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Full Length Research Paper

Drought-resistance traits variability in *Eragrostis tef* X *Eragrostis pilosa* recombinant inbred lines

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Tef [*Eragrostis tef* (Zucc.) Trotter] occupies two million hectares of land each year, which accounts for 28% of the total acreage. However, its productivity is constrained by drought. Development of drought resistant variety through inter-specific conventional crossing is crucial. Twenty five recombinant inbred lines (RILs) of *E. tef* var Kay Murii and *Eragrostis pilosa* were evaluated against the standard check and two parental lines to assess drought resistance trait variability under low moisture-stressed and non-stressed conditions using randomized complete block design of three replications. The experiment was conducted under rainout shelter at Debre Zeit, Ethiopia. Significant (p<0.05) differences were observed among genotypes for days-to-panicle-emergence, days-to-mature, tiller number, root length, root number, root biomass, shoot biomass and grain yield. All traits had shown high level of phenotypic and genotypic coefficients of variation, high estimates of heritability and genetic advance. Most RILs were early maturing and resist the moisture stress effect (<20% yield reduction), while key murii and few other RILs were strongly affected. Under stressed condition, RIL-16 and RIL-290 were superior in grain yield to all genotypes and most RILs had shown high value of water use efficiency. Based on drought susceptible index, 17 drought resistant RILs were identified. The result demonstrated wide variability among RILs for drought resistance traits and the potential of *E. pilosa* to widen tef gene pool.

Key words: Drought resistance*, Eragrostis pilosa,* RILs, tef.

INTRODUCTION

Tef [*Eragrostis tef* (Zucc.) Trotter] is one of the major cereal crops cultivated in Ethiopia. About two million hectare of land is covered by tef each year, which accounts for 28% of the total acreage (CSA, 2008). Tef flour is used by Ethiopians to make an unleavened sourdough bread called "injera.". It is also used as porridge or ingredient of home-brewed alcoholic drinks. The straw is utilized as feed for livestock. The nutritive value of its grain compares well with some of the major cereals such as wheat, barley, maize and sorghum (Wondimu and Tekabe, 2001).

The productivity of tef is very low (10 qt/ha). This is due to low yielding potential of the land races, susceptibility to lodging, poor management practices and moisture stresses (Teferra et al., 2000). Tef is considered to be resistant to moisture stresses, however, significant amount of yield loss were reported by various authors: Ayele (1993) accounted that 40% of grain yield loss of tef was as a result of moisture stress commenced on vegetative stages. Takele (1997, 2001) indicated that 7.3 to 85.1% grain yield loss of tef was due to drought under greenhouse and 69 to 77% yield loss under field conditions occurred at pre-flowering stage. According to these works, huge amount of yield loss is accounted by drought alone and it has to be considered as a major production constraints.

Wild relatives of crop plants are sources of genes for superior traits, which can be incorporated into crop species and have been utilized in most cereal crops (Jones et al., 1995). Little activities have been done in tef as compared to wheat, the most benefited crop from wild species (Jones et al., 1995). The only wild relative that has been used in tef breeding program is *E. pilosa* (Tefera et al., 2003). It is characterized by its wide adaptability including environments more adverse to tef cultivation, early maturing and short stature (Tefera et al., 2003). The Authors produced recombinant inbred lines (RILs) from *E .tef* cv. Key Murri (2n = 4× = 40) cross with a

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Table 1. List of RILs, the two parental lines (*E. tef* and *E. pilosa*) and standard check (DZ-Cr-37) with description of panicle form and seed color.

No	Plant materials	Panicle form	Seed color
1	E. pilosa	Very loose	Brown
2	Key Murri	Compact	Yellow white
3	DZ-Cr-37	Very loose	White
4	RIL-317	Loose	White
5	RIL-252	Very loose	White
6	RIL-118	Loose	White
7	RIL-172	Semi-compact	White
8	RIL-124	Compact	White
9	RIL-12	Compact	White
10	RIL-364	Very loose	White
11	RIL-36	Semi-compact	White
12	RIL-290	Very loose	Light brown
13	RIL-29	Very loose	Light brown
14	RIL-337	Loose	Light brown
15	RIL-173	Loose	Light brown
16	RIL-66	Very loose	Light brown
17	RIL-16	Very loose	Light brown
18	RIL-226	Loose	Light brown
19	RIL-197	Semi-loose	Light brown
20	RIL-37	Loose	Deep brown
21	RIL-9	Very loose	Deep brown
22	RIL-233	Very loose	Deep brown
23	RIL-139	Semi-loose	Deep brown
24	RIL-183	Semi-compact	Deep brown
25	RIL-62	Very loose	Deep brown
26	RIL-222	Semi-compact	Deep brown
27	RIL-275	Very loose	Deep brown
28	RIL-313	Very loose	Deep brown

premise that some desirable traits of *E. pilosa* can be transferred into *E. tef* cv.

Key Murri, which is a tall, thick culmed and late maturing cultivar and susceptible to drought. The meiotic chromosome behavior of the RILs was found to be normal and the variations among RILs will not be attributed by irregularities in moitic chromosome (Admas and Dagne, 2009). Tefera et al. (2003) evaluated the RILs for their performance under field condition and observed wide variability among RILs for most agronomic traits and superior RILs in grain yield to parental lines and standard check were obtained. The RILs have not yet been evaluated under low moisture stressed conditions. Therefore, the experiment was conducted to examine the level of drought-resistance related traits variability among RILs, parental lines and standard check (Dz-Cr-37) and to see the potential of *E. pilosa* to widen tef germplasm for moisture stress.

MATERIALS AND METHODS

Twenty-five RILs derived from a cross between *E. tef* cv. Key Murri and *E. pilosa* (accession 30-5), parental lines and DZ-Cr-37 (standard check) genotypes were used for the study. The descriptions of the genotypes are presented in Table 1. The RILs had been developed using single-seed-descent method from F_2 individual plants. The experiment was carried out using 168 plastic pots (with 30 cm internal diameter and 30 cm depths) in the rainout shelter at Debre Zeit Agricultural Research Center (DZARC), Ethiopia in 2007/2008. The average minimum and maximum temperature of DZARC are 9 and 25°C respectively, but at the experimental time, there were 13.1 and 25.72°C respectively. Each pot was filled with 10 kg of dry black heavy clay soil (that is, Pellic Vertisol). Ten plants were transplanted in each pot and thinned to six plants. Urea (2.2 g/pot) at tillering and DAP (3.8 g/pot) at planting were administered based on 100 kg/ha urea and 150 kg/ha DAP recommended rate for black soil. Randomized complete block design with three replications was employed. The treatments were two moisture regimes (non moisture-stressed and moisture-stressed) and genotypes. Under non-stressed conditions, the genotypes were regularly watered at field capacity until maturity. While in the stress treatment, water stress was induced by withholding irrigation for 20 days at pre-flowering stage (that is, 45 days after sowing). The average weight of the pot at field capacity was 15.6 kg (that is, 15 kg the weight of the soil at field capacity plus 0.6 kg the weight of the pot). The moisture level was maintained at 10 to 20% (11.1 to 11.6 kg of pot weight) for stressed treatment and 70 to 100% (14.1 to 15.6 kg of pot weight) for non-stressed treatment of the available water. This was done by weighing each pot every other day and the moisture loss were replenished to required level.

The following data were collected from both moisture stressed and non-stressed conditions:

(i) Days to panicle emergence (DTPE): Days from sowing to the stage when 50% of the plants in a pot emerge panicle.
(ii) Days to maturity (DTM): Days from sowing to the stage when 90% of the panicle per population mature.
(iii) Tiller number (NT): The average number of fertile tillers of six plants.
(iv) Root length (TRL): The total root length measured from crown up to root tips in cm. Total root length was measured using bar graph paper.
(v) Root number (RN): The number of adventitious roots 1cm below the crown.
(vi) Root weight (RB): Oven dry weight (80°C for 24 h) of roots in gram.
(vii) Shoot weight (SB): Oven dry weight (80°C for 24 h) of above ground part in gram at the beginning and end of the stress.
(viii) Grain yield (GY): The weight of the seed harvested from six plants in gram.
(ix)Relative grain (RGY) and Shoot Biomass (RSBY) yield: The yield difference between non-stress and stress conditions divided by non-stress conditions expressed in percentage.
(x) Drought susceptibility index (DSI): DSI was calculated using the following formula set by Fisher and Maurer (1978):

$$DSI = [(1-Y_S/Y_C) / (1-Y_{AS}/Y_{AC})]$$

where, YS=grain yield from stressed pot of given genotype, Y_C= grain yield from non-stressed pot of the same genotype, Y_{AS}= average grain yield of all genotypes from the stressed pot, Y_{AC}= average grain yield of all genotypes from the non-stressed.

(xi) Excised leaf water loss (ELWL): ELWL was calculated as (FLW-2DLW)/DLWH, where FLW= Fresh leaf weight, 2DLW=two hours dry leaf weight, DLWH= twenty four hours dry leaf weight. The procedures were as follows, ten fully expanded leaves were randomly sampled from each pot during the middle of the stress period. The fresh weight was measured immediately and the leaves were left to wilt for two hours at 30°C and then weighed. The leaves were then oven-dried at 80°C for twenty four hours and the dried weight was measured (Clark, 1987).
(xii) Water use efficiency (WUE): WUE was equated as total dry matter divided by total amount of water used (Blum, 1988).

The collected data for each trait were subjected to statistical analysis of variance using AGRO BASE 99 (1999). The variability of each trait was estimated by simple statistical measures such as mean, range, phenotypic and genotypic variances and coefficient of variation as suggested by Falconer and Markay (1996). Broad sense heritability (H) and expected genetic advance (GA) was calculated using the formula given by Allard (1960).

$Vp = Vg + Ve$; $Vg = (MSg - MSe)/r$; $PCV = [(Vp)\ 1/2/\mu] \times 100$; $GCV = [(Vg)\ 1/2/\mu] \times 100$;

$H = Vg/Vp$; $GA = K \times H \times (Vp)^{½}$ and GA (% of mean) = $(GA/\mu) \times 100\%$,

where: Vp= phenotypic variance, Vg= genotypic variance, Ve= environmental variance, MSg= mean square of genotypes, MSe= mean square of error, r= number of replication, PCV= phenotypic coefficient of variation, μ= population mean, GCV= genotypic coefficient of variation and K= selective intensity at 5% (2.06).

RESULTS AND DISCUSSION

Analysis of variances (ANOVA)

Analysis of variance revealed that significant differences among genotypes were observed for all traits at both moisture levels (Table 2). The variation among genotypes due to error was almost nil for all traits except total root length (254.72 under stressed and 187.52 under none stressed) and root number (9.2 under stressed and 15.29 under none stressed) which means that the difference among genotypes is purely genetic and these variability occurred as a result of recombination in addition to the different degree of contribution of alleles from their parental lines into the RILs.

Coefficients of variation, heritability and genetic advances

Wide range of phenotypic (PCV) and genotypic (GCV) coefficient of variation were observed (Table 3). PCV range of 3.8 (DTM) to 38.9 (GY) and GCV range of 3.5 (DTM) to 36 (GY) under stressed. Generally, PCV and GCV values of all the traits were very close under both moisture levels. The variability observed among genotypes for both moisture leves is sufficient, which is important for creating new gene pool in tef germplasm. All the traits considered have high value of heritability accompanied by high value of genetic advance except shoot biomass under non-stressed condition and number of tiller under stressed. Both are required for effective selection to improve the traits (Johanson et al., 1995). In tef, selections towards shoot biomass and grain yield are highly effective under a low moisture-stressed condition, which has been employed in most cereal crops (Araus et al., 2002).

Phenological development

The phenological result indicated that Key Murri delayed days to panicle emergence (DTPE), while most RILs, *E. pilosa* and Dz-Cr-37 hastened DTPE under stressed condition. No RILs headed before *E. pilosa*. Regarding days to maturity (DTM), *E. pilosa* was the earliest and Key Murri was the latest to mature (Table 4). Early maturing crop varieties often escape drought because they complete the critical stages of crop growth prior to the setting of drought condition. This mechanism involves rapid phenological development (early flowering and early maturity) (Blum, 1988). Result from phenological data indicated that there is a possibility of developing early maturing genotypes which can escape terminal and RILs produced better grain yield and biomass yield and can be considered as drought resistant. Root growth retardation was highest in RIL-364, RIL-275, RIL-290, RIL-36 and Key Murri, which were highly affected by drought.

Table 2. Mean square for drought-resistance related traits of the genotypes in 2007.

Moisture stress						**Mean squares**			
SV	**DF**	**DTPE**	**DTM**	**NT**	**SB**	**TRL**	**RN**	**RB**	**GY**
Replication	2	68.1**	24.7**	14.4**	0.34**	927.9**	14.1**	0.2**	0.68**
Genotypes	27	54.6**	38.4**	11.7**	0.75**	36959**	35.1**	0.68**	9.49**
Error	54	13.1	1.6	5.8	0.31	254.72	9.2	0.182	0.9
CV (%)		8.9	1.3	29.4	52.2	8.24	15.7	24.2	21.3
Non moisture stress									
Replication	2	8.2	0.7	20.2**	88.2**	748.54**	0.23**	0.032**	6.6**
Genotypes	27	66.4**	34**	4.21*	107**	2790.67**	23.7*	0.597**	0.94**
Error	54	4.5	5.3	4.01	23.8	187.52	15.29	0.06	22.76
CV (%)		5.3	2.6	28.4	16.96	7.78	22.1	22.79	2.9

DF = degree of freedom; SV=source of variation; DTPE = days to panicle emergence; DTM = days to maturity; NT = tiller number; SB = shoot biomass; TRL = total root length, RN = root number, RB = root weight; GY = grain yield.

Table 3. Genotypic (GCV) and phenotypic (PCV) coefficients of variation, heritability and genetic advance of drought-resistance related traits of the genotypes in 2007.

Non-stressed						**Stressed**				
Traits	**PCV**	**GCV**	**H (%)**	**GA**	**GA % mean**	**PCV**	**GCV**	**H (%)**	**GA**	**GA % mean**
DTPE	12.3	11.2	82.6	8.5	20.9	11.7	11.3	93.1	9	22.4
DTM	4.5	4.4	97.3	8.7	8.9	3.8	3.5	84.5	5.9	6.7
PnL	14.1	10.1	50.2	3.7	15	17.8	12.6	50.1	4.0	18.4
PLH	11.6	9.9	72.4	11.9	17.3	10.6	8.8	68.6	8.6	15.1
NT	27.1	21.0	60.7	2.8	33.7	16.7	3.7	4.8	0.1	1.6
TRL	19.2	18.7	95.4	72.6	37.6	25	24.1	93.1	67.3	47.9
RN	17.2	11.6	45.2	2.84	16.1	17.7	15.2	73.8	5.2	27.1
RB	61.1	58.9	93.1	1	117.1	38.4	32.9	73.1	0.72	57.9
SB	1.8	1.4	68.2	0.8	2.5	22.8	20.1	77.8	9.6	36.5
GY	42	40.6	93.4	4.1	80.9	38.9	36	85.7	2.6	68.6

DTPE = Days to panicle emergence; DTM = days to maturity; PnL= panicle length; PLH=plant height; NT= tiller number; total root length = TRL, RN = root number; RB = root biomass; SB = shoot biomass; GY = grain yield.

Yield and agronomic drought related traits

The effect of drought varies depending on the intensity of drought stress, genotypes and the stages of growth at which the stress commences. In tef, the effect is more severe when the stress occurs during the vegtative growth stages than at grain filling period (Teferra et al., 2000). In the present study, moisture stress resulted number of

Table 4. Mean values of drought-resistance related traits of genotypes in 2007/2008.

No	RILs	DTPE		DTM		NT		RN		TRL		RB		SB		LSBY	GY		LGY	ELWL		WUE		DSI
		NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S		NS	S		NS	S	NS	S	
1	***E. pilosa***	34	28	88	82	9.4	7.0	15.3	21.3	180.6	206.3	1.1	1.2	33.4	30.1	9.9	4.3	4.1	4.0	1.82	1.03	0.483	0.409	0.34
2	Key Murri	54	57	104	93	6.3	4.8	16.7	20.7	169.3	215.0	0.6	1.7	51.3	25.7	49.9	6.6	2.6	61.4	2.22	2.21	0.731	0.36	2.11
3	DZ-Cr-37	42	41	96	90	7.4	8.0	27.0	22.0	317.5	215.5	1.2	0.9	42.6	37.4	12.2	5.8	5.5	5	1.85	1.06	0.62	0.534	0.49
4	RIL183	43	40	94	86	8.0	6.4	18.3	16.3	205.3	166.1	0.7	1.8	25.6	18.9	26.2	2.7	2.5	8.3	2.13	2.3	0.345	0.326	0.51
5	RIL-62	42	41	97	88	9.7	9.6	13.3	13.3	110.0	176.8	0.9	1.6	38.9	30.7	21.1	7.6	5.4	29	2.32	1.26	0.589	0.532	1.03
6	RIL-252	48	49	101	95	6.1	6.7	18.7	20.7	199.2	209.1	1.3	1.4	33.4	27.6	17.4	2.5	1.9	20	1.5	2.07	0.324	0.31	0.92
7	RIL-29	42	41	98	87	4.5	5.8	18.7	19.0	255.3	195.3	2.1	1.4	31.8	24.3	23.6	4.3	0.3	92.3	2.08	2.17	0.648	0.343	3.25
8	RIL-118	37	38	99	87	9.9	6.3	20.0	19.7	175.1	193.1	0.3[J]	1.5	32.2	23.2	27.9	5.1	4.3	17	2.11	1.35	0.491	0.481	0.5
9	RIL-172	39	39	97	87	12.9	5.5	23.0	16.7	231.2	161.6	0.6	0.9	28.1	19.9	29.2	4.6	3.9	15.7	1.93	1	0.485	0.295	0.54
10	RIL-222	42	49	95	88	7.3	7.3	14.3	16.3	152.9	144.2	1.1	1.3	36.2	30.3	16.6	3.7	1.4	63.5	1.54	1.88	0.388	0.42	2.22
11	RIL-317	35	38	97	88	7.2	8.1	17.7	21.7	122.6	177.8	0.8	0.8	27.6	25.2	8.7	4.9	4.3	11.6	2.15	1.22	0.402	0.43	0.39
12	RIL-337	41	39	97	90	7.3	6.8	16.0	13.3	162.5	141.6	1.1	1.4	28.7	25.9	9.8	5.1	4.7	8.6	2.22	1.06	0.423	0.429	0.31
13	RIL-173	36	36	98	87	11.1	7.4	14.7	22.3	127.9	163.3	0.8	0.8	30.7	27.7	9.8	4.6	3.9	15.7	1.67	1.43	0.413	0.42	0.54
14	RIL-66	37	40	102	94	5.3	8.4	15.0	16.3	145.4	174.8	1.6	1.1	23.5	27.2	-15.8	3.7	2.9	20.3	1.37	1.93	0.345	0.38	0.67
15	RIL-16	46	43	103	94	8.6	8.3	16.3	28.7	158.3	156.1	0.6	1.1	41.6	49.7	-20	5.2	7.9	-53	1.95	0.7	0.59	0.74	0.51
16	RIL-37	43	39	100	89	8.8	6.3	16.7	17.0	224.4	170.4	2.3	1.3	32.9	25.5	22.5	5.1	4.7	7.8	1.88	1.22	0.51	0.49	0.27
17	RIL-226	41	41	92	84	8.1	5.2	16.3	16.7	162.1	194.6	0.9	0.9	45.3	28.6	36.9	7.1	5.4	24.2	2.11	1.2	0.665	0.54	0.81
18	RIL-9	41	38	97	87	8.3	5.5	17.3	17.7	182.0	246.9	0.8	1.2	29.4	26.6	9.5	4.5	3.8	15.1	1.69	1.09	0.445	0.45	0.59
19	RIL-233	40	38	96	88	6.3	7.0	15.7	16.0	177.4	241.3	0.9	1.1	41.4	25.4	38.7	8.0	4.1	48.4	2.4	1.15	0.629	0.49	1.36
20	RIL-139	37	36	92	83	11.1	8.3	18.3	18.0	162.5	181.6	0.8	0.8	22.8	18.9	17.1	6.4	3.7	42.2	1.95	1.65	0.439	0.37	1.45
21	RIL-197	44	42	102	92	9.0	8.3	16.7	24.0	201.6	171.6	0.9	0.9	30.1	26.5	12	5.6	3.5	38	1.78	1.41	0.497	0.39	1.27
22	RIL-124	38	38	94	86	6.8	6.4	21.7	18. 3	282.6	204.2	1.5	1.7	29.1	24.1	17.2	3.9	3.5	10.4	1.62	1.47	0.427	0.38	0.36
23	RIL-364	42	42	98	87	6.7	7.4	19.7	24.0	221.3	166.9	1.5	1.7	34.0	27.5	19.1	4.8	3.7	22.9	1.55	1.73	0.453	0.46	0.8
24	RIL-275	37	36	98	92	5.3	7.7	19.0	20.3	260.4	182.3	1.3	1.3	29.2	24.9	14.7	5.9	2.8	53.0	1.79	2.02	0.454	0.36	1.88
25	RIL-12	42	40	100	86	8.8	8.3	16.3	20.0	189.7	159.0	1.5	1.4	34.9	27.9	20.1	5.4	4.1	25	2.03	1.17	0.482	0.485	0.82
26	RIL-313	35	36	99	90	10.1	8.5	18.3	17.3	193.4	199.5	0.5	0.9	30.1	23.7	21.3	5.6	2.6	53.8	2.05	1.75	0.484	0.35	1.82
27	RIL-290	44	40	93	82	10.2	6.1	17.0	22.7	262.2	147.5	1.3	1.5	36.8	33.7	8.4	5.7	5.8	-0.5	1.96	1.11	0.514	0.52	0.42
28	RIL-36	41	41	97	88	8.3	8.0	17.3	21.0	168.4	140.6	1.1	1.2	34.2	26.5	22.5	4.3	3.5	19.4	1.65	1.47	0.477	0.43	0.66
	Mean	41	40	97	88	8.2	7.1	17.7	19.3	192.9	182.3	0.88	1.2	33.4	26.2	-	5.1	3.8	-	1.9	1.47	0.49	0.43	0.95
	LSD(0.05)	5.9	3.5	2.1	3.8	3.9	3.3	6.4	4.9	65.0	73.16	0.4	0.8	6.2	5.8	-	1.6	1.2	-	-	-	-	-	-

DTPE = Days to panicle emergence; DTM = days to maturity; NT = tiller number; SB = shoot biomass; GY = grain yield; NS = moisture non-stressed; S=moisture stressed, ELWL = excised water loss, DSI = drought susceptibility, WUE = water use efficiency; LSBY = relative shoot biomass yield; RGY=relative grain yield, TRL= total root length; RN=root number; RB = root weight.

tiller, biomass and grain yield reduction at different degree in most genotypes (Table 4). The reduction was not high in most RILs, *E. pilosa* and the standard check, while was severe for Key Murri and some other RILs. Most RILs incurred yield loss of less than 20% of the control, which indicated that most RILs resist the effect of low moisture stress. RIL-16 and RIL-290 gave superior grain yield to the rest genotypes under stressed condition. These were due to the segregation and recombination of desirable traits alleles in the better RILs from *E. pilosa* and Key Murri (Allard, 1960).

So, *E. pilosa* can be a source of drought resistance gene in addition to earliness. Tiller reduction was observed in most RILs under low moisture stress, which is one strategy to cope up the effect of drought.

Physiological drought resistance related traits

Excised leaf water loss (ELWL) (as drought avoidance traits), water use efficiency (WUE) and drought susceptibility index (DSI) have been utilized as indices for measuring the level of drought resistance among tef homozygous line (Ayele, 1993; Takele, 2001; Teferra et al., 2000). Mean values of ELWL, WUE and DSI for RILs are presented in Table 4.

All RILs showed high ELWL value when grown under non moisture stressed conditions than under stressed except RIL-29, RIL-222, RIL-66, RIL-364 and RIL275. Considerable variations of ELWL were observed among RILs under stressed (0.7 to 2.3) and non-stressed condition (1.5 to 2.32). Most RILs loss less water under waterlimited condition and maintain optimum moisture level inside the cell. The mechanism is through stomatal regulation (Blum, 1988).

Identification of genotypes that have a greater ability to use limited available water is important to enhance productivity of the crop. This can be identified using WUE.

Genotypes showing high WUE yield better under water limited condition (Passioura, 1986). The values of WUE for most RILs were higher in non miosture stressed condition (0.324 to 0.731) than stressed conditions (0.295 to 0.74) except RIL-16 and RIL-66. Most RILs, *E. pilosa* and the standard check had shown high WUE under water limited condition.

The levels of drought resistance among genotypes were evaluated using DSI which can only be estimated by comparing the performance of genotypes under stress and non-stress conditions. Wide DSI values were observed among genotypes ranged from 0.27 to 3.25. Five RILs had DSI value of less than 0.5, 12 RILs with in the range of 0.5 to 1 and eight RILs grater than 1. According to Clarke et al. (1987), RILs can be classified into susceptible or resistant using DSI. If the index is less than unity, it is considered as medium to highly resistant. But if it is greater, it is highly susceptible. So, 17 of the RILs are found to be resistant and eight are drought susceptible. There fore based on ELWL, DSI and WUE indices indicated most RILs were drought resistnat and the potential of *E. pilosa* as a source drought resistance related gene in addition to earliness.

CONCLUSION AND RECOMMENDATION

In the present study the possibility of transfering drought resistance related traits and the level of variation among RILs derived from cross between *E. tef* and *E. pilosa* were assessed. Based on the result, wide range of genetic variability in response to water stress was observed among RILs. Seventeen RILs were identified to be drought resistant with considerable yield and the rest were susceptible. RIL-16 and RIL-290 attained the highest grain yeild under stress condition. These RILs have to be considered for yield trials and for further tef breeding activities. Therefore, the result demonstrated that *E. pilosa* can be a potential source of gene associated with drought resistance related traits and the traits can be transfered through conventional crossing followed by selection. Studies like identification of the potential of other wild relatives of tef and their crossability and meiotic chromosome behaviour of the hybrid also required to exploit many traits of agronomic importance.

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REFERENCES

Admas S, Dagne K (2009). Meiotic behaviour of *Eragrostis tef* and *Eragrostis pilosa*. Afr. Crop Sci. J., 16(4): 237-241.

AGROBASE 99 (1999). Agronomix Soft Ware, Inc.171 Waterloo Street, Winnipeg, Manitoba, Canada.

Allard RW (1960). Principle of Plant Breeding. Jhon Wiley and Sons, New York.

Araus JL, Slafer GA, Reynolds MP, Royo C (2002). Plant breeding and drought in C3 cereals: what should we breed for? Ann. Bot., 89: 925-940.

Ayele M (1993). Use of excised-leaf water content in breeding tef [(*Eragrostis tef* (Zucc.) Trotter] for moisture stressed areas. Acta Agron., 42: 261-265.

Blum A (1988). Plant Breeding for Stress Environments. CRC Press, Boca Raton, Florida, USA.

Clark JM (1987). Use of physiological and morphological traits in breeding program to improve drought resistance of cereals. **In**: Drought Tolerance in Winter Cereals. Proceeding of an International Workshop Held in 1985, in Carpi. (Sirvastava, J.P., Proceddu, E. Acevedo, E and Varma,s., eds).New York.

Falconer DS, Markay TFC (1996). Introduction to Quantitative Genetics. 4th. ed. Prentice Hall, Harlow, pp. 107-124.

Fischer RA, Maurer R (1978). Drought resistance in spring wheat cultivars I. Grain yield responses. Aust. J. Agri. Res., 29: 897-912.

Johanson HW, Robinson HF, Comstock RE (1995). Estimates of genetic and environmental variability in Soy bean. Agron. J., 47: 314-318.

Jones SS, Murray TD, Allan RE (1995). Use of alien genes for the development of disease resistance in wheat. Rev. Phytopathol., 33: 429-43.

Passioura JB (1986). Resistance to drought and salinity: Avenues for improvement. Aust. J. Plant Physiol., 13: 191-201.

Takele A (1997). Genotypic variability in dry matter production, partioning and grain yield of tef (*Eragrostis tef* (Zucc.) Trotter) under moisture deficit. SINET. Ethiop. J. Sci., 20: 177-188.

Takele A (2001). Canopy temperatures and excised leaf water loss of tef (*Eragrostis tef* (Zucc.) Trotter) cultivar under water deficit conditions at anthesis. Acta Agronomica Hungarica 49(2): 109-117.

Tefera H, Assefa K, Belay G (2003). Evaluation of interspecific recombinant inbred lines of *Eragrostis tef* x *E. pilosa*. J. Genet. Breed., 57: 21-30.

Teferra T, Tefera H, Simane B, Tuinstra M (2000). The influence of moisture stress on growth, leaf water loss rate and phonological development of tef (*Eragrostis tef*). Trop. Sci., 40: 100-107.

Wondimu A, Tekabe F (2001). Utilization of tef in the Ethiopian diet. In: Narrowing the Rift: Research and Development in Tef: Workshop Proceedings, (Hailu Tefera, Getachew Belay and Mark, S. eds). Ethiopian Agricultural Research Institute, Addis Ababa, pp. 49-57.