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Full Length Research Paper

Effects of drought stress on some agronomic and morphological traits of durum wheat (*Triticum durum* Desf.) landraces under greenhouse condition

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Although, drought stress has been well documented as an effective parameter in decreasing crop production; developing and releasing new varieties which are adaptable to water deficit conditions can be a constructive program to overcome unsuitable environmental conditions. The present study was carried out to study the effect of drought stress under greenhouse conditions in Islamic Azad University of Ardabil Branch, Iran. The agronomic and morphological traits of 25 durum wheat (*Triticum durum* Desf.) genotypes were investigated. The present study was done based on randomized complete block design with three replications in drought stress and normal irrigation conditions in a greenhouse. The analysis of variance has indicated that there are significant differences among the genotypes in all the traits, which indicate that there are great variations among genotypes in order to use in improvement plans. Analysis of variance shows that drought stress has a significant effect on all studied traits except harvest index. The comparison of means indicated that the genotypes; poldash, sari boghda and germi in normal condition and sari boghda, omrabi-5, langan, germi and germi under stress condition, are the superior groups. Grain yield has shown a positive and significant correlation with peduncle length, number of grains per spike, 1000 grain weight, biological yield and harvest index. Cluster analysis divides the genotypes into three groups in each condition. The best genotypes were included in a group which confirms the results of the compared means yield.

Key words: Agronomic traits, durum wheat, genetic diversity, yield components.

INTRODUCTION

Genetic diversity is the base of plant breeding, which has been caused by natural development, and is one of the important components of biological systems stability. Evaluating genetic diversity in cultivated plants for plant breeding programs and heritable resources protection has a vital usage. Being aware of genetic diversity in plant species is important for selecting parental races in order to obtain suitable hybrids, and prediction of hybrids especially in the crops that their hybrid has a commercial value (Mohammadi and Prasanna, 2003; Farahani and Arzani, 2008). Durum wheat (*Triticum durum* Desf.) is a monocotyledonous plant of the *Gramineae* family and of the *Triticeae* tribe and belongs to the genus *Triticum*. For commercial production and human consumption, after common wheat species, durum wheat is the second most important *Triticum* species (*Triticum aestivum* L.) (Talebi et al., 2010). Dryness is one of the most important factors which limits the production of crops, including wheat in the world and Iran. This topic is more important in dry and semi-arid regions of the world (Khayatnezhad et al., 2010; Alaei et al., 2011). Drought is a rising threat of the world. Most countries in the world are facing the problem of drought. It is the creeping disaster that slowly takes an area and tightening its grip with time (Ahmadizadeh et al., 2011). Improving drought tolerance and productivity is the most difficult task for cereal breeders, because of the diverse strategies adopted by plants at various stages of development among the species and cultivars to cope

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with water stress (Rajiv et al., 2010). Almost 32% of wheat culture confronts various types of drought stress during the growth season in developing countries (Shamsi, 2010). The ability of a cultivar to produce high yield over a wide range of environmental condition is very important. Response of plants to water stress depends on several factors, such as developmental stage, intensity and duration of stress and cultivar genetics (Eskandari and Kazemi, 2010). Developing plants with suitable advantages under water stress conditions is a basic challenge for wheat improvement programs. In bread and durum wheat, grain yields can be assessed in terms of three yield components, namely; the number of spikes per unit area, the number of kernels per spike and kernel weight (Moayedi et al., 2010). Developing crop cultivars with high grain yield has been the principle aim of durum wheat breeding programs worldwide (Bhutta, 2006). Morphological and agronomic traits of wheat have a special role to determine the importance of each trait on increasing yield, as well as to use those traits at the breeding programs, which at least lead to improving yield and introducing commercial varieties under end seasonal drought stress condition (Mollasadeghi et al., 2011). Morphological characters include root length, spike number, grain number per spike, 1000 grain weight, awn length (Moustafa et al., 1996; Boyer, 1996; Plaut et al., 2004; Blum, 2005; Eskandari and Kazemi, 2010).

Giunta et al. (1993) and Zhong-hu and Rajaram (1994) reported that under water limitation treatments, kernels spike and the number of spikes m^{-2} were the most sensitive yield components to drought stress while kernel weight remained relatively stable. It has also been reported by Simanae et al. (1993) that the number of spikes and also the number of grain spike were the effective factors to determine the drought stress. Hence, decreasing the amount of these traits under water deficit conditions will indicate a negative effect on grain yield. Saleem (2003) observed that water deficit affects the number of spike and kernels spike in bread and durum wheat genotypes.

Heydari et al. (2006) in his study on genetic diversity of different traits in 157 lines of double haploid bread wheat indicated that their under-study lines have higher genetic diversity for last internodes length, number of fertile spike per area unit, plant height, number of grain and grain yield per spike in comparison with other traits like grain volume weight, days to maturity, days to heading and days to anthesis. Other studies had shown that the number of grain spike had a predominant importance over kernel weight in defining yield in high latitudes (Peltonen-Sainio et al., 2007) whereas kernel weight was well known as a major yield component, determining final yield in certain Mediterranean environments (Garcia Del Moral et al., 2003).

We measure relationships and plant materials by cluster analysis. This method was genetically and environmentally suitable in hybridization for classifying under-study varieties of the plant, as well as to determine parents (Farahani and Arzani, 2008). Saleem (2003) studied four durum wheat (*T. durum* Desf.) genotypes and four bread wheat (*T. aestivum* L.) genotypes, he reported that plant height, ear length, number of spikelet, grain yield and straw weight decreases with water stress in both durum and bread wheat genotypes. Wajid et al. (2002) reported that wheat crop produces highest grain yield by applying irrigation at all definable growth stages. Because irrigation is an expensive input, farmer, agronomist, economist and engineer need to know the response of yield to irrigation. Furthermore, Jahfari (2004) and Rafique (2004) reported that yield and yield components are significantly increased within different wheat cultivars. Garavandi and Kahrizi (2010) by evaluating 20 bread wheat genotypes reports that genotypes has higher genetic diversities for grain yield, spike number per square meter, number of seed per spike, spike density and awn length in comparison with other traits. Development of cultivars with high yield is the main goal in water limited environments, but success has been modest due to the varying nature of drought and the complexity of genetic control of plant responses (Mirbahar et al., 2009).

In Iran, water shortage is very common in late season after the anthesis, even in irrigated lands. Therefore, the availability of tolerant wheat cultivars to the water limitation in the late season is essential to the sustainable production of this important crop. Thus, the present research was conducted to evaluate the genetic diversity among different genotypes of durum wheat to compare their correlation of morphological traits under drought stress conditions, as well as to use them in breeding programs and to identify near and far groups of genotypes in suitable regions.

MATERIALS AND METHODS

Experiments were undertaken on 20 durum wheat (*T. durum* Desf.) landraces, which were selected from northwest of Iran, along with five controls (Korifla, Chakmak, Zardak, Haurani-1 and Omrabi-5). They were grown under irrigated and drought environments, base on randomized complete block design with three replications. The experiment was carried in the greenhouse conditions in agricultural research station of Islamic Azad University, Ardabil branch, Iran (Northwest of Iran), during the 2010 and 2011. The studied characters were plant height, number of tillers, peduncle length, spike length, grain per spike numbers, fertile tillers per plant, 1000 grain weight, awn length, kernel per spike, harvest index and grain yield. For the experiment, plastic pots which had 20 cm diameter and 30 cm height were selected and they were filled with 10 kg soil. Each plastic pot had been filled with cultivated soil, sand and manure with a ratio of 1:1:1 and four seeds had been planted in 3 cm depth with equal spaces. In three leaves phase, in order vernalization, the pots were moved out of the greenhouse from 21 December until 30 January (40 days). After this period, the pots were moved to the greenhouse once again. All the pots were watered in three days period to reach the irrigation capacity. In flowering phase, drought stress was exerted through every day watering control pots and not watering stress pots until they reached to 80% soil moist evacuation via weight. The analysis of variance (ANOVA) for each character was performed following the Duncan's new multiple range test (Steel and Torrie, 1960), to test the significance difference between means. Also, for evaluation of the relation between traits, Pearson correlation was used. To categorize genotypes, cluster analysis was performed using Ward method. The data were statistically analyzed by MSTAT-C and SPSS software's.

RESULTS AND DISCUSSION

Analysis of variance of data showed that there was considerable variability among genotypes in all the traits, which demonstrate the presence of genetic diversity among under studying landraces. Environment mean squares were also significant for all the traits studied except for harvest index, showing that the water stress has significant effect on all traits. Genotype and environment (G × E) interaction was significant for all the traits (Table 1), showing variation of genotypes over environments. Askarinia et al. (2008) and Dohlert et al. (2001) respectively found in their studies on wheat and oat that genotype and environment interaction had the most shares in justifying grain performance variations. This could provide scope for breeding for traits studied, along with yield and its components, under drought stress conditions. Mean performance for all the traits decreased in drought stress environment except harvest index and infertile tillers (Table 1). Similar results were reported by other researchers (Jedynski, 2001; Garcia Del Moral et al., 2003; Nouri-Ganbalani et al., 2009; Golabadi et al., 2005; Khayatnejad et al., 2010). Collaku and Harrison (2002) reported about 45% reduction in wheat performance as a result of drought stress.

Comparison of genotypes mean from cultivated traits and morphological points of view in stress and non-stress conditions

Genotype and environment interaction was significant for the studied agronomy and morphological traits (Table 2), that is, the genotypes did not have the same reaction in different environmental conditions from these traits points of view, so the comparison of genotypes mean was done separately in two conditions. Mean comparison of genotypes, showed that genotypes 1, 2, 16, 22, 24, 11, 13, 14 and 25 had the least infertile tillers in normal condition. Genotypes 17, 6, 11, 7, 9, 23, 24, 13, 14, 16 and 21 had the least infertile tillers in stress condition. The highest fertile tillers number per plant was determined in genotype 4 in normal condition. Under stress condition, genotypes 22, 4, 14, 11, 3, 23, 7 and 1 had the highest fertile tillers number (Table 2). Drought stress caused yield reduction in spike yield stage until grain yield stage, it happens due to fertile spikes reduction and the number of grains in each spike (Sterling and Nass, 1981).

Genotypes 24, 22, 21, 20 and 9 had the most peduncle length in normal condition. Genotypes 2 and 22 had the most peduncle length in stress condition (Table 2). The importance of peduncle length and the role of carbohydrate resources in it which act as transferred store for grain yield and the role of these resources in increasing grain performance under drought stress, had been reported by different researchers (Davidson and Chevalir, 1992; Slafer and Andrade, 1991).

The highest awn length was determined in genotypes 16, 22, 5, 11, 24, 18, 2, 15, 21, 10, 20, 6, 9 and 14 in normal condition. Under stressed condition, genotypes 9, 19, 16, 22, 24, 21, 15, 18 and 2 had the highest awn length. Genotype 9 had the most spike length in normal condition. Genotypes 9 and 24 had the most spike length in stress condition. Genotype 24 had the most plant height in normal condition. Genotypes 21, 22, 17 and 11 had the most plant height in stress condition (Table 2). Due to the capacity of tall wheat genotypes for extracting water of soil and the effective role of stored materials in the stem of these genotypes in grain yield under end seasonal drought, produced more performance as compared to short genotypes (Innes et al., 1985).

The highest number of grain spike was determined in genotypes 5, 15, 2, 1, 22, 23, 12, 17, 19, 9, 18, 16, 11, 24, 13 and 4 under normal condition. Under stressed condition, genotypes 19, 17, 15, 6, 2, 16, 23, 12, 22 and 5 had the highest number of grain spike (Table 2). Giunta et al. (1993) and Zhong-hu and Rajaram (1994) also realized in different cares of drought stress that the number of grains in spike and the number of spikes in m^2 have the most sensitivity to drought stress. Regarding the results of this experiment, genotypes 19, 17, 15, 2, 16, 23, 12, 22 and 5 had more grains than other genotypes in both stress and non-stress conditions (Table 2), which shows the high potential of these genotypes from this trait point of view. But interaction G × E related to genotype 6 in stressed condition and 1, 9, 18, 11, 24, 13 and 4 in non-stressed condition. Genotypes 1, 15 and 2 had the most grain yield in normal condition. Genotypes 17 and 2 had the most grain yield in stress condition. The highest 1000 grain weight was determined in genotype 1 in normal condition. Under stressed condition, except genotypes 8, 20, 11, 14, 12, 10 and 9 other genotypes had the highest 1000 grain weight (Table 2).

Kobota et al. (1992) declared that weight reduction of grain wheat is subsequent to water access reduction due to reduction in further transformation process of spike. Genotypes 1, 17 and 5 had the most biological yield in stress condition. Genotypes 2, 1, 16, 6, 18, 25, 15, 3, 11, 10, 14, 19 and 13 had the most harvest index in normal condition. Genotypes 2, 17, 6 and 13 had the most harvest index in stress condition (Table 2). Grain harvest index as a quantity trait is an indicator of plant efficiency in distributing photosynthetic materials towards the grain, and introducing the genotypes with high harvest index is considered one of the major and important goals of wheat eugenic programs. However, some researchers have reported a low heritability for harvest index (Wang et al.,

Table 1. Mean squares, range, mean, percentage decrease under drought stress (E2) and normal irrigation (E1) under greenhouse condition in durum wheat landraces.

S.O.V	df	Means square										
		Infertile tillers	**Fertile tillers**	**Peduncle length**	**Awn length**	**Spike length**	**Plant height**	**Number of grain spike**	**Grain yield**	**1000 Grain weight**	**Biological yield**	**Harvest index**
Environment (E)	1	13.5***	116.1***	9813.05***	50.588***	4.138***	13711.9***	708.507***	95.074***	408.639**	851.88***	238.115^{NS}
E × Replication	4	0.593	0.28	20.504	0.534	0.142	11.761	6.227	1.393	10.794	9.89	155.947
Genotype (G)	24	3.966***	5.353***	254.509***	14.942***	5.268***	1236.5***	74.326***	4.068***	303.226***	9.91***	455.8***
G × E	24	3.806***	1.813***	84.187***	3.325***	0.538*	451.52***	28.409**	2.243***	364.624***	4.591*	179.015**
Error	96	0.378	0.336	9.365	0.839	0.314	4.846	13.192	0.7	39.718	2.618	70.672
Rang	E1	7	6	39.61	8.2	5.75	75.85	25	7.02	82.22	15.13	54.11
	E2	3	4	28.32	6.95	4.85	37.4	16	3.09	28.66	5.31	53.85
Mean	E1	1.74 ± 0.17	4.4 ± 0.15	46.54 ± 1.1	10.98 ± 0.21	5.93 ± 0.13	82.10 ± 2.4	24.0 ± 0.7	3.66 ± 0.18	69.4 ± 1.73	9.94 ± 0.32	37.6 ± 1.59
	E2	2.34 ± 0.1	2.64 ± 0.11	30.3 ± 0.63	9.82 ± 0.29	5.6 ± 0.108	62.9 ± 1.2	19.6 ± 0.43	2.07 ± 0.07	66.1 ± 0.76	5.18 ± 0.104	40.15 ± 1.2
% decrease		-	40	34.75	10.75	5.59	23.2	18.1	43.4	4.75	47.9	-
Total mean		2.04 ± 0.1	3.52 ± 0.12	38.45 ± 0.9	10.4 ± 0.15	5.76 ± 0.08	72.54 ± 1.5	21.8 ± 0.44	2.87 ± 0.11	67.7 ± 0.95	7.56 ± 0.25	38.8 ± 1.01

***, **,* and Ns, significant at P < 0.001, 1 and 5% level of probability and non-significant, respectively.

2002).

Under drought stress condition, genotypes 17, 2 and 22 were placed in the superior group from most traits points of views. In normal condition, genotypes 2, 4, 16, 18 and 11 were placed in the superior group from most traits points of views. Genotype number 2 was placed in the superior group from most traits points of views in both drought stress and non-stress conditions, it had been an indicator of high potential of the genotype from agronomy and morphological points of views. Therefore, considering the results of mean comparison of the traits, the genotype can be introduced as the superior genotype.

Correlations

Due to significant interaction between genotypes and environment, the Pearson correlation has been evaluated separately for each condition (Table 3). In normal condition, infertile tillers showed negative correlation with all the traits studied. Grain yield showed positive and significant correlation with fertile tillers, plant height, number of grains per spike, 1000 grain weight and harvest index. Under stress condition, grain yield showed positive and significant correlation with peduncle length, number of grains per spike, 1000 grain weight, biological yield and harvest index. Number of grains per spike had a positive and significant correlation with 1000 grain weight and harvest index. Slafer and Andrade (1991) reported positive and significant correlation between wheat grain yield and harvest index. Some researchers know that this index is an

Table 2. Mean values of agronomical and morphological parameters, measured from 25 durum wheat landraces after normal irrigation (C1) and after a drought stress treatment (C2).

S/N	Landraces	Infertile tiller		Fertile tiller		Peduncle length		Awn length	
		C1	C2	C1	C2	C1	C2	C1	C2
1	Kordgheshlaghi	0^{h}	3.66^{a}	5.66^{bcd}	3.33^{abcd}	48.8^{def}	$31.03^{bcdefgh}$	9.8^{defgh}	9.39^{fgh}
2	Sari boghda	0^{h}	2.33^{bcde}	4.66^{def}	2.66^{cdef}	52.4^{bcde}	43.24^{a}	12.24^{abc}	11.11^{abcd}
3	Ardabil	1.33^{efg}	2.66^{abcd}	5^{cdef}	3.66^{abc}	32.5^{jkl}	21.68^{k}	10.32^{cdefgh}	8.63^{hi}
4	Omrabi-5 (control)	2^{def}	2.33^{bcde}	7.33^{a}	4^{a}	30.6^{kl}	26.45^{hij}	9.33^{efgh}	7.90^{i}
5	Langan	1.33^{efg}	3^{abc}	4.66^{def}	2.33^{defg}	46.2^{efg}	30.09^{defgh}	12.83^{ab}	9.67^{efgh}
6	Chakmak (control)	3.33^{bc}	1.33^{ef}	5.33^{bcde}	2.33^{defg}	35.7^{ijk}	26.07^{hijk}	11.46^{abcde}	9.99^{def}
7	Zardak (control)	2.66^{cd}	1.66^{def}	2.66^{h}	3.33^{abcd}	28.9^{l}	26.70^{ghij}	8.43^{h}	8.71^{ghi}
8	Korifla (control)	4.33^{b}	3.33^{ab}	3.33^{gh}	1.66^{fg}	29.7^{kl}	22.45^{jk}	10.82^{bcdefg}	6.34^{j}
9	Germi	1.33^{efg}	1.66^{def}	2.33^{h}	2^{efg}	55.3^{abcd}	27.83^{fghi}	11.2^{abcdef}	12.33^{a}
10	Samrein	1.33^{efg}	3.33^{ab}	2.66^{h}	1.66^{fg}	43.3^{fgh}	27.78^{fghi}	11.56^{abcd}	10.7^{bcde}
11	Germi	1^{fgh}	1.33^{ef}	4.33^{efg}	3.66^{abc}	51.3^{cde}	34.96^{bcd}	12.73^{ab}	10.36^{cdef}
12	Haurani-1 (control)	6.66^{a}	2.66^{abcd}	2.66^{h}	2.33^{defg}	38.4^{hij}	29.13^{efgh}	8.83^{gh}	6.12^{j}
13	Germi	1^{fgh}	2^{cdef}	4^{fg}	1.66^{cdef}	43.5^{fgh}	28.43^{fghi}	10.91^{bcdefg}	7.84^{i}
14	Ardabil	1^{fgh}	2^{cdef}	6^{bc}	4^{ab}	51.3^{cde}	33.93^{bcde}	11.13^{abcdef}	9.41^{fgh}
15	Moghoan	1.33^{efg}	3.66^{a}	6^{bc}	1.33^{g}	52.5^{bcde}	23.85^{ijk}	12.06^{abc}	11.47^{abc}
16	Langan	0.66^{gh}	2^{cdef}	3.33^{gh}	2^{efg}	46.0^{efg}	$31.05b^{cdefgh}$	13.13^{a}	11.70^{ab}
17	Pol dash	1.33^{efg}	1^{f}	3.33^{gh}	3^{bcde}	52.5^{bcde}	35.82^{b}	10.53^{cdefgh}	9.87^{efg}
18	Germi	1.33^{efg}	3^{abc}	4^{fg}	2.66^{cdef}	52^{cde}	29.69^{efgh}	12.3^{abc}	11.45^{abc}
19	Samrein	2.33^{cde}	3^{abc}	4^{fg}	1.66^{fg}	49.6^{cdef}	29.39^{efgh}	9.13^{fgh}	11.86^{ab}
20	Langan	2.33^{cde}	2.33^{bcde}	4.33^{efg}	2^{efg}	55.6^{abc}	30.86^{cdefgh}	11.54^{abcd}	8.77^{ghi}
21	Ahar	2^{def}	2^{cdef}	4.66^{def}	2^{efg}	55.7^{abc}	35.44^{bc}	11.96^{abcd}	11.52^{abc}
22	Germi	0.66^{gh}	2.33^{bcde}	6.33^{b}	4.33^{a}	58.7^{ab}	40.83^{a}	12.86^{ab}	11.68^{ab}
23	Goli bagholia	2.66^{cd}	1.66^{def}	5^{cdef}	3.33^{abcd}	41.3^{ghi}	31.73^{bcdefg}	6.33^{i}	6.32^{j}
24	Magholan	0.66^{gh}	1.66^{def}	4^{fg}	1.66^{fg}	61.1^{a}	28.29^{fghi}	12.3^{abc}	11.55^{abc}
25	Pol dash	1^{fgh}	2.66^{abcd}	4.33^{efg}	2^{efg}	49.8^{cdef}	32.42^{bcdef}	10.76^{bcdefg}	10.79^{bcde}

Values with the same superscript letters are non-significantly different at $P < 0.05$.

Table 2. Cont.

S/N	Landraces	Spike length		Plant height		Number of grain spike		Grain yield	
		C1	C2	C1	C2	C1	C2	C1	C2
1	Kordgheshlaghi	4.92^{fghi}	4.65^{ghi}	97.33^{de}	57.48^{fg}	29^{abcd}	17^{ghij}	7.25^{a}	2.30^{bc}
2	Sari boghda	6.26^{cd}	5.81^{cdef}	93.53^{ef}	62.14^{d}	30^{abc}	22.66^{abcd}	5.83^{abc}	3.49^{a}
3	Ardabil	6.1^{cde}	5.78^{cdef}	54.8^{m}	46.62^{jk}	20^{def}	17.66^{efghi}	4.39^{bcde}	1.83^{cde}
4	Omrabi-5 (control)	4.4^{ij}	4.92^{defghi}	45.5^{o}	49.8^{ij}	23.66^{abcdef}	18.33^{defghi}	2.78^{defg}	1.75^{cde}
5	Langan	7.34^{b}	6.26^{bc}	93.26^{fg}	53.32^{hi}	31.66^{a}	21.33^{abcdefg}	2.42^{efg}	1.81^{cde}
6	Chakmak (control)	5.5^{defgh}	6^{bcd}	65.66^{l}	55.2^{gh}	22^{bcdef}	23.33^{abc}	3.87^{bcdefg}	2.53^{b}
7	Zardak (control)	4.8^{ghi}	5.30^{cdefgh}	46.73^{o}	50.46^{ij}	20.6^{def}	17.66^{efghi}	2.26^{efg}	1.81^{cde}
8	Korifla (control)	4.63^{hi}	4.78^{fghi}	50.46^{n}	48.3^{jk}	11.6^{g}	13.33^{jk}	2.01^{fg}	1.74^{cde}
9	Germi	8.66^{a}	7.63^{a}	110.3^{b}	57.95^{efg}	26.33^{abcde}	12.66^{k}	3.14^{defg}	1.75^{cde}
10	Samrein	6.16^{cde}	6.3^{bc}	91.93^{fg}	61.6^{de}	22^{bcdef}	20.33^{bcdefgh}	3.22^{defg}	1.75^{cde}
11	Germi	6.5^{bcd}	4.86^{efghi}	91.23^{fgh}	78.64^{a}	24.6^{abcdef}	15.66^{ijk}	3.72^{cdefg}	1.96^{bcde}
12	Haurani-1 (control)	5.86^{cdef}	5.05^{defgh}	64^{l}	45.56^{k}	27.33^{abcd}	21.66^{abcdef}	2.05^{fg}	1.42^{e}
13	Germi	6.12^{cde}	5.43^{cdefgh}	84.5^{jk}	62^{d}	23.66^{abcdef}	19^{cdefghi}	3.48^{defg}	2.22^{bcd}
14	Ardabil	5.16^{efghi}	4.97^{defghi}	86.43^{ijk}	70.12^{c}	21^{cdef}	20^{bcdefghi}	4.88^{bcd}	2.19^{bcd}
15	Moghoan	6.4^{bcd}	5.63^{cdefg}	100.03^{cd}	60.90^{def}	30.6^{ab}	24.33^{ab}	5.98^{ab}	1.70^{cde}
16	Langan	6.6^{bc}	6.26^{bc}	83.6^{k}	68.19^{c}	24.6^{abcdef}	22.33^{abcd}	4.12^{bcdef}	2.29^{bc}
17	Pol dash	6.65^{bc}	6.37^{bc}	56.1^{m}	78.91^{a}	27^{abcde}	24.33^{ab}	3.87^{bcdefg}	3.7^{a}
18	Germi	5.43^{defghi}	5.91^{bcde}	93.9^{ef}	69.93^{c}	25^{abcdef}	19.33^{cdefghi}	3.76^{cdefg}	2.27^{bc}
19	Samrein	4.87^{fghi}	4.34^{hi}	87.9^{hig}	74.86^{b}	26.33^{abcde}	25^{a}	4.36^{bcde}	2.29^{bc}
20	Langan	6.15^{cde}	5.78^{cdef}	89.4^{ghi}	62.13^{d}	18^{efg}	17.33^{fghij}	1.81^{g}	1.96^{bcde}
21	Ahar	5.73^{cdefg}	5.26^{cdefgh}	97.83^{d}	80.30^{a}	18^{efg}	18.66^{defghi}	2.66^{defg}	1.68^{cde}
22	Germi	7.32^{b}	5.92^{bcde}	103^{c}	78.93^{a}	28.66^{abcd}	21.33a^{bcdefg}	4.25^{bcdef}	1.93^{bcde}
23	Goli bagholia	3.5^{j}	3.96^{i}	53.5^{mn}	55.15^{gh}	28^{abcd}	22^{abcde}	2.11^{fg}	1.70^{cde}
24	Magholan	7.43^{b}	6.98^{ab}	118.2^{a}	74.71^{b}	23.66^{abcdef}	16^{hijk}	4.21^{bcdef}	1.54^{de}
25	Pol dash	5.83^{cdefg}	5.94^{bcde}	93.33^{fg}	71.16^{bc}	16.3^{fg}	20^{bcdefghi}	3.17^{defg}	2.15^{bcd}

Values with the same superscript letters are non-significantly different at $P < 0.05$.

Table 2. Cont.

S/N	Landraces	1000 Grain weight		Biological yield		Harvest index	
		C1	C2	C1	C2	C1	C2
1	Kordgheshlaghi	114.4^{a}	65.32^{abcdef}	12.96^{a}	7.09^{a}	56.39^{a}	33.33^{ef}
2	Sari boghda	62.47^{efg}	74.74^{a}	10.46^{abcde}	5.63^{bcde}	57.22^{a}	62.54^{a}
3	Ardabil	82.53^{bcd}	67.23^{abcde}	9.82^{abcde}	4.95^{cdef}	45.32^{abcd}	38.12^{cdef}
4	Omrabi-5(control)	44.87^{h}	68.08^{abcde}	8.86^{abcde}	4.32^{ef}	34.09^{bcde}	40.63^{cdef}
5	Langan	88.61^{b}	68.96^{abcd}	12.65^{a}	6.14^{abc}	19.08^{e}	29.27^{f}
6	Chakmak(control)	71.68^{cdef}	71.64^{ab}	8.70^{abcde}	4.71^{def}	47.44^{abc}	53.10^{abc}
7	Zardak(control)	60.19^{fg}	68.09^{abcde}	7.35^{de}	4.30^{ef}	30.69^{cde}	42.55^{bcdef}
8	Korifla(control)	83.77^{bc}	55.32^{f}	9.32^{abcde}	4.93^{cdef}	23.34^{e}	35.87^{def}
9	Germi	83.87^{bc}	63.18^{bcdef}	12.24^{ab}	5.10^{cdef}	26.95^{e}	34.41^{ef}
10	Samrein	63.91^{efg}	62.34^{bcdef}	7.48^{de}	4.34^{ef}	44.61^{abcd}	40.41^{cdef}
11	Germi	69.84^{def}	58.43^{ef}	8.26^{bcde}	4.99^{cdef}	44.97^{abcd}	39.51^{cdef}
12	Haurani-1(control)	61.61^{efg}	59.81^{cdef}	11.67^{abcd}	4.18^{f}	17.67^{e}	34.19^{ef}
13	Germi	63.39^{efg}	68.28^{abcde}	8.11^{bcde}	4.36^{ef}	43.85^{abcd}	51.05^{abcd}
14	Ardabil	72.32^{cdef}	59.13^{def}	11.20^{abcd}	5.31^{bcdef}	44.60^{abcd}	35.91^{def}
15	Moghoan	67.81^{ef}	67.92^{abcde}	12.88^{a}	5.54^{bcdef}	45.74^{abcd}	32.11^{ef}
16	Langan	73.54^{cdef}	72.59^{ab}	8.14^{bcde}	5.30^{bcdef}	50.66^{ab}	43.20^{bcdef}
17	Pol dash	75.23^{cde}	68.18^{abcde}	11.47^{abcd}	6.48^{ab}	33.51b^{cde}	57.22^{ab}
18	Germi	69.74^{def}	70.79^{ab}	7.82^{cde}	5.74^{bcd}	47.35a^{bcd}	39.66^{cdef}
19	Samrein	67.57^{ef}	67.09^{abcde}	9.59^{abcde}	5.57^{bcde}	44.02^{abcd}	41.09^{cdef}
20	Langan	59.7^{fg}	56.4^{f}	9.71^{abcde}	5.46^{bcdef}	18.56^{e}	36.2^{def}
21	Ahar	51.39^{gh}	70.48^{ab}	11.4^{abcd}	5.25^{bcdef}	23.55^{e}	32.53^{ef}
22	Germi	64.93^{efg}	65.31^{abcdef}	12.08^{abc}	5.04^{cdef}	29.85^{de}	38.40^{cdef}
23	Goli bagholia	51.99^{gh}	69.80^{abc}	6.86^{e}	4.53^{def}	30.44^{cde}	37.56^{cdef}
24	Magholan	61.71^{efg}	64.82^{abcdef}	12.94^{a}	5.58^{bcde}	34.31^{bcde}	27.71^{f}
25	Pol dash	68.91^{def}	69.43^{abcd}	6.65^{e}	4.55^{def}	46.59^{abcd}	47.23^{bcde}

Values with the same superscript letters are non-significantly different at $P < 0.05$.

Table 3. Correlation coefficient between studied traits in durum wheat landraces in greenhouse under normal irrigation and drought stress conditions.

Parameter	1	2	3	4	5	6	7	8	9	10	11
Infertile tillers (1)	1	(-0.272)	(-0.305)	(-0.026)	(-0.208)	(-0.296)	(0.036)	(-0.268)	(-0.129)	(0.194)	(-0.362)
Fertile tillers (2)	-0.303	1	(0.330)	(-0.207)	(-0.307)	(-0.012)	(-0.053)	(0.107)	(-0.018)	(0.000)	(0.066)
Peduncle length (3)	-0.531**	0.051	1	(0.330)	(0.001)	(0.621**)	(0.281)	(0.516**)	(0.209)	(0.274)	(0.366)
Awn length (4)	-0.475*	0.045	0.528**	1	(0.557**)	(0.668**)	(0.152)	(0.227)	(0.346)	(0.376)	(0.037)
Spike length (5)	-0.349	-0.269	0.569**	0.688**	1	(0.154)	(-0.146)	(0.115)	(0.142)	(0.134)	(0.052)
Plant height (6)	-0.547**	0.003	0.857**	0.641**	0.633**	1	(0.193)	(0.320)	(0.100)	(0.333)	(0.113)
Number of grain spike (7)	-0.270	0.191	0.325	0.042	0.279	0.281	1	(0.440*)	(0.534**)	(0.110)	(0.410*)
Grain yield (8)	-0.615**	0.397*	0.350	0.263	0.114	0.406*	0.445*	1	(0.409*)	(0.461*)	(0.828**)
1000 Grain weight (9)	-0.237	-0.080	0.028	0.171	0.212	0.181	0.145	0.464*	1	(0.110)	(0.458*)
Biological yield (10)	-0.115	0.199	0.466*	0.290	0.500*	0.440*	0.435*	0.400*	0.378	1	(-0.089)
Harvest index (11)	-0.580**	0.232	0.067	0.172	-0.121	0.182	0.173	0.780**	0.251	-0.325	1

Data on parenthesis are related to drought stress condition. ** and *, significant at 1 and 5% level of probability, respectively.

important factor in increasing the yield and they had declared that an increase in grain yield is as a result of harvest index increase and biological yield had less effect on it (Araghi and Assad, 1998; Slafer and Andrade, 1991).

Biological yield showed positive and significant correlation with plant height spike Length, number of grain spike, peduncle length and grain yield in normal conditions. Nikhkah and Ghanadha (2003) studied the relationship between the quantitative traits and grain yield in some bread wheat genotypes in drought stress and non-stress conditions and they reported that in both drought stress and non-stress conditions, the number of grains in spike, the number of spike in each bush, the weight of 1000 grains and the length of peduncle justified the most yield variations.

The correlation between number of grains per spike and 1000 grain weight with harvest index in stress condition was positive and significant. Also, plant height showed positive and significant correlation with awn length and peduncle length in both conditions. KhodaRahmi et al. (2006) showed the most correlation between grain yield with biological yield and fertile tillers per plant and these are similar to the results of this research. Amini and Rezaei-Danesh (2004), studying genetic variation and correlation between traits in wheat genotypes showed the number of grains per spike, positive and significantly correlation with yield. These results are also in agreement with the findings of otherstudies (Bhutta, 2006; Tavakolli, 2003; Nouri-Ganbalani et al., 2009; Kahrizi et al., 2010; Ahmadizadeh et al., 2011).

Cluster analysis

The data were used for hierarchical cluster analysis using ward method and interval squared Euclidean distance. Cluster analysis, divided the genotypes into three groups in normal and stress conditions (Figures 1 and 2). In order to show the value of each cluster regarding investigated traits, mean deviation percent of each cluster was calculated from the total mean. The cluster which had the highest mean in comparison with the mean of the first cluster will be appropriate for use in different improvement plans. The first cluster included genotypes 11, 18, 14, 19, 25, 16, 10, 13, 2, 15 and 1. The mean deviation percent of this cluster for traits, such as fertile tillers, number of grain per spike, grain yield, 1000 grain weight and harvest index showed maximum deviation from ground mean and this group maybe recommended as superior groups in normal condition. Under stress condition, the third cluster included genotypes 2, 17, 6, 13, 16, 18, 25 and 19. The mean deviation percent of this cluster for traits, such as spike length, number of grain per spike, biological yield, grain yield, 1000 grain weight and harvest index showed maximum deviation from ground mean and this group may be recommended as superior groups in stress condition.

Considering the results of mean comparison of genotypes 2, 16, 18 and 11 in normal condition and also genotypes 2 and 17 in stress condition, they were introduced as superior genotypes, in

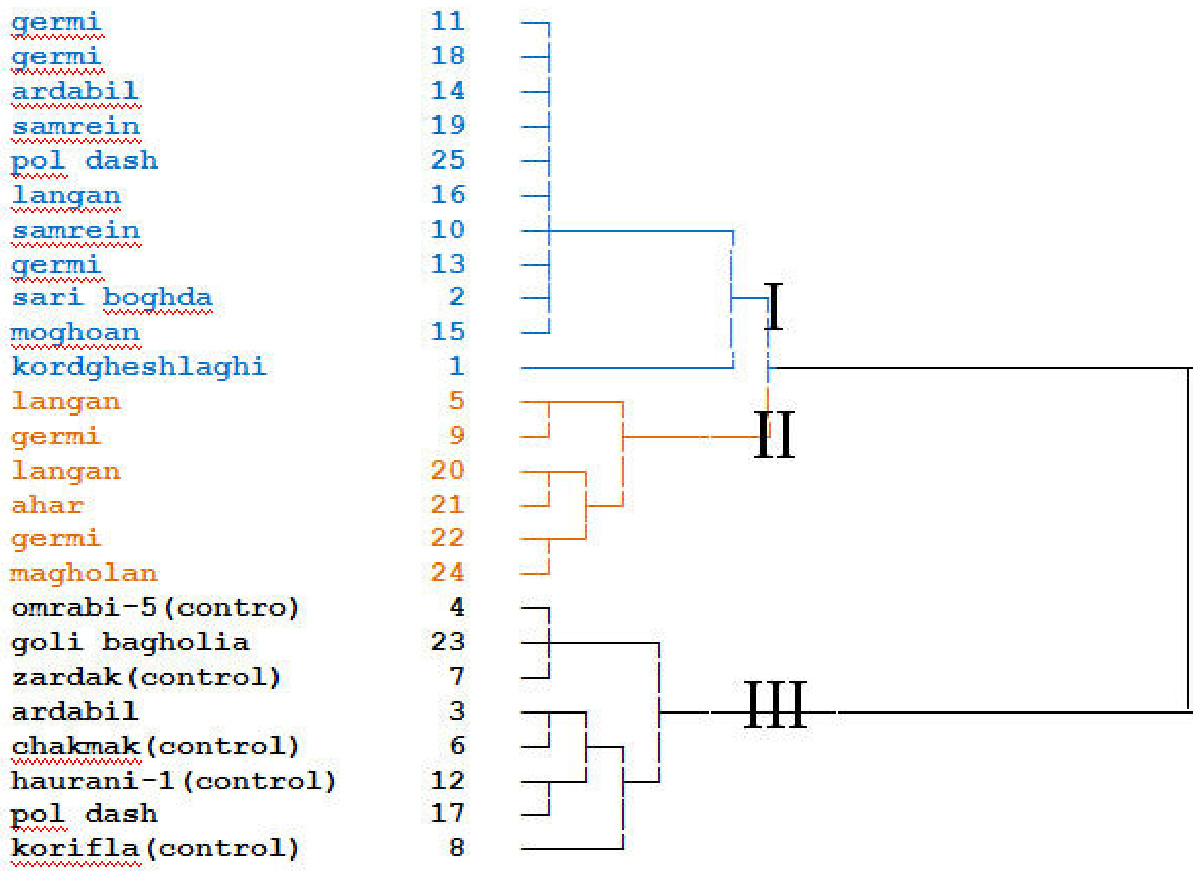

Figure 1. Dendogram of cluster analysis of durum wheat landraces classified according to all the traits studied in greenhouse under normal irrigation condition.

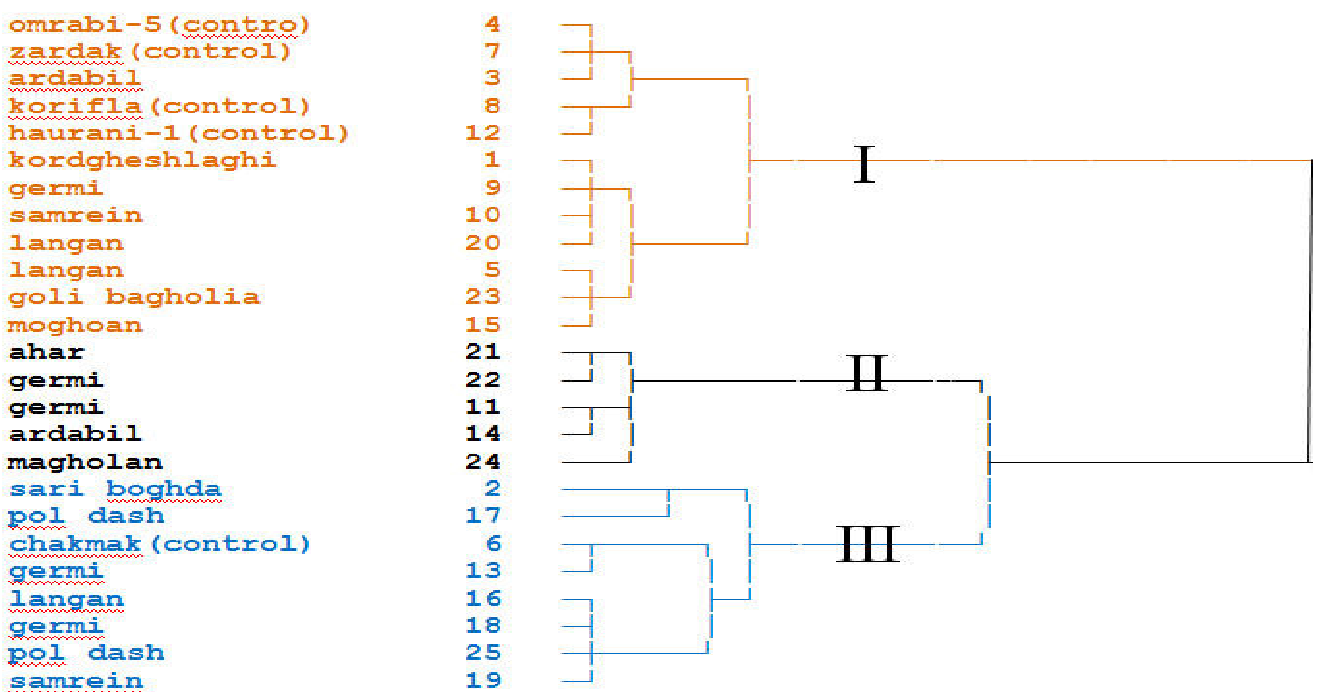

Figure 2. Dendogram of cluster analysis of durum wheat landraces classified according to all the traits studied in greenhouse under drought stress condition.

separated cluster analysis of the environments; these genotypes were also placed in superior group. So, we can declare that analyzing the cluster confirms the results of mean comparison.

Conclusion

Landraces are important genetic resources for improvement of crops in dry areas, since they have accumulated adaptation to harsh environment over long time. Collection and characterization of various agronomic and physiological traits of landraces are primary steps in plant breeding programs. Results show that drought stress causes low grain yield. Thus, wheat, a staple food, appears to be suffering yield losses due to deficiency of irrigation water at any critical stage. The results concluded under stress condition, that grain yield showed positive and significant correlation with peduncle length, number of grains per spike, 1000 grain weight, biological yield and harvest index. So, these traits suggested considerable prospects for improvement in drought tolerance. Considering the results of mean comparison and cluster analysis, genotypes 2 and 17 were selected as superior genotypes in both conditions. These genotypes could be used as source of germplasm for breeding of drought tolerance.

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