), grain yield per plant (g), harvest index (%), lodging index [18], rind penetrometer resistance and crushing strength on the first and second basal internodes using a rind penetrometer force gauge [19] and the values were expressed in Kg. Main tillers were evaluated for rind puncture resistance one cm from the first and the second nodes; two one cm cut sections of the main tiller stem, 2 cm up the first and second nodes were used to determine crushing strength.

Table 1: Description of the tef recombinant inbred lines (RILs) tested at Debre Zeit and Alem Tena

Sr. No.	Identification	Panicle form	Lemma color
1	RIL 6	Very loose	Purple
2	RIL 14	Very loose	Purple
3	RIL 16	Very loose	Variegated (yellow and red)
4	RIL 18	Very loose	Purple
5	RIL 22	Very loose	Purple
6	RIL 29	Very loose	Red
7	RIL 36	Very loose	Purple
8	RIL 38	Fairly loose	Variegated (grey and purple)
9	RIL 42	Compact	Purple
10	RIL 48	Compact	Red
11	RIL 72	Very loose	Purple
12	RIL 83	Very loose	Purple
13	RIL 86	Very loose	Purple
14	RIL 91	Very loose	Yellowish white
15	RIL 99	Very loose	Purple
16	RIL 118	Very loose	Variegated (yellow and purple)
17	RIL 123	Very loose	Variegated (yellow and purple)
18	RIL 133	Very loose	Variegated (grey and purple)
19	RIL 136	Very loose	Variegated (yellow and purple)
20	RIL 152	Very loose	Variegated (yellow and purple)
21	RIL 156	Very loose	Variegated (grey and purple)
22	RIL 168	Very loose	Purple
23	RIL 173	Very loose	Purple
24	RIL 197	Very loose	Red
25	RIL 222	Very loose	Grey
26	RIL 234	Very loose	Variegated (yellow and purple)
27	RIL 248	Very loose	Grey
28	RIL 257	Compact	Variegated (yellow and purple)
29	RIL 264	Very loose	Red
30	RIL 298	Very loose	Variegated (yellow and purple)
31	RIL 308	Very loose	Purple
32	RIL 313	Very loose	Purple
33	RIL 323	Very loose	Purple
34	RIL 344	Compact	Variegated (yellow and purple)
35	RIL 356	Compact	Purple
36	RIL 369	Very loose	Purple
37	RIL 371	Very loose	Variegated (grey and purple)
38	RIL 376	Very loose	Variegated (grey and purple)
39	RIL 383	Very loose	Red
40	RIL 397	Very loose	Purple

Hartley's [20] F-max ratio was used to test the homogeneity of error variances before analysing the combined data over locations. Genotypic and phenotypic components of variances were estimated as suggested by Burton and DeVane [21]. Heritability (h^2) in the broad sense for all traits was computed by the formula suggested by Allard [22]. Genetic advance (GA) was computed as per Johnson *et al.* [23]. Genetic advance as per cent of the mean was estimated by dividing the expected genetic advance by the respective population mean of the traits studied and multiplying by hundred. Correlation coefficients were estimated according to Miller *et al.* [24]. Significance of genotypic correlation coefficients was tested as per Robertson [25]. Path coefficient analysis was carried out to partition the genotypic correlation coefficients of the yield attributing traits into direct and indirect effects on grain yield using the general formula of Dewey and Lu [26].

RESULTS

Genetic Variability

The combined analysis of variance over the two test locations showed highly significant ($P<0.01$) mean squares due to RILs for the 17 traits evaluated. This reveals the presence of variability for the traits investigated (Table 2). Sizeable ranges of values were found for days to maturity, plant height, panicle length, 100-kernel weight, grains yield per plant, kernels per panicle, rind penetrometer resistance of the first and the second basal internodes (Table 3).

The estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) values of the traits studied are depicted in Table 5. The PCV values ranged from 5.63% for days to maturity to 20.58% for 100-kernel weight. Values of GCV ranged from 3.98% for days to maturity to 18.26% for 100-kernel weight.

Heritability

The estimates of heritability values of the traits studied are shown in Table 4. Heritability values ranged from 21.76% to 86.87%. Panicle length depicted the highest (87%) heritability followed by rind penetrometer resistance of the second (81.81%) and first (80.49%) basal internodes, 100-kernel weight (78.71%), kernel weight per panicle (77.78%), plant height (76.98%) and days to heading (74.81%). However, productive tillers (21.76%) and harvest index (25.22%) had relatively lower magnitudes of heritability.

Genetic Advance

Traits with higher estimates of genetic advance include 100-kernel weight (33.37%), rind penetrometer resistance of

Table 2: Combined analysis of variance for the traits investigated in interspecific RILs of Kaye Murri x *E. pilosa* (30-5)

Traits	Location (df=1)	RILs (df=39)	Location x RILs (df=39)	Error (df=234)	CV (%)
Days to heading	5144.0**	70.952**	17.874**	2.75	5.7
Days to maturity	17199.1**	196.689**	98.202**	20.833	5.18
Plant height (cm)	54389.8**	434.595**	100.046*	60.447	13.33
Panicle length (cm)	3565.8**	94.08**	12.338*	7.611	11.76
Productive Tillers	122.1**	4.655**	3.642**	1.207	13.9
Spikelets per panicle	776054.9**	7301.353**	4049.058**	1965.08	16.85
Kernels per panicle	26782005.3**	385243.791**	275284.373**	68955.2	15.23
Kernel weight/ Panicle (g)	0.248**	0.009**	0.002**	0.001	17.24
100- kernel weight (mg)	105.23**	121.499**	25.869**	8.745	15.62
Biomass yield/ Plant (g)	526.59**	4.223**	2.461**	0.582	12.66
Grain yield/ Plant (g)	63.48**	0.457**	0.147**	0.059	17.09
Harvest index (%)	2670.56**	93.147**	69.654**	17.407	17.82
Lodging index (%)	39874.68**	347.033**	117.646**	66.896	15.82
PF (kg)	0.001	0.041**	0.008	0.006	18.56
PS (kg)	0.024**	0.022**	0.004**	0.002	17.23
CS_1 (kg)	0.843	0.563**	0.316**	0.171	15.94
CS_2 (kg)	0.045	0.632**	0.307**	0.14	15.10

**, *=Significant at 1% and 5% probability levels, respectively. PF& PS =Rind penetrometer resistance of the first and the second basal internodes. CS_1 & CS_2=crushing strength of the first and the second basal internodes, df= degree freedom

Table 3: Estimates of means, ranges, standard error of mean of the traits investigated in interspecific RILs of Kaye Murri x *E. pilosa* (30-5) combined over locations

Characters	Range	Mean	SE (±)	LSD (5%)
Days to heading	24.0-34.38	29.097	0.586	2.31
Days to maturity	81.13-101.25	88.044	1.614	6.36
Plant height (cm)	40.4-80.4	58.33	2.749	10.83
Panicle length (cm)	17.16-32.34	23.456	0.975	3.84
Productive tillers	6.31-9.79	7.903	0.389	1.53
Spikelets/ panicle	203.69-327.13	263.09	15.67	61.76
Kernels/panicle	1189.8-2203.6	1724.7	92.84	365.8
Kernel weight/panicle (g)	0.12-0.25	0.188	0.012	0.04
100-kernel weight (mg)	13.0-29.63	18.933	1.046	4.12
Biomass yield/plant (g)	4.6-7.92	6.023	0.27	1.06
Grain yield/plant (g)	0.91-1.89	1.425	0.086	0.34
Harvest index (%)	13.19-33.26	23.408	1.475	5.81
Lodging index (%)	35.79-64.04	51.702	2.892	11.39
PF (kg)	0.29-0.53	0.405	0.027	0.12
PS (kg)	0.18-0.38	0.286	0.017	0.06
CS_1 (kg)	2.07-3.12	2.597	0.146	0.58
CS_2 (kg)	1.90-2.99	2.480	0.132	0.52

PF& PS= Rind penetrometer resistance of the first and the second basal internodes. CS_1 and CS_2= crushing strength of the first and the second basal internodes

the first (29.31%) and the second (30.90%) basal internodes, kernel weight per panicle (28.58%), panicle length (26.17%), grain yield per plant (23.44%) and plant height (20.04%). However, productive tillers (4.33%), days to maturity (5.81%), kernels per panicle (7.48%), harvest index (7.57%) and crushing strength of the first basal internode (9.23%) were traits with lower values (Table 4).

Correlation of Grain Yield Per Plant with other Agronomic Traits

The correlation study showed a positively significant ($p<0.01$) genotypic and phenotypic associations of grain yield per plant with days to maturity, panicle length, 100-kernel weight, biomass yield per plant and harvest index (Table 5).

Genotypic Path Analysis of Grain Yield Per Plant

The result of the genotypic path analysis is presented in Table 6. Nine traits, out of the total 16 used, depicted positive direct effect on yield per plant. Traits like panicle length (0.436), biomass yield per plant (0.391), crushing strength of the second basal internode (0.380), harvest index (0.371), days to heading (0.233), penetrometer resistance of the first basal internode (0.157) and kernel weight per panicle (0.111) exerted strong positive direct effects. However, plant height, 100-kernel weight, rind penetrometer resistance of the second and crushing strength of the first basal internodes exerted higher negative effects. Generally, most of the traits investigated exerted strong and positive indirect effects via panicle length, biomass yield per plant, harvest index and crushing strength of the second internode.

DISCUSSION

In this study, the highly significant difference detected and the substantial ranges of means for most of the traits considered indicate the presence of sufficient genetic variability in the RILs and the possibility of genetic improvement of the test lines through selection. The finding is in harmony with the findings of Assefa *et al.* [13,14].

The PCV value was generally higher than the corresponding GCV for all the traits studied. However, the differences between PCV and GCV values for harvest index, kernels per panicle and productive tillers were comparatively wide, indicating the influence of environment in determining these traits. Similar findings were reported by Tefera *et al.* [10] and Assefa *et al.* [13] for days to heading and maturity, plant height and panicle length in germplasm lines of tef. Low magnitude PCV values were estimated for kernel weight per panicle, biomass yield per plant and grain yield per plant as compared to the findings of Assefa *et al.* [13].

Table 4: Estimates of PCV, GCV, heritability in the broad sense (h^2) and genetic advance (GA) of the traits investigated in interspecific RILs of Kaye Murri x *E. pilosa* (30-5) combined over locations

Characters	PCV (%)	GCV (%)	h^2 (%)	GA	GA as % of mean
Days to heading	10.235	8.852	74.81	4.58	15.77
Days to maturity	5.632	3.985	50.07	5.12	5.81
Plant height (cm)	12.636	11.086	76.98	11.69	20.04
Panicle length (cm)	14.620	13.628	86.87	6.14	26.17
Productive tillers	9.652	4.503	21.76	0.34	4.33
Spikelets/ panicle	11.483	7.664	44.54	27.72	10.54
Kernels/panicle	12.723	6.798	28.54	129.03	7.48
Kernel weight/panicle (g)	17.841	15.734	77.78	0.054	28.58
100-kernel weight (mg)	20.584	18.261	78.71	6.32	33.37
Biomass yield/plant (g)	12.063	7.792	41.72	0.62	10.37
Grain yield/plant (g)	16.773	13.814	67.83	0.33	23.44
Harvest index (%)	14.577	7.321	25.22	1.77	7.57
Lodging index (%)	12.739	10.357	66.09	8.97	17.35
PF (kg)	17.676	15.858	80.49	0.12	29.31
PS (kg)	18.336	16.585	81.81	0.09	30.90
CS_1 (kg)	10.215	6.766	43.87	0.24	9.23
CS_2 (kg)	11.333	8.127	51.42	0.29	12.01

PCV= phenotypic coefficient of variation, GCV= genotypic coefficient of variation. PF and PS= Rind penetrometer resistance of the first and the second basal internodes. CS_1 and CS_2= crushing strength of the first and the second basal internodes

The high GCV values of 100-kernel weight, rind penetrometer resistance of the second and the first basal internodes, kernel weight per panicle, grain yield and panicle length shows that genetic improvement of these traits could be effective due to the presence of comparatively higher level of genetic variability. Similar results were reported for kernel weight per panicle in intraspecific RILs of tef [27], for days to heading and maturity, plant height and panicle length [13]. The values were generally of low-order of magnitude for most traits except plant height and days to maturity, which are comparable to the findings of Tefera *et al.* [10] in tef germplasm lines. Low order GCV values were estimated for kernel weight per panicle, biomass yield per plant and grain yield per plant as compared to the findings of Assefa *et al.* [13].

High heritability values of panicle length, rind penetrometer resistance of the second and first basal internodes, 100-kernel weight, kernel weight per panicle, plant height and days to heading shows that the characters are least influenced by environmental factors and genetic improvement through selection could be effective. The result is in harmony with the findings of Tefera *et al.* [10]. Similar findings were reported by Assefa *et al.* [13-15] and Hundera *et al.* [12] for panicle length and days to heading in germplasm lines of tef. On the other hand, the comparatively lower estimates of productive tillers, harvest index and kernels per panicle, however, indicates limited possibility of improvement of these traits via direct selection. In this work, the heritability estimates were generally of high-order of magnitude for most of the traits considered as compared to the findings of Tefera *et al.* [27,28] in intra- and inter-specific RILs of tef.

The expected genetic advance, expressed as per cent of the mean by selecting the top five per cent of the RILs, varied from 4.33% to 33.37%. This indicates that selecting the top 5 per cent of the base population could result in an advance of 4.33% to 33.37% over the population mean depending on the traits. Hundred-kernel weight, rind penetrometer resistance of the first and the second basal internodes, kernel weight per panicle, panicle length, grain yield per plant and plant height were traits with higher estimates of genetic advance. The result generally agreed to that reported by Assefa *et al.* [15] and Tefera *et al.* [10]; however, the values were generally high in magnitude for most traits considered as compared to the findings of Tefera *et al.* [27,28].

Traits like 100-kernel weight, rind penetrometer resistance of the first and the second basal internodes, kernel weight per panicle, panicle length, plant height and grain yield per plant depicted high heritability along with high genetic advance. Similar observation was reported by Tefera *et al.* [10] and Hundera *et al.* [12] Johnson *et al.* [23] stated that the utility of heritability is increased when it is used in concurrence with genetic advance. Also, GCV together with heritability estimate would indicate the amount of advance expected from selection [29,30]. In this study panicle length, rind penetrometer resistance of the first and the second basal internodes, 100-kernel weight, kernel weight per panicle, plant height and grain yield per plant had high estimates of GCV, heritability in the broad sense and genetic advance. These traits could, therefore, be used for improvement of tef RILs through selection. Direct selection for these traits could be very effective due to minimum environmental masking effect.

The correlation of grain yield per plant suggests that RILs with longer phenology, vigorous plant types, higher kernel weight per panicle, larger seed size and higher harvest index are high yielders. These findings are in conformity with that of Mengesha *et al.* [9]. However, it is always important to partition the correlation coefficients into direct and indirect effects through component traits.

The genotypic path analysis revealed that the traits included in the study explained 95.6% of the variability of yield per plant. Only 4.4% of the variability was attributed to other factors (error and traits which are not included). The higher direct effects of panicle length (0.436), biomass yield per plant (0.391), crushing strength of the second basal internode (0.380), harvest index (0.371), days to heading (0.233), penetrometer resistance of the first basal internodes (0.157) and kernel weight per panicle (0.111) implies the possibility of yield improvement by simultaneous indirect selection for these traits. These traits also have strong correlation with yield except penetrometer resistance of the first and crushing strength of the second basal internodes. The weak association of these two traits with yield was due to the high negative counterbalancing effects of rind penetrometer resistance of the second and crushing strength of the first basal internodes. However, the positive and strong direct effects of these two traits connote that yield improvement could be brought about by selection of lines with strong internodes.

Table 5: Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients in 40 RILs of *Eragrostis tef* (Kaye Murri) x *E. pilosa* (30-5) for the combined data over two locations

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Days to heading		1.04**	0.83**	0.73*	0.24	0.33	-0.08	0.62	0.88**	0.78	0.65	0.59	0.24	0.51	0.54	0.28	0.58
2. Days to maturity	0.58**		1.13**	1.08**	0.33	0.69	0.07	0.84**	1.14**	0.13	0.99**	1.66	0.62	0.48	0.59	-0.26	0.45
3. Plant height (cm)	0.73**	0.66**		0.90**	-0.04	0.36	0.09	0.84**	0.94**	0.62	0.53	0.61	0.35	0.76*	0.80**	0.46	0.71
4. Panicle length (cm)	0.67**	0.66**	0.87**		-0.08	0.50	0.33	0.80**	0.84**	0.70	0.75*	0.89**	0.31	0.70	0.75*	0.36	0.67
5. Productive tillers	-0.08	0.01	-0.15	-0.13		0.57	0.12	-0.23	0.01	0.65	0.50	0.52	0.27	-0.95**	-0.67	-0.62	-0.63
6. Spikelets/ panicle	0.19	0.21	0.38*	0.43**	0.02		1.11*	0.80*	0.17	0.14	0.23	0.58	0.55	0.07	0.84**	1.28	1.32
7. Kernels/panicle	0.06	-0.02	0.16	0.26	-0.13	0.65**		0.77	-0.19	-0.13	0.27	1.01**	0.55	1.30	1.05**	2.01	1.43
8. Kernel weight/panicle (g)	0.40**	0.55**	0.67**	0.70**	-0.11	0.51**	0.40**		0.57	0.35	0.67	0.97**	0.30	0.70	0.78*	0.24	0.68
9. 100-kernel weight (mg)	0.62**	0.74**	0.72**	0.72**	-0.01	0.13	0.02	0.58**		0.93**	0.98**	0.96**	0.65	0.49	0.58	-0.05	0.72
10. Biomass yield/plant (g)	0.44**	0.32*	0.36*	0.43**	0.19	-0.04	-0.12	0.23	0.51**		0.98**	0.76	0.31	0.33	0.51	-0.39	0.39
11. Grain yield/plant (g)	0.45**	0.58**	0.45**	0.59**	0.19	0.13	0.03	0.60**	0.69**	0.58**		0.95**	0.52	0.24	0.37	-0.42	0.29
12. Harvest index (%)	0.19	0.43**	0.29	0.38*	0.10	0.18	0.16	0.57**	0.43**	-0.10	0.74**		0.79	0.17	0.26	-0.45	0.25
13. Lodging index	0.20	0.42**	0.27	0.24	0.14	0.12	0.16	0.22	0.49**	0.16	0.35*	0.32*		0.10	0.21	-0.26	0.25
14. PF (kg)	0.38*	0.29	0.65**	0.62**	-0.31*	0.05	0.57**	0.63**	0.45**	0.20	0.23	0.14	0.08		0.94**	0.94**	1.12**
15. PS (kg)	0.42**	0.38*	0.68**	0.67**	-0.28	0.51**	0.51**	0.68**	0.51**	0.30	0.32*	0.16	0.14	0.92**		0.76	1.07**
16. CS_1 (kg)	0.09	-0.04	0.29	0.26	-0.23	0.48**	0.64**	0.27	0.05	-0.11	-0.20	-0.16	-0.13	0.68**	0.56**		0.68
17. CS_2 (kg)	0.33*	0.25	0.49**	0.50**	-0.13	0.53**	0.51**	0.52**	0.46**	0.20	0.31*	0.22	0.18	0.81**	0.75**	0.54**	

**, *= Significant at 1% and 5% probability levels, respectively. PF& PS =Rind penetrometer resistance of the first and the second basal internodes
CS_1 and CS_2= crushing strength of the first and the second basal internodes.

Table 6: Genotypic direct (bold face and diagonal) and indirect effects of various characters on grain yield per plant of 40 RILs of *Eragrostis tef* (Kaye Murri) x *E. pilosa* (30-5) for the combined data over two locations

Characters	r_g	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Days to heading	**0.653**	**0.233**	-0.119	-0.201	0.317	-0.004	0.006	0.003	0.069	-0.193	0.304	0.218	0.020	0.081	-0.210	-0.090	0.220
2. Days to maturity	**0.992**	0.242	**-0.115**	-0.275	0.471	-0.005	0.013	-0.003	0.093	-0.251	0.051	0.614	0.052	0.076	-0.229	0.084	0.173
3. Plant height (cm)	**0.531**	0.193	-0.130	**-0.242**	0.392	0.001	0.007	-0.003	0.094	-0.208	0.243	0.228	0.029	0.119	-0.312	-0.149	0.268
4. Panicle length (cm)	**0.752**	0.169	-0.124	-0.218	**0.436**	0.001	0.009	-0.013	0.089	-0.186	0.274	0.330	0.026	0.109	-0.293	-0.115	0.256
5. Productive tillers	**0.497**	0.045	0.016	0.049	0.124	**0.000**	0.000	0.000	0.007	0.040	0.074	0.050	0.001	0.010	0.066	0.013	0.059
6. Spikelets/ panicle	**0.234**	0.077	-0.080	-0.087	0.216	-0.009	**0.019**	-0.042	0.090	-0.038	0.054	0.214	0.046	0.011	-0.327	-0.411	0.501
7. Kernels/panicle	**0.269**	-0.019	-0.008	-0.021	0.146	-0.002	0.021	**-0.038**	0.086	0.042	-0.050	0.375	0.046	0.204	-0.406	-0.648	0.542
8. Kernel weight/panicle (g)	**0.674**	0.145	-0.096	-0.204	0.348	0.004	0.015	-0.029	**0.111**	-0.126	0.136	0.360	0.025	0.110	-0.303	-0.077	0.257
9. 100-kernel weight (mg)	**0.980**	0.204	-0.131	-0.228	0.367	0.000	0.003	0.007	0.064	**-0.221**	0.363	0.357	0.055	0.077	-0.226	0.016	0.273
10. Biomass yield/plant (g)	**0.980**	0.181	-0.015	-0.151	0.306	-0.010	0.003	0.005	0.039	-0.205	**0.391**	0.282	0.026	0.052	-0.196	0.124	0.148
11. Harvest index (%)	**0.947**	0.137	-0.190	-0.149	0.387	-0.008	0.011	-0.038	0.108	-0.213	0.297	**0.371**	0.066	0.027	-0.099	0.145	0.096
12. Lodging index	**0.519**	0.055	-0.071	-0.085	0.136	-0.004	0.011	-0.021	0.033	-0.144	0.121	0.293	**0.084**	0.016	-0.083	0.083	0.096
13. PF (kg)	**0.237**	0.120	-0.055	-0.184	0.303	0.015	0.001	-0.049	0.078	-0.108	0.130	0.063	0.009	**0.157**	-0.367	-0.303	0.427
14. PS (kg)	**0.370**	0.126	-0.068	-0.195	0.329	0.011	0.016	-0.040	0.087	-0.129	0.197	0.095	0.018	0.148	**-0.388**	-0.244	0.407
15. CS_1 (kg)	**-0.415**	0.065	0.030	-0.112	0.155	0.010	0.024	-0.077	0.027	0.011	-0.151	-0.167	-0.022	0.148	-0.295	**-0.322**	0.259
16. CS_2 (kg)	**0.291**	0.135	-0.052	-0.171	0.294	0.010	0.025	-0.054	0.075	-0.158	0.152	0.094	0.021	0.176	-0.416	-0.219	**0.380**

r_g =genotypic correlation. PF& PS =Rind penetrometer resistance of the first and the second basal internodes. CS_1 and CS_2=crushing strength of the first and the second basal internodes
Residual effect =0.044

CONCLUSION

The study revealed the presence of immense variability and sizable association of traits in the RILs of tef under investigation. To improve the tef RILs, direct selection for rind penetrometer resistance of the first and the second basal internodes, 100-kernel weight, kernel weight per panicle, plant height and grain yield per plant could be very effective due to high level of variability and minimum environmental masking effect.

It could also be concluded that panicle length, biomass yield per plant, crushing strength of the second basal internode, harvest index, days to heading, penetrometer resistance of the first basal internode and kernel weight per panicle, could be set as indirect simultaneous selection criteria in the interspecific RILs of tef besides selection for yield *per se*.

ACKNOWLEDGMENTS

This study was financed by the McKnight Foundation's Collaborative Crop Research Project on tef. The work of the technical staff of Tef Improvement Project, Debre Zeit Agricultural Research Center is highly appreciated.

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