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Recovery Response of Durum Wheat Landraces in Drought Stress under Laboratory and Greenhouse Conditions

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Abstract: Environmental stresses can play an important role in the reduction of the plant growth stage, especially drought during germination in arid and semi arid regions in Iran. In order to study of the response of 37 of durum wheat landraces from Iran and Azerbaijan republic were evaluated in drought stress under laboratory and greenhouse conditions at recovery germination was investigated, on base of the completely randomized design with three replications. Analysis of variance has indicated that there were significant differences among the genotypes in total germination percentages, recovery germination percentages in greenhouse condition and recovery germination percentages in laboratory condition, which indicate that there are great variations among genotypes in order to use in breeding programs. Recovery germination percentages in laboratory condition showed positive and significant correlation with recovery germination percentages in greenhouse. Cluster analysis divides the genotypes into three groups. The best genotypes were included in a group which confirms the results of the compared means yield, these genotypes could be used as source of germplasm for breeding of drought tolerance.

Key words: Cluster analysis, durum wheat, germination, recovery, water stress

INTRODUCTION

Durum wheat is a cultivated and important food crop in the world. The total area and production was about 20 million hectares and 30 million metric tons in the world, respectively. Durum wheat is mainly (>90%) cultivated in the Mediterranean basin, Europe and India (Maniee *et al*., 2009; Kahrizi *et al*., 2010). In many part of the region durum wheat production is replaced by modern cultivars; landraces are only cultivated by farmers in very limited areas (Moragues *et al*., 2006; Akar *et al.,* 2009; Ahmadizadeh *et al*., 2011a). Nowadays, several breeding programs aim to develop new cultivars as well as release old durum landraces (Ahmadizadeh *et al*., 2011a). Landraces of wheat generally tolerant to biotic and abiotic stress have been grown under low-input or sustainable farming conditions where they produce reasonable yield. A landrace, being composed a mixture of homozygous genotypes, usually exhibits considerable genetic variation for developmental, qualitative, and quantitative characters (Moghaddam *et al*., 1997). Landraces have not been used under modern farming conditions mainly due to low productivity. Landraces are mainly cropped in remote rural areas for local use because of their high end- product quality and recently in the framework of organic farming (Akcura, 2009).

Dryness is one of the most important factors which limit 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; Ahmadizadeh *et al*., 2011b). 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*., 2011c). The uniform establishment seedling in stress condition is conducted to higher yields (Gholami *et al*., 2009). New variety selection is difficult due to the wide range of plant stress responses with overlapping functions between their components which is creating complex mechanisms of resistance (Kostukova *et al*., 2008; Ahmadizadeh *et al*., 2011d).

Seedling emergence is one of the stages of growth that is sensitive to water deficit. Therefore, seeds germination, are prerequisites for the success of stand establishment of crop plants. Under semiarid regions, low moisture is limiting factor during germination. The rate and degree of seedling establishment are extremely important factors in determination of both yield and time of maturity (Rauf *et al*., 2007; Garg, 2010). Crop establishment depends on an interaction between seedbed environment and seed quality (Ahmadizadeh *et al*., 2011d). It is critical to understand the seed germination ability of drought-tolerant forage species under drought stress and their recovery response when removed from drought condition. This information will help in the successful establishment of pastures in dry land. Stress tolerance of plants varies among species and their ecotypes (Gul and Weber, 1999; Pujol *et al*., 2000; Shen *et al*., 2003). Recovery germination of seeds in fresh-

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Table 1: Origin and taxonomy of durum wheat landraces tested.

No.	Landraces	Origin	Name
1	Korifla	Control	Korifla
2	Chakmak	Control	Chakmak
3	Zardak	Control	Zardak
4	Haurani-1	Control	Haurani-1
5	Omrabi-5	Control	Omrabi-5
6	Germi-langin	Iran	Niloticum
7	Ardabil-samrein	Iran	Albobscurum
8	Germi-langin	Iran	No-name
9	Germi-langin	Iran	Riechenbachii(G1)
10	Germi-moghoan	Iran	Riechenbachii(G2)
11	Kordgheshlaghi	Iran	Albiprovinciale(1)
12	Germi-langin	Iran	Albiprovinciale(2)
13	Germi-langin	Iran	Melaleucum
14	Ahar	Iran	Leucurum(1)
15	Ardabil-bagh oliya	Iran	Leucurum(2)
16	Germi-boldash	Iran	Murciense(1)
17	Germi-langin	Iran	Boeufii(1)
18	Germi-langin	Iran	Africanum(1)
19	Sari boghda	Iran	Africanum(2)
20	Ardabil-samrein	Iran	Apolicum(1)
21	Ardabil	Iran	Apolicum(2)
22	Germi-moghoan	Iran	Hordeiforme(1)
23	Germi-langin	Iran	Melasnopus(1)
24	Naxcevan	Azerbaijan	Boeufii(2)
25	Naxcevan	Azerbaijan	Africanum(3)
26	Naxcevan	Azerbaijan	Leucumelan(1)
27	Lerik	Azerbaijan	Leucumelan(2)
28	Naxcevan	Azerbaijan	Leucurum(3)
29	Xanlar	Azerbaijan	Murciense(2)
30	Guba	Azerbaijan	Hordeiforme(2)
31	Xatmaz	Azerbaijan	Murciense(3)
32	Naxcevan	Azerbaijan	Boeufii(3)
33	Gux	Azerbaijan	Leucurum(4)
34	Ardabil	Iran	Hordeiforme(3)
35	Ardabil	Iran	Melasnopus(2)
36	Shamaxi	Azerbaijan	Hordeiforme(4)
37	Naxcevan	Azerbaijan	Leucurum(5)

water after they were exposed to saline conditions has been investigated (macke and Ungar, 1971; woodell, 1985) to determine if seeds can remain viable after being exposed to hypersaline conditions (Khan and Ungar, 1999). The recovery germination of seeds that were previously exposed to hypersaline conditions is affected by the temperature regime to which seeds are exposed (Khan and Gul, 1998). Gulzar *et al.* (2001) showed the rate of germination, percent recovery germination and rate of recovery were greatest at 20-30ºC, with the lowest germination and recovery occurring at the 10-20ºC temperature regime. Variation in recovery germination responses have been demonstrated by (Clarke and Hannon, 1970; Woodell, 1985; Shahbazi *et al*., 2010).

The objective of this investigation was to determine the total germination percentage under drought stress, and the recovery response of durum wheat landraces.

MATERIALS AND METHODS

In this study 37 durum wheat (*Triticum durum* Desf.) landraces from Iran and Azerbaijan republic were evaluated under laboratory and greenhouse conditions (Table 1). Base on randomized completely design with three replications. The experiment was carried out in agricultural research station of Islamic Azad University, Ardabil branch, Iran (Northwest of Iran) in 2010. Experiments were performed using method of Blum *et al.* (1980) and Total germination and Recovery germination percentages were measured using the following formulas; Total Germination percentage (TG):

$$TG = (a/b)\ 100$$

where a is germinated seeds total, and b is total number of seeds for germination.

Recovery germination percentage:

$$RP = (c/d)\ 100$$

where c is the germinated seeds number in the recovery experiment, and d is the seed number total for the recovery germination experiment.

The analysis of variance (ANOVA) for each character was performed followed by Duncan's new multiple range test (Steel and Torrie, 1960) to test the significance difference between means. The data were statistically analyzed by SPSS software's.

RESULTS AND DISCUSSION

Analysis of variance showed that there was considerable variability among genotypes in total germination percentages (P<0.01), recovery germination percentages (p<0.05) in greenhouse condition and recovery germination percentages in laboratory condition (p<0.01) (Table 2). Which demonstrate the presence of genetic diversity among under studying landraces, this subject consists of height potential value in breeding wheat. Khan *et al.* (2000) reported that species vary greatly in their germination recovery responses when exposed various salinity and drought stress.

Table 2: Mean squares, range and mean under greenhouse and laboratory conditions in durum wheat landraces.

S.O.V	df	TG greenhouse	RP greenhouse	TG laboratory	RP laboratory
Genotype	36	214.114**	1097.673*	150.128^{NS}	1068.104**
Error	74	57.658	699.996	117.317	474.98
Rang		33.33	70.74	41.11	75.11
Mean		91.71±1.38	61.65±3.14	91.65±1.16	60.67±3.10

**: significant at 1% level of probability; *: significant at 5% level of probability; Ns: and non-significant; TG: Total germination percentages; RP: Recovery germination percentages

Table 3: Mean values of TG and RP, measured from 37 durum wheat landraces in greenhouse and laboratory conditions

No.	Landraces	TG greenhouse	RP greenhouse	RP laboratory
1	Korifla(control)	80 c-f	74.73 a-d	76.42 a-e
2	Chakmak(control)	100 a	53.33 a-d	64.24 a-i
3	Zardak(control)	93.3 a-c	52.5 a-d	65.18 a-i
4	Haurani-1(control)	90 a-c	61.85 a-d	32 f-i
5	Omrabi-5(control)	66.66 f	80.15 a-d	47.88 c-i
6	Germi-langin	90 a-c	85.18 a-c	64.22 a-i
7	Samrein	96.66 ab	76.29 a-d	63.55 a-i
8	Germi-langin	100 a	100 a	75.55 a-f
9	Germi-langin	100 a	100 a	58.66 a-i
10	Moghoan	96.66 ab	76.29 a-d	56.91 a-i
11	Kordgheshlaghi	86.66 a-d	65.27 a-d	67.48 a-h
12	Germi-langin	73.33 d-f	72.61 a-d	71.11 a-g
13	Germi-langin	96.66 ab	51.48 a-d	63.33 a-i
14	Ahar	90 a-c	29.62 d	69.36 a-h
15	Bagh oliya	80 c-f	32.22 cd	61.11 a-i
16	Germi-boldash	96.66 ab	52.59 a-d	50 c-i
17	Germi-langin	96.66 ab	48.51 a-d	69.77 a-h
18	Germi-langin	100 a	50 a-d	86.44 a-c
19	Sari boghda	93.33 a-c	60.37 a-d	77.77 a-e
20	Samrein	96.66 ab	62.22 a-d	53.55 a-i
21	Ardabil	93.33 a-c	45.83 b-d	54.14 a-i
22	Germi	96.66 ab	50 a-d	58.31 a-i
23	Germi-langin	96.66 ab	44.07 b-d	41.55 d-i
24	Naxcevan	93.33 a-c	39.25 b-d	78.88 a-e
25	Naxcevan	90 a-c	48.14 a-d	23.55 i
26	Naxcevan	93.33 a-c	40.74 b-d	31.11 g-i
27	Lerik	93.33 a-c	85.18 a-c	84.66 a-d
28	Naxcevan	93.33 a-c	29.25 d	22.44 i
29	Xanlar	70 ef	90.47 ab	97.55 a
30	Guba	90 a-c	46.66 a-d	26.69 hi
31	Xatmaz	86.66 a-d	39.81 b-d	52.88 b-i
32	Naxcevan	100 a	76.66 a-d	37.55 e-i
33	Gux	100 a	66.66 a-d	57.11 a-i
34	Ardabil	83.33 b-e	76.66 a-d	67.55 a-h
35	Ardabil	100 a	80 a-d	94.22 ab
36	Shamaxi	93.33 a-c	78.51 a-d	83.33 a-d
37	Naxcevan	96.66 ab	58.14 a-d	58.66 a-i

Values with the same superscript letters are non significantly different at $p<0.05$; TG: Total germination percentages; RP: Recovery germination percentages

Mean comparison of genotypes, showed that genotypes 35, 33, 32, 18, 9, 8, and 2 had the most total germination percentages in greenhouse condition, these genotypes were not significantly different with other genotypes except 34, 15, 1, 12, 29 and 5 genotypes. The highest recovery germination percentages in greenhouse condition was determined in genotypes 9 and 8, which these genotypes were not significantly different with other genotypes except 21, 23, 26, 31, 24, 15, 14 and 28 genotypes (Table 3). Recovery experiments showed that exposure of seeds to stress condition had little effect on viability of seeds. Similar effect was observed in *Limonium stocksii* seeds (Zia and Khan, 2004) and *Salsola imbricata* Forssk (Zaman *et al.*, 2010) where only 5% of seeds germinated at stress conditions but 100% germination was achieved when transferred to distilled water. Under laboratory condition, genotype 29 had the highest recovery germination percentages, were not significantly different between this genotype and 35, 18, 27, 36, 24, 19, 1, 8, 12, 17, 14, 34, 11, 3, 2, 6, 7, 13, 15, 37, 9, 22, 33, 10, 21 and 20 genotypes (Table 3).

Therefore, considering the results of mean comparison of the traits, the genotypes can be introduced most of these landraces to breeding program for resistance to drought stress. Moreover, plant response to drought at the whole plant level is more complex than at cellular level and is related to morphology, cell division, cell expansion, net photosynthesis, assimilate partitioning and many other factors (Blum, 1996). The researchers had investigated some of these traits in other plants and conditions; Gulzar *et al.* (2001) found that seeds of *U. setulosa* had 85% recovery when pretreated with 500 mM NaCl for 20 d at moderate temperatures (20/30ºC). Khan and Ungar (1999) reported 72% recovery of germination of *Triglochin maritima* seeds after a 20 day exposure to 500 mM NaCl. Macke and Ungar (1971) reported 88% recovery germination of *Puccinellia nutalliana* seeds in distilled water after a 25 day exposure to 900 mM NaCl.

Recovery germination percentages in laboratory condition showed positive and significant correlation with recovery germination percentages in greenhouse condition and total germination percentages in laboratory condition (Table 4). Figure 1 showed liner regression equation between recovery germination percentages in laboratory with recovery germination percentages in greenhouse condition. The germination had the most important effect

Table 4: Correlation coefficient between studied traits in durum wheat landraces in greenhouse and laboratory conditions

	TG greenhouse	RP greenhouse	TG laboratory
RP greenhouse	-0.096		
TG laboratory	0.167	0.163	
RP laboratory	-0.085	0.415*	0.374*

*: significant at 5% level of probability; TG: Total germination percentages; RP: Recovery germination percentages

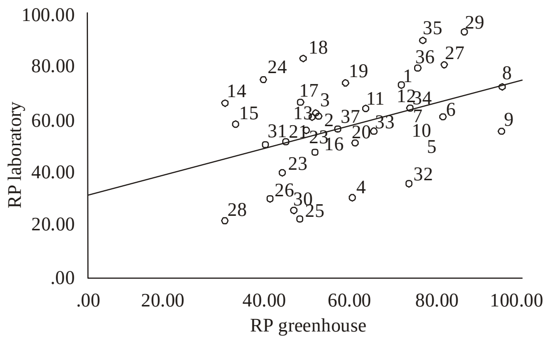

Fig. 1: Relationship between recovery germination percentagesin greenhouse and laboratory conditions

on stand establishment and plan density under laboratory and greenhouse conditions. This agreed with the results of Ram and Wiesner (1987) and Alizadeh (1977) obtained the same result on wheat seed lots under unfavorable storage conditions. Rahimi *et al.* (2006) with studied on two *plantago* species reported that recovery of their germination capacity after transferring the treated seeds to distilled water was determined.

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 (Fig. 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 another clusters will be appropriate for use in different improvement plans. The first cluster included genotypes 2, 13, 3, 17, 20, 37, 33, 15, 31, 21, 22, 16, 23, 14, 24 and 18. The second cluster included genotypes 4, 25, 32, 26, 30 and 28. The third cluster included genotypes 7, 10, 6, 34, 1, 12, 11, 19, 5, 8, 9, 27, 36, 35 and 29.The mean deviation percent of third cluster for three traits, showed maximum deviation

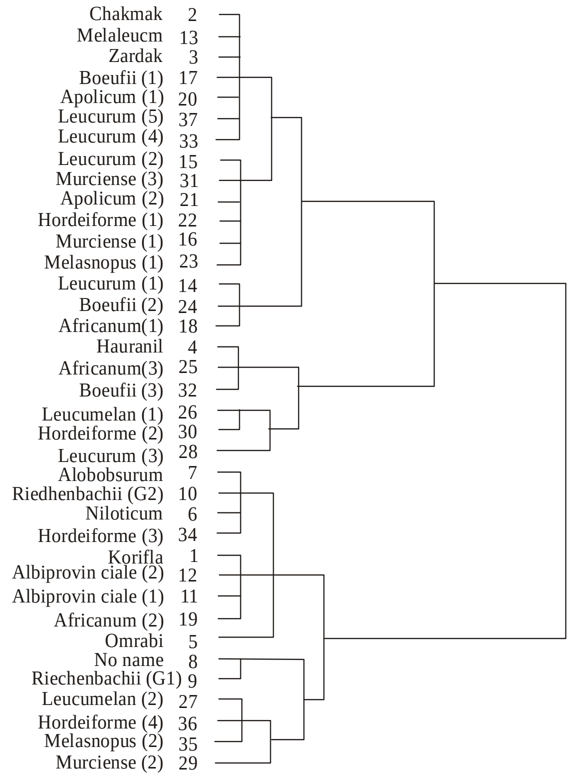

Fig. 2: Clustering of durum wheat landraces using Wards method based on total germination percentages and recovery germination percentages in greenhouse and laboratory conditions

from ground mean and this group maybe recommended as superior groups (Table 5). The genotypes in this group, also considering the results of mean comparison they were introduced as superior genotypes, in separated cluster analysis of the these genotypes were also placed in superior group. So, we can declare that analyzing the cluster confirms the results of mean comparison. This variation in recovery responses could be helpful for survival of plants following salt stress. *A. lagopoides* (Gulzar and Khan, 2001) and *U. setulosa* (Gulzar *et al.*, 2001) showed a high (85%) recovery at 600 mM NaCl at 20-30C, whereas *S.ioclados* (Khan and Gulzar, 2003) showed overall poor recovery response. Macke and Ungar (1971) found 87% recovery in seeds of *Puccinellia nuttalliana* (Schult.) Hitchc.

Table 5: Groups mean and difference percentage from total mean in durum wheat landraces

Group		TG greenhouse	RP greenhouse	TG laboratory	RP laboratory
1	Mean difference %	94.58	48.51	93.12	61.53
		3.03	-27.08	1.58	1.4
2	Mean difference %	92.77	50.55	85.74	28.89
		1.14	-21.96	-6.89	-109.9
3	Mean difference %	88.22	80.11	92.44	72.46
		-3.9	23.03	0.85	16.27
Total	Mean	91.71	61.65	91.65	60.67

TG: Total germination percentages; RP: Recovery germination percentages

CONCLUSION

The germination pattern varied among landraces under drought stress in this experiment, 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 some traits related to germination of landraces are primary steps in plant breeding programs. The total germination percentage was more than 90% in greenhouse and laboratory conditions. The recovery germination percentage for 37 species indicated that inhibit germination under drought stress. The recovery germination percentage was 60% in both conditions. Although, recovery germination percentage in greenhouse and laboratory conditions had positive relationship with each other but quite diverse at different stage of plant development, Salt and drought tolerant is developmentally regulated and the responses to salt and drought stress maybe quite diverse at different stage of plant development. Considering the results of mean comparison and cluster analysis, genotypes 7, 10, 6, 34, 1, 12, 11, 19, 5, 8, 9, 27, 36, 35 and 29 were selected as superior genotypes. These genotypes could be used as source of germplasm for breeding of drought tolerance.

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